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Automated vendor selection for industrial service shares

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Abstract

Industrial Product-Service Systems (IPS²) fulfil specific customer needs in the industrial area due to the appropriate combination of product and service shares. Through the customer individual orientation of IPS² the need for identification of suitable network partners for service delivery arises.
In this paper a method for the automated vendor selection for industrial service shares will be developed and evaluated. To achieve this goal, an investigation of possible service shares in the field of machine tools is necessary. Subsequently the parameters of the identified service shares and their potential values will be assigned.
The comparison of defined parameter values of the customer's query and all registered providers facilitates the automated mediation of appropriate providers. For IPS², the presented approach holds several benefits compared to existing approaches. These include the ability of standardised comparison of the providers' potential for service delivery and the efficient selection of appropriate providers under consideration of uncertainty.
Subsequently an application example of possible service shares for a customer request in the machine tool domain will be given.
An outlook on further work and future potential will complete the paper.

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Keywords: Industrial Services; Vendor Selection; Service Directory; Industrial Product-Service Systems

1. Introduction

Industrial Product-Service Systems (IPS²), solutions or hybrid products refer to a new product paradigm combining product as well as service shares in order to fulfil a specific customer need [1, 2]. In contrast to classical, transactional business models, the offering of IPS² imposes several challenges on the provider, who has to continously provide service processes throughout the whole lifecycle [3] in order to fulfil the superordinate customer need, e. g. the guaranteed availability of a machine tool [4]. As the service processes have to be performed in a timely and economic manner, it is common practice to collaborate with local service providers, which are located in the customer's proximity and offer the specified service share commisioned by the IPS² provider [5].

The abovementioned trend leads to the transformation of machine tool manufacturers from builders of equipment to customer individual solution providers [6] who are relying on value creation networks which have to be organized and directed in real time [7].

A common classification of IPS² types has been elaborated by TUKKER [8], who differentiates between product oriented, use oriented and result oriented IPS² which can be located along a spectrum between a classical product-centered view and a service-centered view of goods. Especially the use and result oriented IPS² feature a high degree of integrated service shares which are necessary to fulfil a superordinate customer requirement. In order to ensure the timely and efficient delivery of service processes for the customer, IPS² providers can commission external service providers for the delivery of service shares. The management of such IPS² value creation networks is an important key to offer IPS² business models [9]. However, its management imposes an organisational challenge on the IPS² provider [10].

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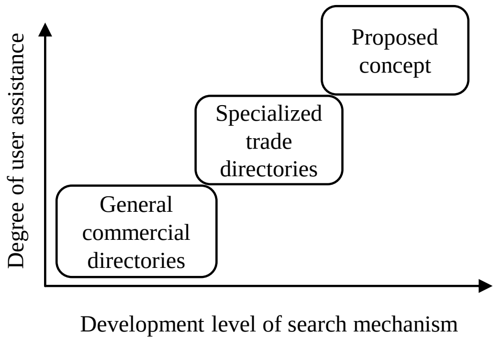

Fig. 1. Means of industrial service provider selection.

The contribution at hand presents an approach for the automated selection of suitable service providers for the fulfillment of specific customer needs by the IPS² provider. Therefore, a concept for an automated service provider selection will be presented in chapter 2. Subsequently, the implementation will be shown in chapter 3 and an assessment as well as a conclusion will be given at the end.

2. Existing approaches for selection of industrial services

For finding suitable providers for specific customer requests, various approaches exist, see Fig. 1. The simplest, yet most general way of searching for industrial service providers is by the use of general commercial directories, such as the yellow pages.

The next level regarding the degree of user assistance are specialized trade directories such as Industrystock, Europages or Wer Liefert Was. Although such business-to-business search engines provide more effective means of provider search compared to conventional internet search engines [11], these directories are mainly product-centered and offer only rudimentary search capabilities for industrial services. Industrial services can be classified as concretely as e. g. “machine tool maintenance” (Industrystock) or “repair of machine tools” (Wer Liefert Was). However, when searching for suitable service shares, one has to directly contact the provider in order to concretize the manifold details of the service offer, contract and delivery. This makes it difficult to precisely search for suitable service offers, objectively compare different service providers or even automate the selection of one optimal provider for a specific customer request.

3. Relevant industrial services

In order to tackle the abovementioned challenge, a concept for the improved description and selection of industrial services will be proposed.

3.1. Identification of industrial services

In a survey, 18 types of industrial services in the field of machine tools were identified [12, 13, 14].

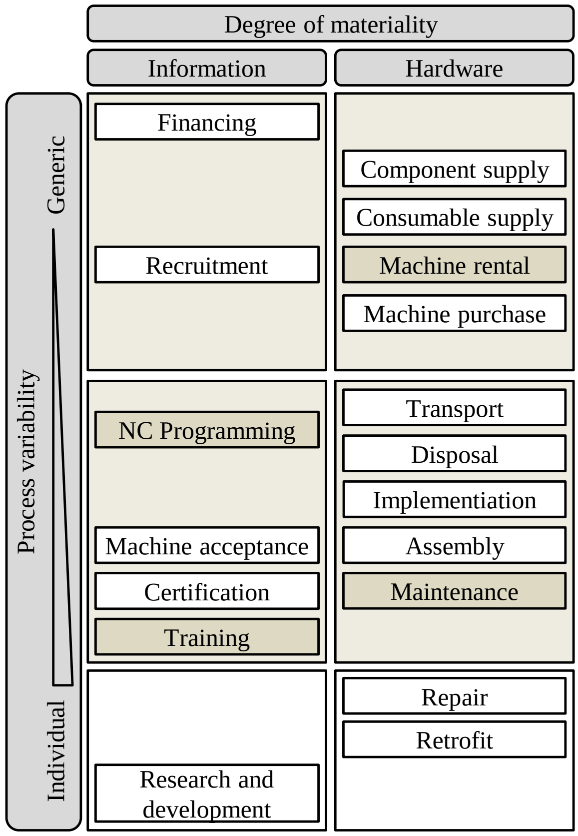

Fig. 2. Classification of industrial services.

The identified service types were then clustered into six categories according to their degree of materiality and process variability, see Fig. 2.

The degree of materiality describes the extent to which tangible components are part of the service’s process or result dimension, determining its organisational effort. The process variability describes the need of individualization of the service share. The two categories with the highest degree of process variability will not be considered in the framework of this paper, as the necessary amount of attributes to describe such service shares inhibits an automated comparison of different offers. The four service types machine rental, NC programming, training and maintenance (highlighted in Fig. 2) will be selected as examples for further description and demonstration.

3.2. Description of industrial services

In a next step, the identified industrial services need to be described in order to ensure the precise selection of services. Therefore, description attributes are used which will be introduced in Fig. 3.

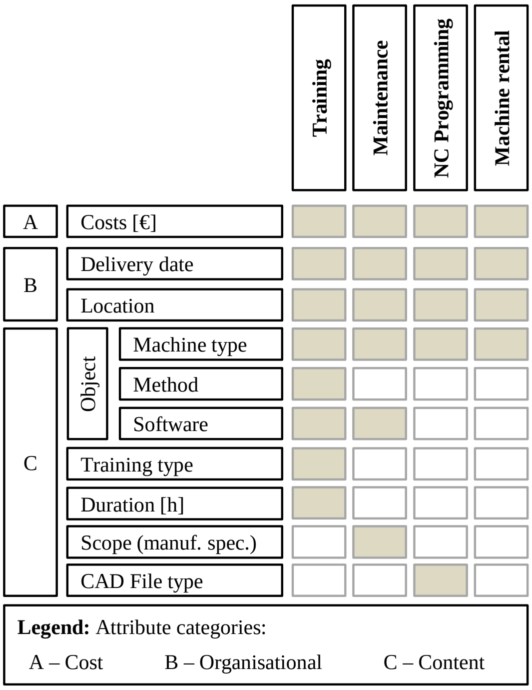

Fig. 3. Service description attributes.

The cost information of a service is probably the most relevant attribute for describing a service offer. Furthermore, the information about the required delivery date and the location of the service delivery are described through attributes grouped in an organisational category. The content category is the most comprehensive and contains all necessary attributes for describing the characteristics of the service as well as the extent, to which a service offer matches a particular request.

The attributes can be composed of different data types. Attributes like costs and delivery date are expressed as scalar values. The location is expressed in form of an address field and can be translated into a distance, e. g. by the Google Distance Matrix API [15] in order to rank different service offers according to the requester's proximity.

The attributes of the subcategory "Object" of the content category contains a hierarchially ordered categorization of the service object. Depending on the service type, the object is categorized in one or more dimensions. In Fig. 4, a categorization is exemplarily shown for the "machine type" subcategory.

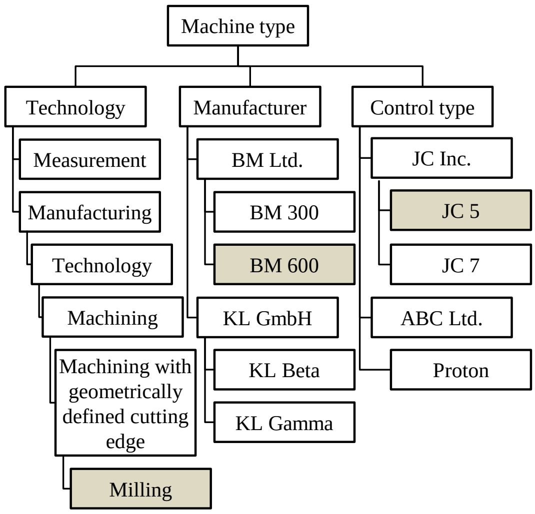

Fig. 4. Attribute structure in the content category.

Within the subcategory "machine type" a distinction is made between the machine tool's underlying technology [16], its manufacturer as well as its control type. Through determining a service's membership in each category, a service offer as well as service request can be described unambiguously.

4. Automated vendor selection for industrial service shares

4.1. Calculation methods for attribute matching

Through the abovementioned description of industrial services, it is now possible to query available service offers in a database and sort the result according to how well they match the request. For this purpose, a function will be used to calculate a matching score s_{total}. The matching score s_{total} is the product of a set of subordinate matching scores for each service type attribute. Depending on the attribute type, different means of calculating the matching score are possible, see Fig. 5. For the k. o.-match function, the matching score will be $s = 1$ only when the attribute matches exactly a specified value k. For all other values, the score will be $s = 0$. The one-sided cutoff function calculates a score of $s = 1$ for attribute values smaller than the specified quantity k. For values greater than the specified value, the score will be $s = 0$ accordingly. The local optimum function computes a score according to a gaussian distribution function around the specified value k. The polynomial function calculates a score e. g. according to a rational function. The discrete relation function calculates the matching score in dependence of fixed intervals on the attribute scale. For each interval, a constant score is given. Lastly, the linear relation constitutes a special case of the polynomial function.

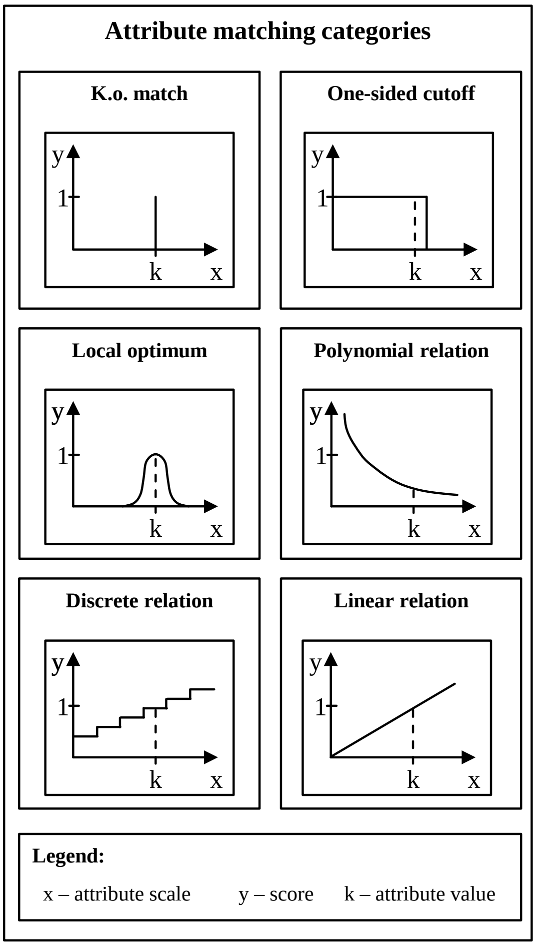

Fig. 5 Categories of score calculation for attribute matching.

An overall score can be calculated with these functions. As an example, a request for a “Training” service for a specific machine tool type BM 600 is considered. For this request, three possible service offers are available, see Table 1. Since no available offer matches the request perfectly, the most adequate match has to be determined.

Table 1. Exemplary matching of offers for industrial service “Training”

Service attributes	Request	Provider I	Provider II	Provider III
Costs c [€]	1,000	1,500	800	2,000
Delivery date d [days]	7	3	7	4
Location l [km]	Berlin	< 500	< 800	< 800
Machine type				
Technology	Milling	Milling	Milling	Milling
Manufacturer	BM 600	BM 300	KL Beta	BM 600
Control type	JC 5	JC 7	Proton	JC 5
Training type	On site	On site	On site	On site
Duration p [days]	2	2	2	2

The overall matching score s_{total} is computed for each request through the addition of each attribute’s score:

$$s_{total} = \sum s_i \quad (1)$$

For this example, the score s_{costs} assessing the costs of a service offer is calculated through a linear matching function:

$$s_{costs} = 1 + \left(\frac{c_{request} - c_{offer}}{c_{request}} \right) \quad (2)$$

Such function assures that offers that cost less than the requested amount are ranked higher than more expensive offers. For the delivery date, a one-sided cuttoff function is chosen, as all offers should be selected that can be delivered within the requested time. No difference shall be made between offers with earlier or later delivery date within the specified time.

$$s_{delivery} = \begin{cases} 0 & for \quad x > d_{requested} \\ 1 & for \quad x \le d_{requested} \end{cases} \quad (3)$$

A cutoff function will be applied analogously to equation (3) for the location respectively distance attribute.

$$s_{location} = \begin{cases} 0 & for \quad x > l_{requested} \\ 1 & for \quad x \le l_{requested} \end{cases} \quad (4)$$

Regarding the “Object” subcategory of attributes, the degree of accordance will be determined through its position in the hierarchical taxonomy. This will be achieved through a discrete relation function.

$$s_{tech} = \begin{cases} 1 & for\ direct\ match \\ 0.8 & for\ first\ order\ relation \\ 0.4 & for\ second\ order\ relation \end{cases} \quad (5)$$

For a direct match of request and offer in one “Object” dimension, e. g. “manufacturer”, a match score of $s_{tech} = 1$ will be given. If request and offer type differ, but belong to the same category, a first order relationship will be assumed and a match score of $s_{tech} = 0.8$ will be given. Furthermore, if request and offer type don’t share the same category, however their categories belong to the same superordinate category, a second order relationship will be determined an a score of $s_{tech} = 0.4$ will be given.

The remaining attributes are determined analogously to the illustrated functions.

4.2. Customer dependent evaluation of attributes

In addition to the evaluation of fulfillment of customer needs, a customer-specific evaluation of attributes for an automated vendor selection is required.

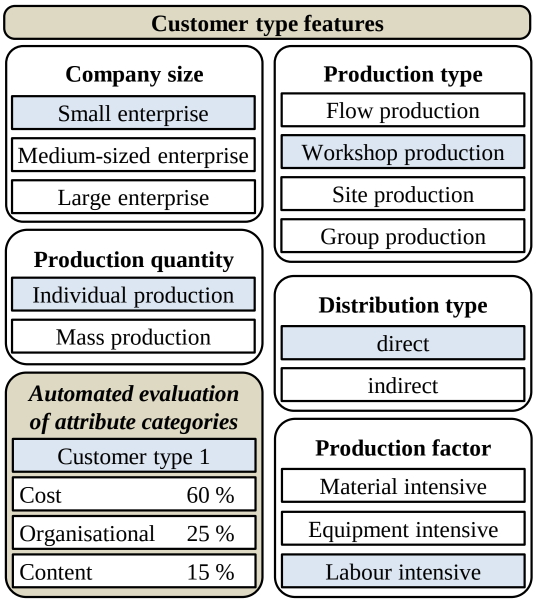

Fig. 6. Overview of relevant customer type features.

Distinction can be made between the automated selection based on weighted customer characteristics and the individual selection of the attribute categories. The automated customer-based weighting requires a selection of relevant features to describe the company type, like company size, production type or production quantity (see Fig. 6). Based on these features, a customer type is determined, which includes a preconfigured evaluation of the attribute categories. In Fig. 6 an exemplary automated evaluation of attribute categories for the industrial offer “Training” is shown. The customer is categorized by the features small enterprise, workshop production, individual production, direct distribution and labour intensive as the dominating production factor. Based on these features the customer type 1 is recognized with a customer-specific evaluation of the attribute categories for the industrial service “Training”.

4.3. Offer uncertainty

When customers request industrial services, a high degree of customer information for a binding offer price and delivery date is required.

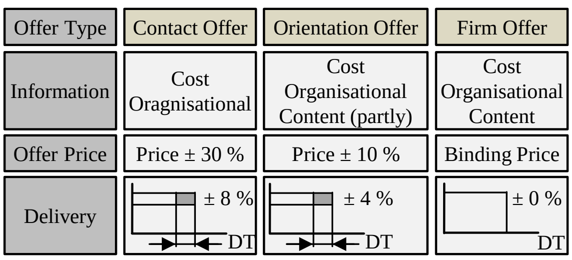

Fig. 7. Overview of the different offer types.

But not in all cases the customer has the knowledge about all necessary attributes. In this case the literature distinguishes between three offer categories which are referred to as contact offer, orientation offer and firm offer, see Fig. 7.

In the provision of industrial services, the three offer categories differ in the detail level of the customers request. For the contact offer the customer has to provide the industrial service, the costs and organizational attributes. For the orientation offer additional information on the attribute category “content” are necessary, whereas all attributes must be provided by the customer to request a firm offer. The three offer categories differ mainly in the uncertainty of offer price and delivery time.

4.4. Overall match calculation

For selecting the most appropriate service offer for a specific request, the proposed match score calculation is performed according to Fig. 8. By considering request as well as customer specific aspects, the best offer will be found that matches the customer’s request.

$$\begin{aligned} s_{P1} &= w_A \cdot s_A + w_B \cdot s_B + w_C \cdot s_C \\ &= 0.646 \end{aligned} \tag{6}$$

The function of the customer specific weighting is illustrated in Table 2.

Table 2. Exemplary matching of offers for industrial service “Training”

	Service attributes	Customer weight	Provider I	Provider II	Provider III
A	Costs Score	60 %	0.5	1.2	0
	Resulting Score		0.3	0.72	0
B	Organisational Score	25 %	1	1	1
	Resulting Score		0.25	0.25	0.25
C	Content Score	15 %	0.640	0.16	1
	Resulting Score		0.096	0.024	0.15
	Overall Score		**0.646**	**0.994**	**0.4**

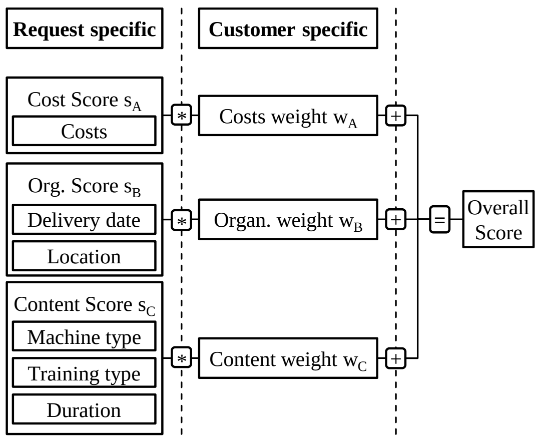

Fig. 8. Relation of sub scores and weights to overall score.

It can be seen how the customer weight influences the overall score. For example, as the customer profile is mainly adjusted towards cost sensitivity, the offer of provider III is ranked the lowest.

5. Conclusion and Outlook

A method for the automated vendor selection of industrial service shares was described in this paper. Therefore, the initial identification of relevant services in the field of machine tools was mandatory. The subsequent clustering of industrial services under consideration of their degree of materiality and process variability allowed the definition of different service types. In order to measure how adequately offerings match a request, the services are described precisely through different types of attributes. The calculation of subordinate matching scores for each service type allows the automated determination of a total matching score s_{total} for each offering and thereby the selection of an optimal offering for a customer request.

Further work will aim on the transfer of the method to an internet-based platform. A necessary step is the implementation of a website and its connection to the database for the calculation method. To ensure the industrial acceptance which is a prerequisite of a platform for industrial service shares, workshops with industrial partners have to be organized. The aim of these workshops consists of the validation of attributes, mentioned in this paper, and the calibration of the algorithm for the calculation of the score to rank the suitable offerings for customer requests.

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