Product⋎service system configuration: a generic knowledge-based model for commercial offers

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At a time when modes of consumption are rapidly evolving, consumer attitudes and expectations are changing. Today, customers want more and more products and services that can be customised to their needs. Furthermore, they are more willing to pay for usage of a product rather than ownership. On the other hand, companies are adding more and more services to the products they are bringing to market in order to create added value and differentiate themselves from their competitors. To adapt to these new market trends, companies now have to offer their customers a more sophisticated catalog of solutions, in both product and services, including all conceivable combinations of the two. The aim of this article is to propose a generic knowledge-based model, dedicated to commercial offer configuration which is able to cope with the whole variety of solutions a company can deliver. To our knowledge, although some works on product configuration, service and product-service system configuration exist, none of them is generic enough to support product, service and product-service configuration at the same time when defining commercial offers. In this article, after giving a state-of-the-art assessment of product and service configurations, the need for a generic model able to cover the whole range and diversity of commercial offers is established, a knowledge-based model is defined and its relevance is demonstrated on seven use-cases coming from secondary and tertiary sector companies.

Keywords: product configuration; service configuration; knowledge-based model; customer–supplier relationship; commercial offer definition

1. Introduction

Current market trends are evolving in at least two important ways: firstly, from standard products and services to customised ones, and secondly, from the purchase of goods to their rental, as one can now do for cars, mobile phones or professional coffee machines. In effect, customers today want more and more personalised products and services and, at the same time, they are changing the way they consume them. Furthermore, companies are adding more and more services to their products in order to enhance their competitivity, product performance, and margins. To adapt to these new trends, companies now have to put a more sophisticated catalog of customisable solutions on the market, ranging from the product to the service, including product/service combinations, also named Product-Service System or *PSS* (Mont 2002). These customisable solutions rely on predefined artefacts, such as components, sub-assemblies, services and modules, that can only be combined in specific ways. It seems that the need for customisable solutions is totally independent of the company's business model, i.e. business-to-customer (B2C) or business-to-business (B2B) models (Forza and Salvador 2002). For instance, this assumption can be demonstrated by Hvam, Pape, and Nielsen (2006), for cement plant configurations from Smidth™, the global cement plant manufacturer leader, for B2B situations, and by Luo et al. (2008), for e-commerce from Dell™, the US multinational computer technology company, for B2C situations.

The definition of a commercial offer has also changed: it must take into account both a technical solution (what the company sells to its customers, i.e. product and/or service) and its delivery process (how the company produces and delivers it) (Levin and Nisnevich 2001). These two complementary parts of a commercial offer do not have the same impact on the definition of that offer, in terms of the variability of the artefacts and the business model. On the one hand, if the diversity of the technical solution does not induce a strong variability in the cost and/or duration of its delivery process, only the technical solution is needed to develop a commercial offer and to give a good evaluation of the selling price and delivery date. The delivery date is basically standard and can be adjusted according to the attributes of some key artefacts. This is especially true in B2C situations, such as for cars, computers or bicycles. On the other hand, if the diversity of the technical

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*Corresponding author. Email: elise.vareilles@isae-supaero.fr solution induces a greater variability on the process in terms of cost and/or duration, the development of the commercial offer requires a focus on the delivery process in order to provide a more accurate delivery date and to take account of the cost of this process. This condition is especially valid and critical in B2B situations, where providing the best and most precise due-date can be crucial in winning a contract, such as for cranes, machine tools or robots. The delivery process has then to be conceived at the same time as the technical solution: the impacts of the choices made for the technical solution (selection of a specific artefact) have to be reflected in the process (selection of resource or sizing of the activity), and vice-versa.

In the rest of the paper, regardless of the customisable solution (product or service) and the business model (B2C or B2B), we shall consider that a commercial offer is composed of two intertwined parts: a technical solution and a delivery process. These two parts rely on predefined artefacts (components, sub-assemblies, service components and modules) for the technical solution and activities, for the delivery process, which can only be combined and integrated in a specific way. In view of these assumptions, it seems logical to consider the problem of commercial offer definition as a concurrent configuration problem (Schierholt 2001; Zhang, Vareilles, and Aldanondo 2013; Pitiot, Aldanondo, and Vareilles 2014). Product configuration can be defined as a specific design activity relying on a generic model which is instantiated into a specific product. As previously stated, customers no longer want to buy a product but mainly to exploit it, thus moving from a product-based to a service-based economy, a process known as servitisation (Baines et al. 2009; Vandermerwe and Rada 1988). To our knowledge, although some works exist on product configuration, service configuration and concurrent product-process configuration, none of the solutions they propose are generic enough to support product, service and product-service configuration at the same time when defining commercial offers. Furthermore, in most cases, the notion of a delivery process is not clearly differentiated from a service, considered as a process (Grönroos 2000).

Consequently, the aim of this article is to propose a generic knowledge-based model, dedicated to commercial offers configuration (technical solution and delivery process), which is able to cope with the whole range and variety of solutions a company can deliver. This generic model is based on the concept of Product $\curlyvee$ Service System, or $P\curlyvee SS$, which allows companies to configure their offer without worrying about the type of artefacts to combine (products or services), nor the types of activities required to deliver it.

The paper is organised as follows. In Section 2, a state-of-the-art review of product configuration, service configuration and concurrent configuration is conducted. This review highlights the need for a generic model to support commercial offers configuration. In Section 3, all the possible combinations of tangible artefacts and intangible artefacts are identified and characterised under the name of $P\curlyvee SS$. Then, the building blocks of the knowledge-based model are laid down, defined and architectured into a generic model. In Section 4, the generic model is instantiated on seven industrial cases, going from product to service, to highlight the strengths of our proposal. Some conclusions and future research conclude this paper.

2. Concurrent configuration state-of-the-art

As seen in the introduction, a commercial offer is composed of two dependent parts (a technical solution and a delivery process), which must be configured separately but concurrently, with respect to their requirements, constraints and relations. Thus, we consider that the configuration problem of a commercial offer is similar to a concurrent configuration problem. Consequently, this section introduces the scientific background necessary to support our contribution. We start by recalling the definition of product-process configuration (see Section 2.1) and continue with the definition of service and product-service system configuration (see Section 2.2).

To clearly distinguish products from services, we have adopted the point of view of Shostack (1977) saying that products are tangible while services are intangible. In such a definition, 'tangible' means 'palpable', and 'material' whereas 'intangible' is an antonym, meaning 'impalpable', and 'not corporeal'.

For each of these concurrent configurations, we briefly introduce the framework used to support them. The need for a unique generic model capable of supporting the configuration of commercial offers, as well as the definition of a Product$\curlyvee$Service System are put forward in the synthesis.

2.1. Product-process configuration

In concurrent product-process configuration situations, many authors, such as Mittal and Frayman (1989); Schierholt (2001); Aldanondo and Vareilles (2008); Zhang, Vareilles, and Aldanondo (2013), agree that the product can be considered as a set of physical or tangible artefacts (commonly called sub-assemblies or components) and its delivery process as a set of activities or operations.

With respect to the customers needs and the generic model of the product, the configuration of a product is achieved either by selecting components in component families (such as an engine reference in all the engine references presented in the catalog) or by choosing values for descriptive attributes (such as the power of a given engine). Of course, not all combinations of components and attribute values are allowed. For modelling and solving product configuration problems, Hotz et al. (2014) have discussed and compared a variety of approaches: constraint-based and rule-based feature models, case-based reasoning, UML, description logic and ontology. Given that many approaches are possible, constraint satisfaction problems or *CSP* (Montanari 1974) are strongly favoured by authors as (1) there is a clear distinction between the configuration problem modelling and the approaches to solve it, and (2) *CSP* can cope with different kinds and natures of variables and constraints within the same problem, such as discrete and continuous variables, compatibility, activity and temporal constraints. Then, a product configuration variable is either a component family or a descriptive attribute, and a constraint restricts possible combinations of variable values.

In a similar way, with respect to (1) the customer's needs, (2) the configured product and (3) the process generic model, the configuration of the delivery process is achieved by selecting the set of relevant activities and for each one of these, choosing resources in resource families (such as a small machine in a machine list), along with a quantity (Schierholt 2001). Of course, the selection of resources and quantities is strongly constrained by the configured product and customer's needs. For that reason, the process configuration problem can also be considered as a CSP (Barták 1999) where a process configuration variable is either an activity resource family or a required quantity for resources, and a constraint restricts possible combinations.

Given these elements and in accordance with the model architectures discussed in (Zhang, Vareilles, and Aldanondo 2013; Pitiot, Aldanondo, and Vareilles 2014) and the use of a CSP to formalise the configuration generic model (Mailharro 1998; Felfernig, Friedrich, and Jannach 2000; Rossi, van Beek, and Walsh 2006; Felfernig et al. 2014), a generic model architecture that supports concurrent product-process configuration can be composed of three sets of variables:

(1) One set, associated with the CSP product model, corresponds to a generic bill of materials of the product.
(2) A second one, associated with the CSP process model, corresponds to a generic delivery process.
(3) The third one gathers variables that are directly associated with the two previous models in the sense that they have been identified as customer's needs

We shall now consider the service and the *PSS* configuration situation.

2.2. *Services and product-service systems configuration*

In a similar way as products, services can also be broken down into artefacts, called modules (Böttcher and Klingner 2011) or service components (Shen, Wang, and Sun 2012). There is no clear definition of a service in the literature: a service can be seen as a process (Grönroos 2000; Carlborg and Kindström 2014) or a performance (Parasuraman, Zeithaml, and Berry 1985; Zeithaml, Parasuraman, and Berry 1985). Four main features have been identified to characterise a service, gather under the term *IHIP* : Intangibility, Heterogeneity, Inseparability, Perishability (Edvardsson, Gustafsson, and Roos 2005). Lovelock and Gummesson (2004) have proposed another feature: the absence of property transfer when a service is sold. Even if these features are not a consensus, all the authors agree on the point that a service is intangible. This common feature makes services difficult to separate from their delivery process. This is one of the key modelling points that this article will clarify.

In addition, one can notice that more and more products are associated with services under the name of *Product-Service Systems*, also called *PSS* (Mont 2002), as for example: installation, training or maintenance. A *PSS* is formally defined as 'a system of products, services, supporting networks and infrastructure that is designed to be: competitive, satisfy customer needs and have a lower environmental impact than traditional business models' (Mont 2002). Tukker (2004) has defined three categories of *PSS* (notated $\boldsymbol{C_i}$, divided in eight types of *PSS*, notated $\boldsymbol{T_j}$) :

C_1: *Product-oriented Service:* A product is sold with an extra service. Some authors use the term *Product Extension Service or PES* (Shen, Wang, and Sun 2012) or *Extended Product* (Thoben, Eschenbacher, and Jagdev 2001) to refer to this kind of association. In this case, there is a property transfer from company to customer. Tukker (2004) distinguishes two types of product-oriented services :

  T_1: *Product-related service:* The maintenance, the supply of consumables or a warranty extension is added to a product, such as the maintenance of a truck for a given period (Lenfle and Midler 2009),
  T_2: *Advice and consultancy:* Some advice on the most efficient use of the product is given to the customer, such as eco-friendly driving courses on trucks to reduce fuel consumption and environmental impacts.

C_2: *Use-oriented Service:* Here the business model changes: the customer no longer buys a product, but a functionality, meaning that instead of selling products, companies are selling functionalities (Mont 2002). In the literature, this phenomenon is also called the service economy, or functional economy. In this case, there is no property transfer from company to customer. Tukker (2004) distinguishes three types of use-oriented services according to the number of users and their simultaneous use:

  - T_3: *Product leasing:* Only one user is allowed to use the product. An example would be truck leasing dedicated to a specific company,
  - T_4: *Product renting or sharing:* Several users are allowed to use the same product but at different times, such as truck sharing for short periods of time,
  - T_5: *Product pooling:* Several users are allowed to use the same product at the same time. An example would be freight transport pooling which is the mutual and contemporary use of a truck by two or more companies (Gonzalez-Feliu 2011).

- C_3: *Result-oriented Service:* As with use-oriented service, the business model of a service or functional economy is applied: the customer buys a functionality rather than a product. There is not always a pre-determined product involved. The customer and the provider agree on a result for a given price. Tukker (2004) distinguishes three types of result-oriented services :

  - T_6: *Outsourcing:* A functionality is regularly subcontracted to an outside supplier with some control retained of the way the activity is carried out. For example, renting an annual transport volume in a truck whatever the actual use,
  - T_7: *Pay-per-unit:* In this case, the client only pays on those occasions when the functionality is used, often guaranteeing a minimum of usage per period, such as using a truck at least three times a month for a delivery for a specific journey.
  - T_8: *Functional result:* In this case, the customer pays for a functionality without any requirement on the product involved, only the result (quality, price, duration) counts, such as an emergency delivery to avoid lateness penalties.

Given these elements, Shen, Wang, and Sun (2012) propose an ontology-based approach which supports *PES* configuration, where:

(1) Product sub-ontology provides information and knowledge about products necessary to configure the *PES* service part,
(2) Service sub-ontology describes all legal combinations of service components (its intangible part) as well as the delivery (or routing) process and their links or constraints,
(3) Customer sub-ontology describes what the customer wants, as well as restrictions on the desired outcomes.

This architecture is consistent with the one for concurrent product-process configuration, presented in Section 2.1, as it brings out customer requirements, the tangible product and the concept of the delivery process, which is included in the service ontology.

2.3. *Synthesis*

In this section, we have introduced the scientific background on concurrent configuration of products, services and processes. We have synthesised the different definitions found in the literature and indicated the definition used in our research, for both products, services, *PSS* and delivery processes.

With regard to all these definitions, some similarities have emerged:

- First of all, the technical solution, whether we are dealing with a product, a service or a *PSS*, always requires an architecture based on predefined artefacts, which can be indifferently tangible (sub-assemblies and components) or intangible (modules or service components),
- Secondly, the delivery process has to be taken into account to complete the cost of the commercial offer and better estimate its due-date.
- Thirdly, some works have already considered concurrent product-process configurations and service or *PSS* configurations by proposing models and tools to support their configuration. But none of them is generic enough to cover the wide spectrum of commercial offers, or to differentiate the technical solution from its delivery process.

The similarities identified above, regardless of the tangible or intangible nature of artefacts, along with the studies carried out by Shen, Wang, and Sun (2012) and Tiihonen et al. (2014), have convinced us to fill this gap. Consequently, the aims of Section 3 are (1) to define and discuss the concept of Product$\curlyvee$Service System or $P\curlyvee SS$ and (2) to propose the generic items of a configuration model for commercial offers, based on this definition and on existing studies.

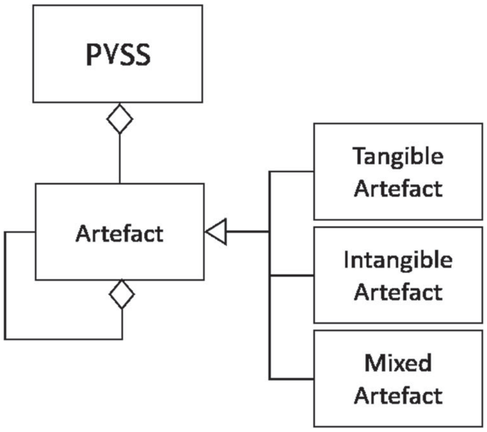

Figure 1. Product⋎Service System architecture.

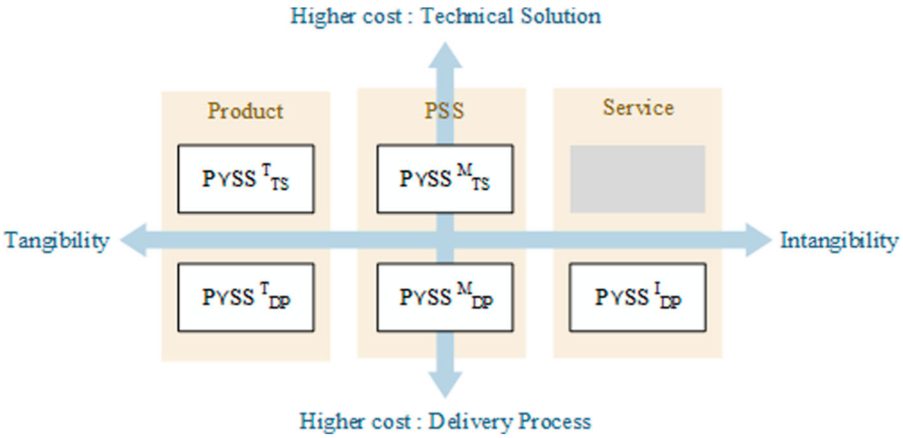

Figure 2. *P⋎SS* positioning versus PSS.

3. Commercial offer generic model

As previously mentioned, companies now need to put on the market a wide range of customisable technical solutions, ranging from products to services, with all their combinations, known as a *PSS*. The literature review conducted on product, service and *PSS* configuration has highlighted the lack of a generic model capable of combining all artefacts (components, sub-assemblies, service components and modules) into a single commercial offer model. This section is therefore dedicated to proposing and defining these artefact combinations, which we have called *P⋎SS* (cf. Section 3.1), and of the generic model that can support its configuration (cf. Section 3.2).

3.1. Product⋎Service System definition

As we have seen, the literature review shows that commercial offers have now to cover from products to services, including all their combinations. Today, no concept is wide enough to encompass this diversity. We therefore propose the concept of *Product⋎Service System* , which allows a multilevel structure to be built, combining tangible and intangible artefacts in a single technical solution (Figure 1). The definition of a wide range of products and their related services is therefore possible and quite simple to achieve. Thus, *P⋎SS* allows the combination of all types of artefacts in a single commercial offer and includes both products, services and *PSS*, as presented in Figure 2.

Besides, we propose distinguishing five types of *P⋎SS* by taking into account firstly the percentage of tangible artefacts in the technical solution and secondly, the weight of the technical solution cost in the global cost of a commercial offer. Two types of costs are therefore considered in the global cost as explained in Helberg, Galletly, and Bicheno (1994):

- the *technical solution cost*, corresponding to the cost of raw materials and physical components of the artefacts composing its architecture,

Table 1. $P\curlyvee SS$ typology.

$P\curlyvee SS$ Type	Number of Tangible artefacts	Number of Intangible artefacts	Dominant cost	Examples in sections
$P\curlyvee SS^{T}_{TS+}$	[1.. *]	0	Technical solution	4.1.1
$P\curlyvee SS^{T}_{DP+}$	[1.. *]	0	Delivery process	4.1.2
$P\curlyvee SS^{M}_{TS+}$	[1.. *]	[1..*]	Technical solution	4.1.3 & 4.2.3
$P\curlyvee SS^{M}_{DP+}$	[1.. *]	[1..*]	Delivery process	4.1.4 & 4.2.2
$P\curlyvee SS^{I}_{DP+}$	0	[1..*]	Delivery process	4.2.1
$P\curlyvee SS^{I}_{TS+}$	0	[1..*]	Tech. solution ⇒ Not Applicable	

- the *delivery process cost* corresponding to the cost of all the activities and resources needed to produce and deliver the technical solution.

These two types of costs allow us to differentiate between technical solutions with little or no design activity, such as in Configure-To-Order, notated CTO, or Assemble-To-Order, notated ATO situations, (Atan et al. 2017; Hoekstra, Romme, and Argelo 1992) or light Engineering-To-Order, notated light ETO (Brière-Coté, Rivest, and Desrochers 2010), situation; and those which require a high level of engineering to be designed, such as in high Engineering-To-Order situations, notated high ETO.

We propose the notation $P \curlyvee SS^{superscript}_{subscript}$, where:

- P stands for Product (i.e. tangible artefact),
- $\curlyvee$ for the logical OR operator, i.e. logical disjunction,
- S for Service (i.e. intangible artefact),
- S for Systems,
- with a superscript characterising the level of tangibility of the $P\curlyvee SS$ such as:
  - T for 100% of Tangible artefacts,
  - I for 100% of Intangible artefacts,
  - and M for the mix of tangible artefacts and intangible artefacts,
- with a subscript characterising where the main cost of the commercial offer is :
  - TS if the cost of the Technical Solution is higher than that of the delivery process,
  - DP if the Delivery Process is more costly than the technical solution.

The typology of $P\curlyvee SS$, synthesised in Table 1, is as follow:

- A $P\curlyvee SS\,^{T}_{TS+}$ is 100% composed of tangible artefacts, and its technical solution is more costly than the cost of its delivery process. This is exactly the case in CTO, ATO or light ETO situations.
- A $P\curlyvee SS\,^{T}_{DP+}$ is 100% composed of tangible artefacts, but its technical solution is less costly than the cost of its delivery process. This is exactly the case in high ETO situation.

$P\curlyvee SS\,^{T}_{TS+}$ and $P\curlyvee SS\,^{T}_{DP+}$ differ only by their cost allocation. For customers, the difference is transparent: the cost of the technical solution and the commercial offer remain the same. For companies, this distinction gives them a better view of their costs are generated and and how they can reduce them.

- A $P\curlyvee SS\,^{M}_{TS+}$ is composed of tangible and intangible artefacts, and its technical solution is more costly than the cost of its delivery process. This is exactly the case in CTO, ATO or light ETO situations.
- A $P\curlyvee SS\,^{M}_{DP+}$ is composed of tangible and intangible artefacts, but its technical solution is less costly than the cost of its delivery process. This is exactly the case in high ETO situation.
- A $P\curlyvee SS\,^{I}_{DP+}$ is 100% composed of intangible artefacts, and its cost relies only on its delivery process (resources and activities involved in carrying it out.) This type of $P\curlyvee SS$ is completely independent of the CTO, ATO or ETO situations.
- It should be noted that the notion of $P\curlyvee SS\,^{I}_{TS+}$ has no meaning since a $P\curlyvee SS\,^{I}$ does not have any tangible artefact. Therefore, the cost of the commercial offer cannot be allocated to its technical solution.

This typology is very useful and complementary to that proposed by Tukker (2004) as it takes into account the percentage of tangible and intangible artefacts in the technical solution as well as the commercial offer's cost allocation. With

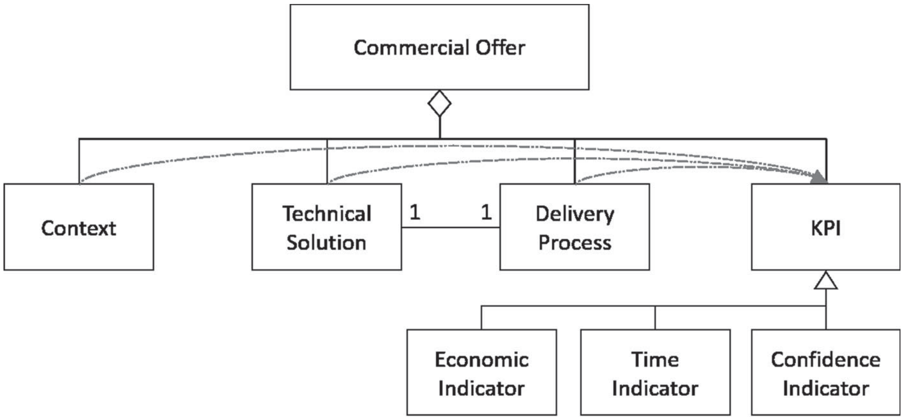

Figure 3. Commercial offer generic model inspired by Shen, Wang, and Sun (2012).

such a generic model, the difference between products, services and *PSS* no longer exists. It corresponds to various settings, including the degree of tangibility and weight of the cost of the technical solution. The technical solution is broken down into artefacts, which can themselves be broken down into other artefacts, regardless of their tangible or intangible nature.

As mentioned above, the delivery process can not be decorrelated from the technical solution. The two parts of a commercial offer are closely related to each other and have to be conceived at the same time. By considering the technical solution architecture (by means of $P\curlyvee SS$) and its delivery process, it is possible to overcome the modelling issue of products, services and PSS for offer configuration. All of our proposals are strongly based on this non-differentiation. In addition, the delivery process is clearly separated from the service.

3.2. *Commercial offer generic model*

A $P\curlyvee SS$ allows the combination of all types of artefacts (components, sub-assemblies, service components and modules) in a single commercial offer. In order to do so, a generic configuration model for commercial offers has to be formalised. This model must integrate the specificities of the commercial offers, distinguishing between the technical solution (what the company sells to its customers) and the delivery process (how the company produces and delivers it).

The proposed model is inspired by the work of Shen, Wang, and Sun (2012), who has proposed configuring *PES*, using three sub-ontologies : service (including the process), product and customer sub-ontologies. We propose completing and extending this model by the following information, as illustrated in Figure 3:

(1) the **key performance indicators** (Kang et al. 2016; Vareilles, Aldanondo, and Gaborit 2007) which allow the characterisation of commercial offers with relevant indicators and their comparison, as explained in Section 3.2.1.
(2) the **context** in which the offer is taking place, corresponding to the state of the market, the customer's profile, the future state of the company in case of success and the customer's requirements, as explained in Section 3.2.2,
(3) the **architecture of the technical solution**, modelled as a $P\curlyvee SS$, as explained in Section 3.2.3,
(4) the definition of the **delivery process**, corresponding to the list of activities and resources involved to produce and deliver the technical solution to the customer, as explained in Section 3.2.4.

3.2.1. *Key performance indicators of the offer*

Key performance indicators, or *KPI*, allow the comparison of several commercial offers, defined in the same context, which differ by their technical solution and / or delivery process. We consider as relevant *KPI*:

- economic indicator, taking into account both technical solution cost and delivery process cost, to estimate the cost and to price the commercial offer,
- time indicator, taking into account the duration of activities, in order to better estimate the due date,
- confidence indicator, taking into account the company's trust in its ability to provide the technical solution under the specified conditions (quality, price and due date) (Sylla et al. 2017b).

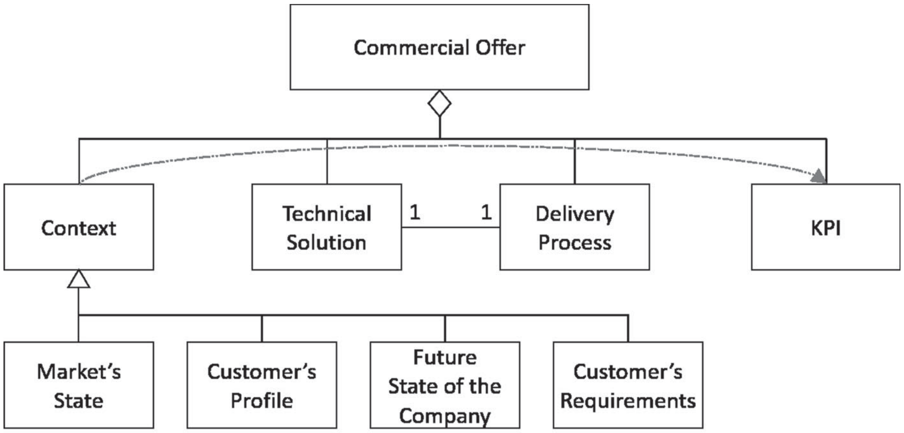

Figure 4. Context of a Commercial Offer.

3.2.2. *Context of the offer*

The context in which the offer is taking place has a strong impact on the way a company is designing its commercial offers, both on the technical solution and on the delivery process. For this reason it is important to characterise the context with relevant information dedicated to (Figure 4):

> *The current state of the market:* For instance, some questions have to be answered, such as 'Are there potential competitors?', 'Is it a market penetration strategy or an emerging market?', 'Is it a private or a public market?',
>
> *The customer's profile:* Some questions about the potential client need to be addressed, such as 'Is it a new or a regular customer?', 'Is it a strategic customer?', 'Are there any prices negotiated with this customer?', 'Have there been any problems with this customer in the past?',
>
> *The future state of the company in case of success:* Some questions about the ability of the company to manufacture and deliver the technical solution in good conditions need to be answered, such as 'What will the status of the order book be if we win the deal?', 'Will my human and material resources be available on D-Day?', 'Will the workshop be able to handle the workload of this business?',
>
> *The customer requirements:* The needs, requirements or specifications must be carefully analysed to customise the solution that best suits the stakeholders. Customer requirements are considered non-negotiable and must be understood appropriately. In the same way than Shen, Wang, and Sun (2012), we consider that customer requirements can impact:
>
> - a function of the technical solution, such as 'a vacuum table is required for the CNC[1] cutting machine',
> - a component, such as 'the centrifugal vacuum pump referenced *S55KFGTPO45* is the one to use',
> - a service, such as 'the operators have to be trained to use this CNC cutting machine',
> - an economic indicator, such as 'the price should not be over 150 K$',
> - a time indicator, such as 'the CNC cutting machine must be delivered and installed within 6 weeks'.

3.2.3. *Technical solution or $P\curlyvee SS$*

As customers increasingly want to personalise what they buy, regardless of whether it is a product, a service or a *PSS*, companies need to define solutions which are configurable and able to mix tangible and intangible artefacts in the same architecture. Customer requirements are therefore turned into a technical solution, by the selection of the relevant artefacts composing it.

Only $P\curlyvee SS$, defined in Section 3.1, allow such a combination of tangible and intangible artefacts and their decomposition at multiple levels. $P\curlyvee SS$ are generic enough to ensure that an artefact, no matter how tangible, can be decomposed into tangible and/or intangible artefacts, as illustrated in Figure 5.

Let us focus on $P\curlyvee SS\,^{T}_{..+}$. In such a case, the technical solution contains 100% of tangible artefacts, no matter where the cost allocation is. *A contrario*, a $P\curlyvee SS\,^{I}_{DP+}$ contains 100% of intangible artefacts and therefore the cost allocation is only due to the delivery process.

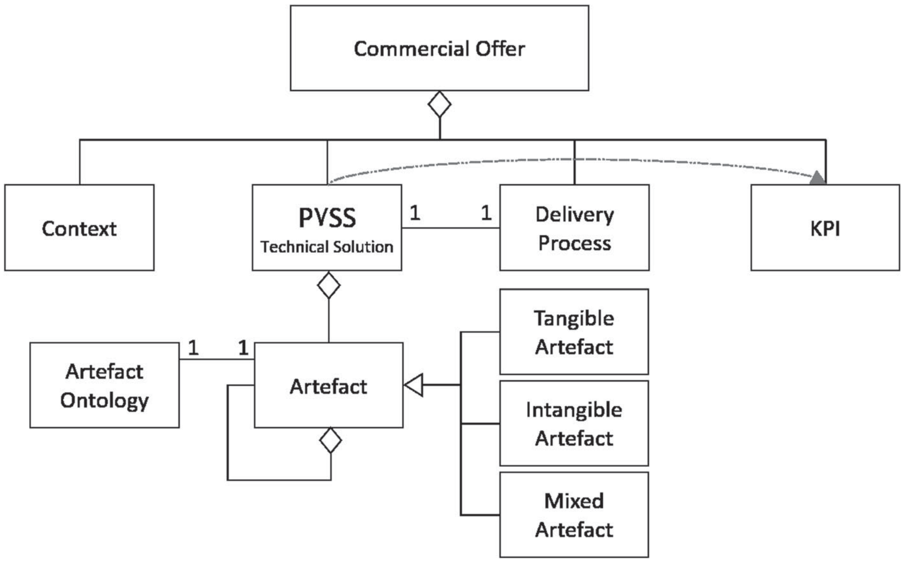

Figure 5. Technical Solution Architecture based on $P\curlyvee SS$.

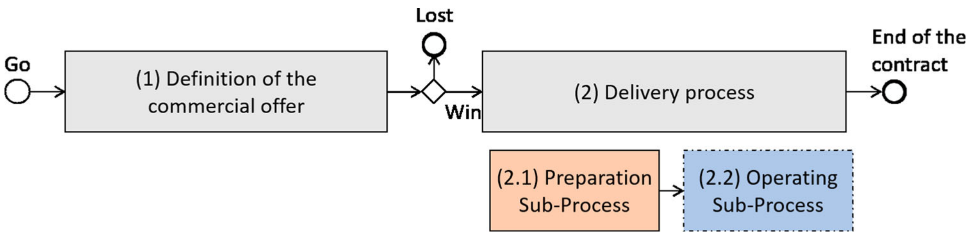

Figure 6. Two phases of the sale process.

Let us now focus on $P\curlyvee SS^{M}_{..+}$. Such a definition makes it possible to decompose an artefact (component or sub-assembly) into both tangible artefacts (components and sub-assemblies) and intangible artefacts (modules and services). For instance, a lease can be directly associated with a particular component of a tangible artefact, as is currently the case for the battery of certain electric cars. In the same way, considering the results-based *PSS* type, the customer purchases a functionality that can be associated with a tangible artefact, as is currently the case for CNC cutting machine rental.

The technical solution model is based on $P\curlyvee SS$ and is structured as illustrated in Figure 5. An artefact can be decomposed into other artefacts, and each artefact can be either tangible, intangible or mixed with regard to the concept it represents. The tangibility of any artefact relies on its association with a particular concept of the artefact ontology, in the same way as described in Shen, Wang, and Sun (2012). Any artefact can therefore be 100% tangible, 100% intangible or mixed, composed of tangible and intagible sub-artefacts. In Section 4, tangible artefacts are depicted by rectangles, intangible artefacts by ovals and mixed artefacts by rounded rectangles.

As previously stated, the technical solution is closely linked to the delivery process and vice versa, and has a direct impact on the economic indicator. Following the work of Vareilles et al. (2015), any artefact can be associated with a delivery process. This association is supported by the use of an artefact ontology coupled with a *CSP* (Abeille et al. 2010).

3.2.4. Delivery process

A sale process can be split into two main phases, as illustrated in Figure 6:

(1) the *definition of the commercial offer*, or *pre-sale phase*, in which the commercial offer is designed and proposed to the customer (Chalal and Ghomari 2006) and
(2) the *delivery process*, or *post-sale phase*, which exists if and only if the commercial offer has been accepted.

To be more precise, the *definition of the commercial offer* phase starts after the analysis of the business opportunity. It consists in the definition of the technical solution and the delivery process (composing a commercial offer) and stops when

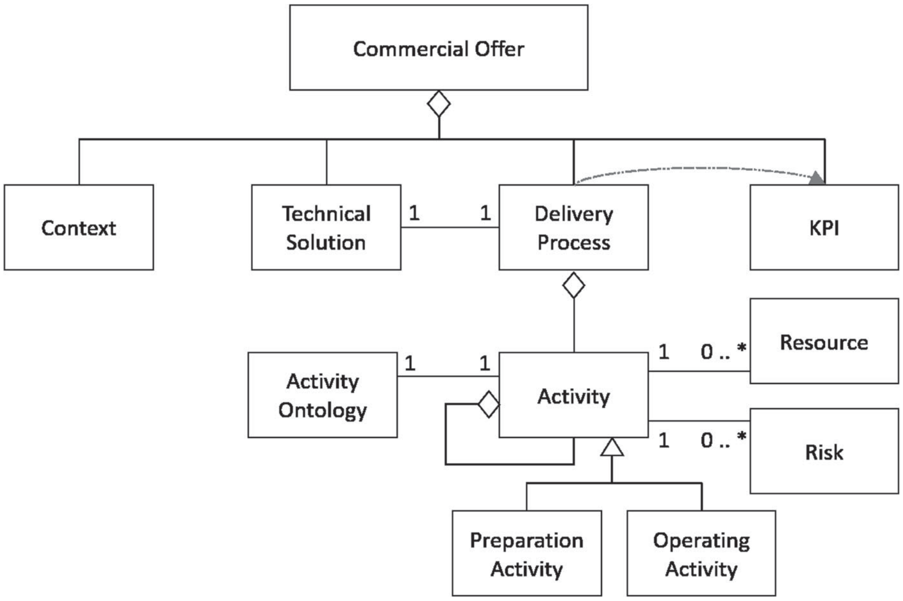

Figure 7. Delivery process architecture.

the commercial offer has been proposed to a customer. The *delivery process* phase starts when the customer has accepted the commercial offer. It can be decomposed into two main sub-processes depending on the $P\curlyvee SS$:

- **(2.1)** the first sub-process is dedicated to the design, manufacturing and delivery of the technical solution, which can also be named *preparation sub-process*. This sub-process is carried out within the company and requires limited interaction with the customer, except to finalise the needs and requirements if needed. In the rest of the paper, *preparation sub-process* activities are depicted by solid orange rectangles, as shown in Figure 6,
- **(2.2)** while the second one corresponds to the use or operation of the technical solution by the customer. It can also be called the *operating sub-process*. This sub-process is performed on the customer's premises with a strong customer involvement. The *operating sub-process* of a delivery process can therefore be rather long if the technical solution contains an artefact with long-term contract, such as a warranty extension or a 10-year leasing service. In the rest of the paper, *operating sub-process* activities are depicted by dotted blue rectangles, as shown in Figure 6,

The delivery process stops when its last activity is carried out. This can be any type of activity of the *preparation sub-process* or *operating sub-process*.

The delivery process needs to be carefully configured, so to be as accurate as possible on the delivery date, on the cost of the delivery process and on the risks taken by the company of not being able to deliver what has been sold to the customer in term of quality, price or due-date (Sylla et al. 2017a; Ayachi et al. 2018).

The delivery process is structured as presented in Figure 7. Each activity, whatever the sub-process considered, (*preparation sub-process* or *operating sub-process*), is linked to an artefact (tangible, intangible or mixed) of the technical solution and eventually to some resources and risks. The delivery process can therefore contain several types of activities, such as design activity, production activity, maintenance activity, lease activity, training activity, and so on, depending on the associated concept, as inspired by Shen, Wang, and Sun (2012). Therefore, we can emphasise that one of the side effects of using $P\curlyvee SS$ for the technical solution definition is the ability to take into account any kind of activity in the same delivery process thanks to an activity ontology.

The delivery process has a direct impact on economic and time indicators. As in the literature review on concurrent product-process configuration (see Section 2.1), the configuration of delivery process can be efficiently supported by use of *CSP* (Aldanondo and Vareilles 2008; Zhang 2014).

3.3. Synthesis

In this section, we have proposed and defined a new concept of a technical solution based on $P\curlyvee SS$. $P\curlyvee SS$ relies on tangible artefacts (components and sub-assemblies) and intangible artefacts (modules and services) which can be easily combined

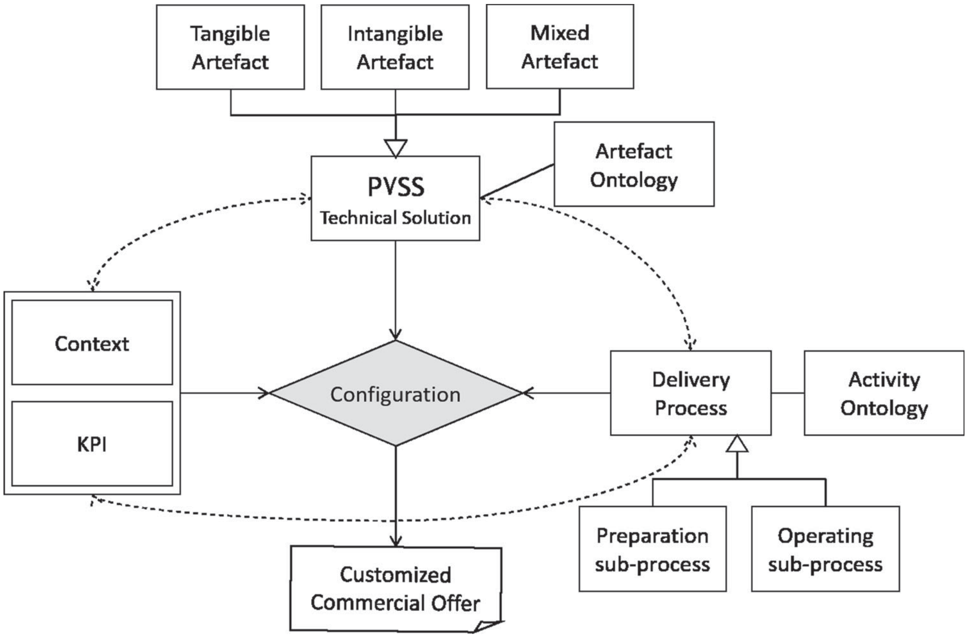

Figure 8. Generic Commercial Offer Model and Entities.

and broken down in any way. With the use of $P\curlyvee SS$, the distinction between products, services and PSS no longer exists for commercial offer definition.

A typology of $P\curlyvee SS$ has been proposed, considering two criteria: the first one is the percentage of tangible and intangible artefacts while the second one relies on the cost allocation between the technical solution and the delivery process. Five different types of $P\curlyvee SS$ can therefore be identified, going from $P\curlyvee SS\ ^{T}_{TS+}$ composed of 100% tangible artefacts, to $P\curlyvee SS\ ^{I}_{DP+}$composed of 100% intangible artefacts. Furthermore, the delivery process has been detailed in *preparation* and *operating* sub-processes. This allows different types of activities associated with the tangible and intangible artefacts to be combined in a single delivery process and clearly distinguishes the delivery process from the intangible artefacts (or services). Seven examples will be presented in Section 4.

Based on $P\curlyvee SS$, a generic model for commercial offers has been proposed. As presented in Figure 8, this model is based on three types of information and knowledge:

- the context in which the offer is taking place, characterising the current market state, the customer's profile, the company's future state in case of success and the stakeholders'requirements, constraints and needs,
- the technical solution (what the company sells), based on $P\curlyvee SS$ and the artefact ontology,
- a delivery process (how the company produces and delivers the technical solution), composed of a *preparation* and an *operating* sub-process, and based on the activity ontology.

A set of relevant KPI complements this model:

- economic indicators, based on the technical solution cost and on the delivery process cost, in order to compute the cost and the price of the commercial offer,
- time indicators, based on the duration of the delivery process activities' duration, in order to make an good estimation of the due-dates,
- confidence indicators relying on the feeling of being able to deliver what has been sold in accordance with the agreement (quality, price and due-date).

The KPI are aggregated at each level of decomposition, both for the technical solution and for the delivery process.

All items of the generic model are closely related and have impacts on each other. These impacts are propagated thanks to the ontologies coupled with a *CSP*.

For companies, the operational benefits of our generic model are twofold:

- companies can easily configure the technical solution of offers by using predefined artefacts of their catalog (products or services), by associating them without any trouble, and without regard to their tangibility,

- the associated delivery process is configured in parallel with two types of activities, belonging either to the *preparation* or *operating* sub-processes, which can intertwine.

The proposed generic model gives companies real flexibility to respond a call for tender while respecting their catalog of solutions and their production capacity and evaluating their responses using relevant KPI, such as economic, time and confidence indicators. Companies therefore have a good command of their offers and a real competitive advantage.

The aim of Section 4 is to illustrate our proposals with realistic examples and to emphasise their genericity and applicability to industrial problems.

4. $P\Upsilon SS$ illustrative examples

In this section, we illustrate the generic model we have proposed in Section 3.2, on seven different examples, going from products ($P\Upsilon SS\,{}^{T}_{TS+}$) to services ($P\Upsilon SS\,{}^{I}_{DP+}$) and vice-versa. We do not illustrate the whole bid model, only the technical solution part and the delivery process part. These seven examples highlight the diversity that companies face when defining a commercial offer and show that our proposal can handle them. We have voluntarily chosen a single simple example that we modify each time to illustrate the diversity of situations encountered both in the technical solution (notated $\mathbb{TS}$), in the delivery process (notated $\mathbb{DP}$) and in the cost allocation (notated $\mathbb{CA}$). It is true that sometimes our examples seem far-fetched, but a real continuity between them is necessary for an easier understanding.

In each example, we show firstly the interest of mixing tangible and intangible artefacts in the same technical solution and secondly, the different shapes that the delivery process can have, depending on the customer's requirements. In Section 4.1, a 100% tangible technical solution, or $P\Upsilon SS\,{}^{T}_{TS+}$, (a CNC cutting machine) becomes less and less tangible ($P\Upsilon SS\,{}^{M}_{DP+}$) while in Section 4.2, an intangible technical solution, or $P\Upsilon SS\,{}^{I}_{DP+}$, (a service of maintenance) becomes more and more tangible ($P\Upsilon SS\,{}^{M}_{TS+}$). Table 1 synthesises these examples.

4.1. *From* $P\Upsilon SS\,{}^{T}_{TS+}$ *to* $P\Upsilon SS\,{}^{M}_{DP+}$

In this subsection, a CNC[2] cutting machine is taken as an illustrative example to show how the definition of a commercial offer addressing a tangible technical solution can become less tangible, and can be associated with different types of delivery process.

4.1.1. Assemble-to-order CNC cutting machine: $P\Upsilon SS\,{}^{T}_{TS+}$

The first type of $P\Upsilon SS$ is that composed of 100% of tangible artefacts with a technical solution cost greater than the delivery process cost, or $P\Upsilon SS\,{}^{T}_{TS+}$. This is typically the case for assemble-to-order products or ATO products. Let us consider an ATO CNC cutting machine and focus on its technical solution and its delivery process, as presented in Figure 9. As an example, the customer requirements could be translated as follow:

- 'Needs for a standard CNC cutting machine'
- 'Able to cut metal and PVC'
- 'Without a vacuum pump'
- 'Ready in 6 weeks'
- 'No other service is required'

$\mathbb{TS}$: In this case, the technical solution is a standard one composed of components which are tangible, standard and already defined, then assembled to fit the customer requirements.

$\mathbb{DP}$: The delivery process is also a standard one and corresponds only to the preparation sub-process. It starts with the activity of component sourcing, then component assembly and finishes with the delivery/installation of the machine on the customer's site.

$\mathbb{CA}$: As the delivery process is a standard one, we consider that the main cost allocation is the tangible component costs of the technical solution.

4.1.2. Engineer-to-order CNC cutting machine: $P\Upsilon SS\,{}^{T}_{DP+}$

The second type of $P\Upsilon SS$ is the one composed of 100% of tangible artefacts with a delivery process cost greater than the technical solution cost, or $P\Upsilon SS\,{}^{T}_{DP+}$. This is typically the case for engineer-to-order products or ETO products. Let us now consider an ETO CNC cutting machine and focus on its technical solution and its delivery process, as presented in Figure 10. As an example, the customer requirements could be the following:

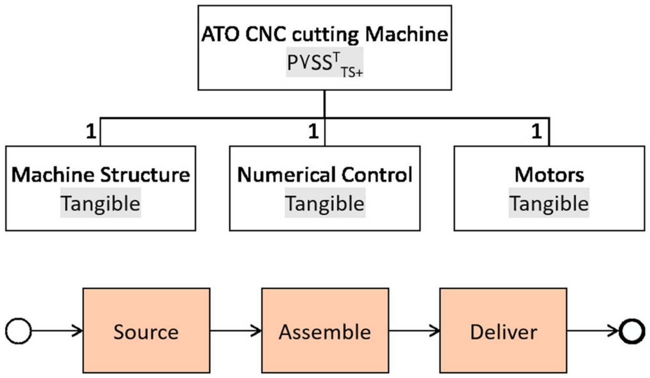

Figure 9. $P\curlyvee SS^{M}_{DP+}$ example: ATO CNC cutting Machine.

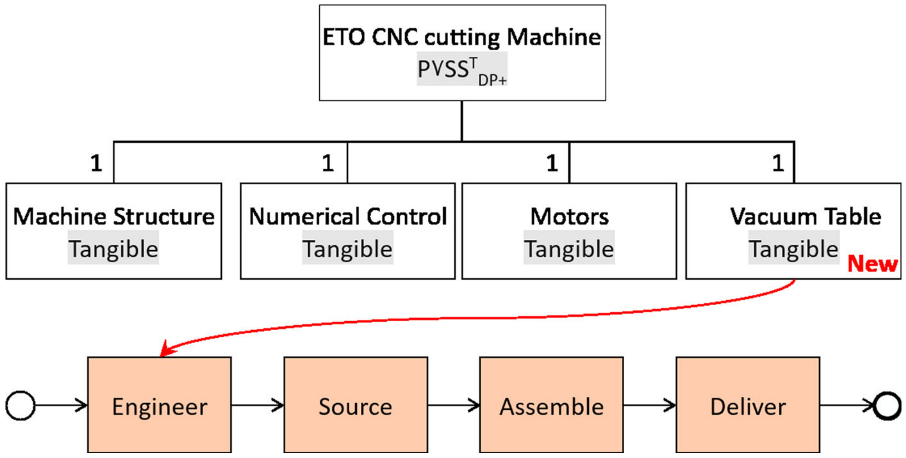

Figure 10. $P\curlyvee SS\ ^{T}_{DP+}$ example: ETO CNC cutting Machine.

- 'Needs for a CNC cutting machine'
- 'Able to cut metal, PVC and **honeycomb material**'
- '**With a vacuum pump with an operating suction temperature between $[20, 35]$ degrees Celsius**' (which is not in the company's catalogue)
- 'Ready in **12 weeks**'
- 'No other service is required'

$\mathbb{TS}$: In this case, the technical solution is less standard and required some specific design to meet customer requirements on the vacuum pump. The components are still tangible, but predefined for 80% of them and needing to be designed for 20%.

$\mathbb{DP}$: The delivery process still corresponds to the preparation sub-process and stops with the delivery of the ETO CNC cutting machine to the customer's site. But now it includes a specific design activity for the new component. This activity is more risky than the others and has a direct impact on the confidence KPI.

$\mathbb{CA}$: The main cost allocation is therefore due to the engineering part of the delivery process where engineers have to design, test and develop the new components.

4.1.3. ATO CNC cutting machine & standard training: $P\curlyvee SS\ ^{M}_{TS+}$

The third type of $P\curlyvee SS$ is the one composed of tangible and intangible artefacts with a technical solution cost greater than the delivery process cost, or $P\curlyvee SS\ ^{M}_{TS+}$. This is typically the case for ATO products associated with standard services. Let us now consider an ATO CNC cutting machine with a standard training course and focus on its technical solution and its delivery process, as presented in Figure 11. As an example, the customer requirements are the following:

- 'Needs for a standard CNC cutting machine'

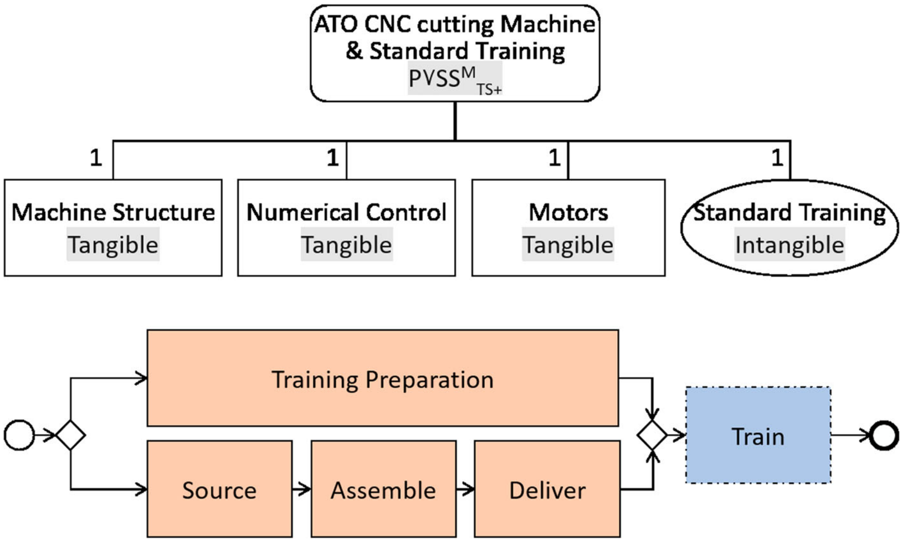

Figure 11. $P\curlyvee SS^{M}_{TS+}$ example: ATO CNC cutting Machine & standard training.

- ‘Able to cut metal and PVC’
- ‘Without a vacuum pump’
- ‘Ready in 6 weeks’
- ‘**A standard training course is required to use the CNC cutting machine properly**’

$\mathbb{TS}$: In this case, the technical solution is built on tangible artefacts (components and sub-assemblies of the CNC cutting machine) and intangible artefacts (for the standard training module). All of the artefacts are standard, predefined and assembled together to meet customer requirements.

$\mathbb{DS}$: The delivery process now includes the preparation sub-process as well as the operating one. The preparation sub-process is dedicated to manufacturing the CNC cutting machine and delivering it, and simultaneously preparing the standard training module. It is thus split into four main activities: the training preparation (which is rather light in term of time and resources workload), the sourcing of the components, their assembly and the delivery/installation of the machine on the customer’s site. The operating sub-process consists in carrying out the training, and is composed of only one activity, the training of operators on the client’s premises.

$\mathbb{CA}$: As for $P\curlyvee SS^{T}_{TS+}$ (cf. Section 4.1.1), all the artefacts are standard. We consider that the main cost allocation is mainly due to the tangible artefacts of the technical solution.

4.1.4. ATO CNC cutting machine & personalised training: $P\curlyvee SS^{M}_{DP+}$

The fourth type of $P\curlyvee SS$ is that composed of tangible and intangible artefacts with a delivery process cost greater than the technical solution cost, or $P\curlyvee SS^{M}_{DP+}$. This can be the case for ATO or ETO products associated with personalised services. Let us now consider the previous ATO CNC cutting machine but with a personalised training course. Let us have a focus on its technical solution and its delivery process, as presented in Figure 12.

This example differs from the previous one (see Example 4.1.3) only by the fact that a specific training course is required by the customer. The customer is willing to pay more for personalised training that will contribute to a better understanding of the CNC cutting machine. The cost allocation is therefore transferred from the technical solution to the delivery process. As an example, the customer requirements could be the following:

- ‘Needs for a standard CNC cutting machine’
- ‘Able to cut metal and PVC’
- ‘Without a vacuum pump’
- ‘Ready in 6 weeks’
- ‘**A specific training is required to use the CNC cutting machine properly as it is the first time the customer has bought one**’

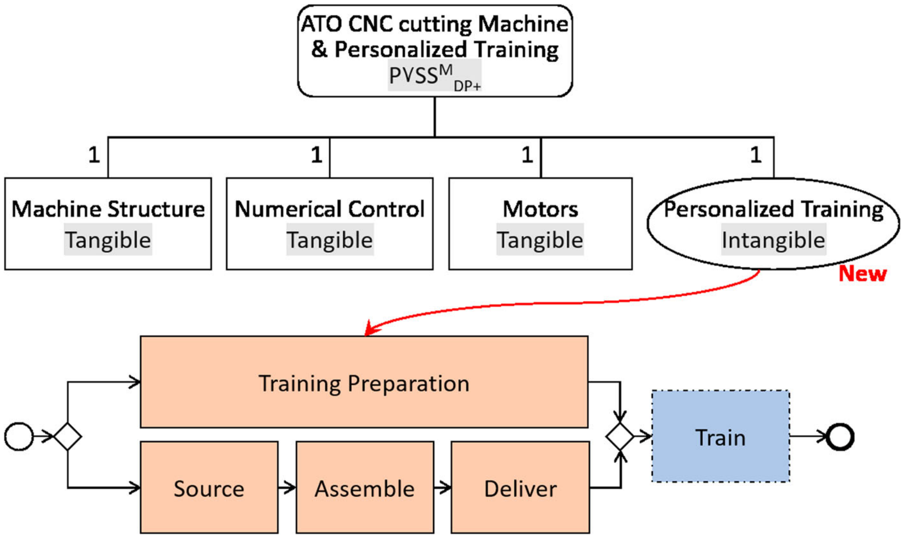

Figure 12. $P\Upsilon SS^{M}_{TS+}$ example: ATO CNC cutting Machine & personalised training.

$\mathbb{TS}$: In this case, the technical solution is built on tangible artefacts (components and sub-assemblies of the CNC cutting machine) and intangible artefacts (for the specific training module). Some of the artefacts are standard and predefined while some of them need to be designed before being assembled to meet the customer requirements.

$\mathbb{DP}$: As previously, the delivery process includes the preparation sub-process (to manufacture the CNC cutting machine and deliver it) as well as the operating sub-process (to train the company's operators). The preparation sub-process is split into four main activities: preparation of training (which in this case is more time and resource-consuming as it needs to be adapted to the specific needs), the sourcing of the components, their assembly and the delivery/installation of the machine on the customer's site. The operating sub-process is composed of only one activity, the training of operators on the client's premises.

$\mathbb{CA}$: As for $P\Upsilon SS^{T}_{DP+}$ (cf. Section 4.1.2), we can consider that the main cost allocation will involve the intangible artefacts of the technical solution which have to be personalised and to meet customer requirements. The training preparation task has become the most costly activity and makes the delivery process costs higher than the technical solution costs.

4.2. From $P\Upsilon SS^{I}_{DP+}$ to $P\Upsilon SS^{M}_{TS+}$

In this subsection, a diagnosis and maintenance service is taken as an illustrative example to show how the definition of a commercial offer addressing an intangible technical solution can become more tangible, and can be associated with different types of delivery process.

4.2.1. Diagnosis before maintenance: $P\Upsilon SS^{I}_{DP+}$

The fifth type of $P\Upsilon SS$ is composed of 100% of intangible artefacts with a cost allocation only due on the delivery process, or $P\Upsilon SS^{I}_{DP+}$. This is typically the case for standard services composed of several modules. Let us now consider the requirement for a diagnosis in order to conclude on the state of the CNC cutting machine with respect to its capability: high, medium or low. Therefore, an analysis of the CNC cutting machine is conducted without any refurbishing. The focus will be on its technical solution and its delivery process, as presented in Figure 13. As an example, the customer requirements could be the following:

- 'Needs for a quote and diagnosis before maintenance of a CNC cutting machine'
- 'Price less than 1K$ for the diagnosis'
- 'No needs to change any parts'

$\mathbb{TS}$: In this case, the technical solution is a standard one composed of modules which are intangible, already defined and carried out together to meet the customer requirements. In our example, these modules correspond to one acoustic diagnosis, one vibration diagnosis, one pressure diagnosis and finally one report and debriefing with the supervisor.

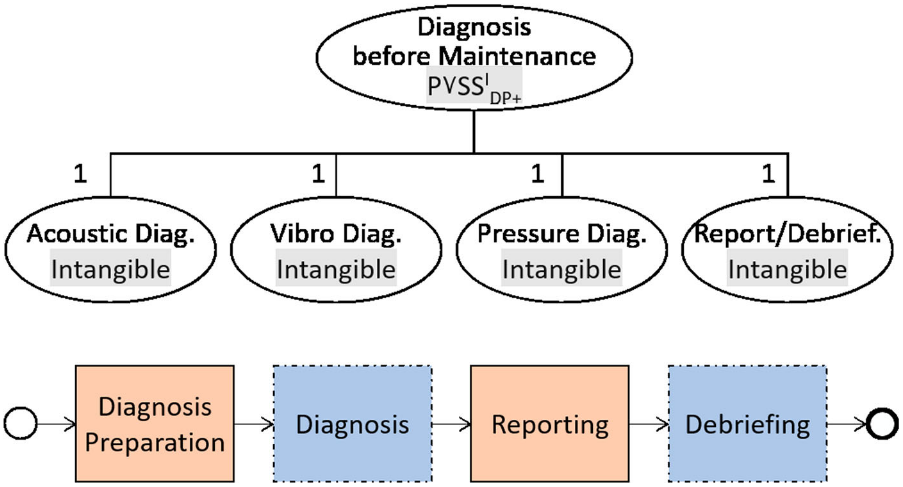

Figure 13. $P\Upsilon SS^{I}_{DP+}$ example: Diagnosis before Maintenance.

$\mathbb{DP}$: The delivery process is also a standard one and includes the two sub-processes, which in this case are intertwined. The preparation sub-process is dedicated to the diagnosis preparation (mainly the administrative procedure, the planning of the diagnosis, etc) and the writing of the diagnosis report. The operating sub-process consists of the performance of the different diagnoses and the debriefing.

$\mathbb{CA}$: As there are no tangible artefacts in the technical solution, the cost is directly linked to the delivery process activities.

4.2.2. Diagnosis & light maintenance: $P\Upsilon SS^{M}_{DP+}$

The sixth example follows the same philosophy as the one presented for an ATO CNC cutting Machine & Personalised Training (cf. Section 4.1.4). This $P\Upsilon SS$ is composed of tangible and intangible artefacts with a delivery process cost greater than the cost of the technical solution, or $P\Upsilon SS^{M}_{DP+}$. This type of $P\Upsilon SS$ can be encountered when a maintenance operation requires low-cost spare parts. Let us now consider a diagnosis/maintenance service requiring spare parts, focusing on its technical solution and its delivery process, as presented in Figure 14. As an example, the customer requirements could be the following:

- ‘Needs for a quote and diagnosis before maintenance of a CNC cutting machine’
- ‘Price less than 1.5 K$ for the diagnosis’
- **‘If needed and cost $\leq 0.5K\$$, change small defective parts.’**

$\mathbb{TS}$: In this case, the technical solution is built on standard intangible artefacts corresponding to the diagnoses, maintenance, report and debriefing with the supervisor, and standard tangible artefacts, which are the spare parts needed to repair the CNC cutting machine.

$\mathbb{DP}$: The delivery process is also a standard one and includes the two sub-processes. The preparation sub-process is dedicated to the diagnosis preparation (the administrative procedure, the planning of the diagnosis, etc), the sourcing of the spare parts and the writing of the diagnosis report. The operating sub-process consists of the different diagnoses, the performing of the maintenance, and the debriefing with the workshop supervisor.

$\mathbb{CA}$: Although there are tangible artefacts in the technical solution, as the maintenance is light, we can consider that the cost of the spare parts is negligible compared to the cost of the delivery process.

4.2.3. Diagnosis & heavy maintenance: $P\Upsilon SS^{M}_{TS+}$

The seventh example follows the same philosophy as the one presented for an ATO CNC cutting Machine & Personalised Training (cf. Section 4.1.3). This $P\Upsilon SS$ is composed of tangible and intangible artefacts with a technical solution cost greater than the delivery process cost, or $P\Upsilon SS^{M}_{TS+}$. This type of $P\Upsilon SS$ can be encountered when a maintenance operation requires expensive spare parts. Let us now consider a diagnosis/maintenance service requiring costly spare parts, and focus on its technical solution and its delivery process, as already presented in Figure 15. As an example, the customer requirements could be the following:

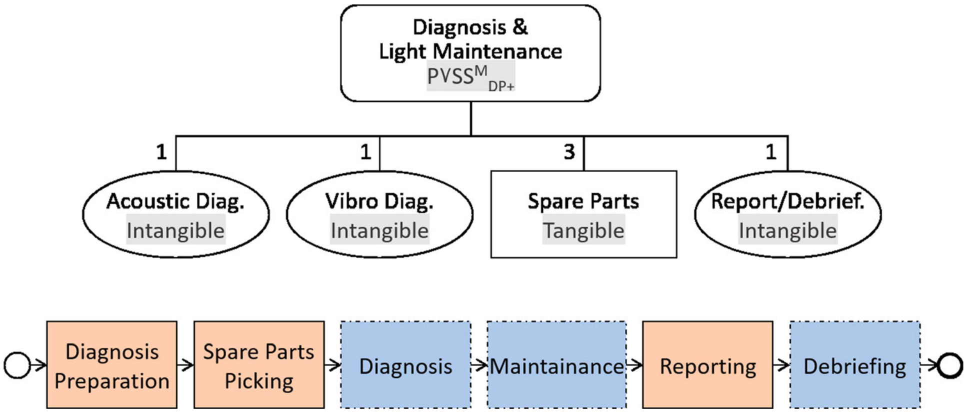

Figure 14. $P\curlyvee SS_{DP+}^{M}$ example: Diagnosis & Light Maintenance.

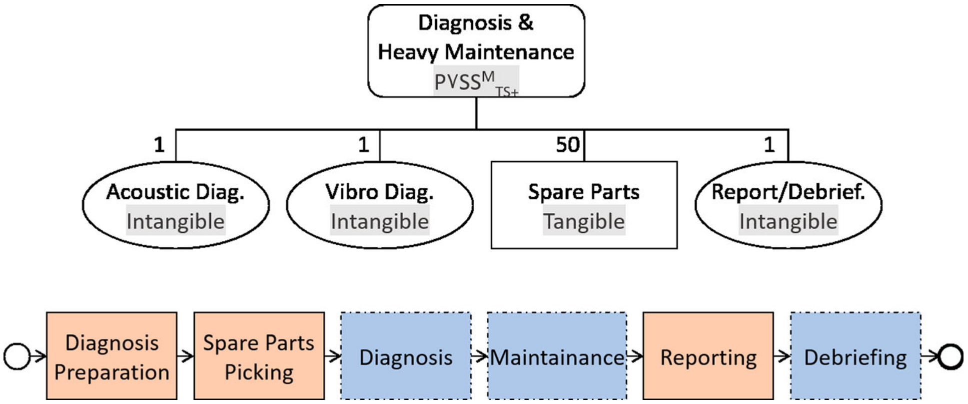

Figure 15. $P\curlyvee SS_{TS+}^{M}$ example: Diagnosis & Heavy Maintenance.

- ‘Needs for a quote and diagnosis before maintenance of a CNC cutting machine’
- ‘Price less than 2.5K$ for the diagnosis’
- **‘If needed and cost ≤ 1.5*K*$, change defective parts.’**

$\mathbb{TS}$: In this case, the technical solution is built on standard tangible artefacts, which are the spare parts needed to fix the CNC cutting machine, and on standard intangible artefacts corresponding to the diagnoses, maintenance, report and debriefing with the supervisor.

$\mathbb{DP}$: The delivery process is roughly the same as in the previous example and includes exactly the same activities.

$\mathbb{CA}$: Where a heavy maintenance is required, the cumulative price of all the components can be very expensive or the price of one particular part can be very costly. For example, the CNC cutting engine blocks can cost several thousand dollars each. Therefore, we can consider that the main cost allocation involves the tangible artefacts of the technical solution which makes the delivery process cost lower than the cost of the technical solution.

4.3. Synthesis

In this section, we have instantiated the $P\curlyvee SS$ and *Delivery process* generic models on seven different examples which cover different situations encountered by companies designing commercial offers.

These seven examples show that a technical solution can be more or less tangible depending on the customer requirements and the need to use tangible and intangible artefacts. The generic model supporting the definition of the technical solution, proposed in Section 3.2.3, allows companies to build technical solutions without worrying about any characteristic of the artefacts that compose them.

With regard to the delivery process, the seven examples have shown the different forms it can take, ranging from a simple preparation sub-process to a more complicated one combining and mixing activities of the preparation and operating sub-processes. The generic model supporting the definition of the delivery process, allows companies to define any form of delivery process without needing to be concerned about the type of activities to be carried out.

5. Conclusion & future research

Customers' needs and habits have rapidly evolved in recent decades and these changes have led them to completely change their consumption pattern. Now, it seems almost unthinkable to buy a standard product or service when it can be personalised to one's own needs. Furthermore, customers increasingly feel they have no need to buy and own products; instead, they prefer to pay for instant use of the product when needed. Companies have to adapt their catalog to these new trends by proposing customisable solutions, wide enough to cover products, services and all their combinations.

In this article, an innovative generic model has been proposed to help companies define their commercial offers in such a context. This generic model is completely new and original, and allows a real flexibility for companies in the way they respond to a bid. Our proposal is based on a detailed examination of the commercial offer in bidding process (Chalal and Ghomari 2006). Inspired by the works of Tiihonen et al. (2014) and Shen, Wang, and Sun (2012), a commercial offer is characterised by (1) a context in which the offer is taking place, (2) a technical solution defined using an ontology of artefacts (Vareilles et al. 2015), (3) a delivery process defined through an ontology of activities and finally (4) a set of key performance indicators, which includes economic, time and confidence indicators (Kang et al. 2016; Sylla et al. 2017a, 2017b; Ayachi et al. 2018). In our proposal, unlike Shen, Wang, and Sun (2012), a clear distinction between the service (what the company sells), modelled as intangible artefacts, and the delivery process (how the company delivers it) is made.

The first key element in our proposal derives its originality from the concept of Product$\curlyvee$Service System, or $P\curlyvee SS$, defined in Section 3.1, for the technical solution. $P\curlyvee SS$ allows the combination of different types of artefacts (components, sub-assemblies, service components and modules) in a unique technical solution architecture. Each artefact, regardless of its tangible or intangible nature, can be decomposed recursively into other artefacts until the technical solution has been defined. In a similar way to Tukker (2004), a typology of five types of $P\curlyvee SS$, based on two criteria, has been proposed: the first criterion is the degree of tangibility of the technical solution, while the second one is relative to the cost of the technical solution compared to the cost of the delivery process.

The second key element in our proposal is the delivery process. The delivery process is composed of two sub-processes which do not involved the same types of activities. The first sub-process is the *preparation sub-process* and is dedicated to the design, manufacturing and delivery of the technical solution. This sub-process ends when the product leaves the factory or when the service is ready to be implemented at the customer's site. The second sub-process is the *operating sub-process* and corresponds to the use or operation of the technical solution by the customer. This sub-process ends when any service has been performed on the customer's premises. If we keep in mind that the delivery process and the technical solution are intertwined, the fact of mixing tangible and intangible artefacts in the technical solution has the side effect of mixing the activities of the two sub-processes in the delivery process. The form of the delivery process is therefore closely related to the architecture of the technical solution.

To summarise, the benefits and the originality of the proposed generic model are the following:

- our model handles products and services, tangible and intangible artefacts, in the same model,
- our models makes a clear distinction between the technical solution and the delivery process,
- our model proposes a decomposition of the delivery process into two sub-processes, *preparation sub-process* and *operating sub-process*.

The three previous key characteristics of our model allow companies to define commercial offers without worrying about the type of artefacts to combine, nor the types of activities. Seven simple but realistic examples have shown the simplicity and the power of the proposed generic model. More examples, with other specificities, could have been added, such as a CNC cutting machine leasing process. This particular example of $P\curlyvee SS\,{}^{M}_{TS+}$ differs from the one given in Section 4.1.3 on two points. First, the technical solution only contains two artefacts: one tangible artefact (the CNC cutting machine) and one intangible artefact (the rent lease). Secondly, the *operating* sub-process of the delivery process may be longer than the *preparation* sub-process, depending on the rental period. Theoretically, all the combinations of technical solution architectures and delivery process forms are possible. The inconsistencies between artefacts and activities need to be formalised by using the ontologies and constraints in order to avoid, for instance, an ETO tangible artefact associated with a standard training module.

Our next objective is to implement the generic model in a decision support system or DSS, dedicated to defining commercial offers. The DSS has already been specified within a French project named OPERA (https://research-gi.mines-albi.fr/display/OPERA/Welcome), which involves three universities as well as four companies in the secondary and tertiary sectors. The DSS is fully compliant with our proposals and it is currently under development. The first version of the DSS should be available on-line in Spring 2020. Some videos will be provided on the OPERA project website. When the DSS is ready, we need to validate it on industrial examples to test the relevance of the commercial offer generic model and the $P\curlyvee SS$, in order to determine its usability and scalability in real situations.

Acknowledgements

We would like to thank all the industrial partners of the ANR Project OPERA for their involvement in the project.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes

1. Computer Numerical Control
2. Computer Numerical Control

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