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AN ENTERPRISE META MODEL FOR THE ASSESSMENT AND IMPROVEMENT OF SUSTAINABILITY AND MASS CUSTOMIZATION PERFORMANCE

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ABSTRACT: In a mass customization and sustainability context, enterprises are endeavouring to provide customized products, gain new markets while enhancing social, economic and environmental sustainability. Moreover the performance of the firm needs to be measured in order to control the progress towards the above mentioned goals. At this point, all performance inductors have to be considered in order to ensure a complete assessment. In this paper, a meta-model of the enterprise that takes into account these considerations is presented. The meta-model attempts to depict all enterprise components and factors arising from its environments in order to provide a global vision of the Sustainable Mass Customized (SMC) enterprise model which in turn will be exploited in farther steps for the assessment and performance improvement of such firms.

KEYWORDS: Enterprise meta-model, sustainability, mass customization, performance assessment.

1 INTRODUCTION

Enterprises are faced by big demand and variety of customer preferences that require the delivery of customized products with important quantities using efficient production systems. These requirements form the essence of mass customization which presents opportunities for new markets holding and improvement of firm’s competitiveness.

Nevertheless, additional factors emerged from governments’ pressure and customer consciousness about sustainability issues. Such factors need to be considered in order to survive the nowadays market competition while satisfying all stakeholders. Accordingly, sustainable mass customized (SMC) enterprises gain more competitive advantages against traditional enterprises.

Moving towards a SMC enterprise suggests the deployment of processes and resources to provide customized products, gain new markets while enhancing social, economic and environmental sustainability. Moreover, the performance of the firm needs to be measured in order to control the progress towards the SMC model. At this point, all performance inductors have to be considered in order to ensure a complete assessment.

In this paper, a meta-model of the enterprise that takes into account these considerations is presented. The meta-model attempts to depict all enterprise components (i.e. processes, etc.) and factors arising from its environments (i.e. social, economic, and ecological) in order to provide a global vision of the SMC enterprise model which in turn will be exploited in farther steps; performance assessment and improvement of such firm.

The rest of the paper is organized as follows; section 2 highlights the requirements of sustainable mass customized enterprise assessment which were used to build up the model components presented in section 3. Section 4 describes the SMC-E model. Research perspectives are discussed in section 5.

2 MASS CUSTOMIZATION AND SUSTAINABILITY ASSESSMENT REQUIREMENTS

Mass customization literature is quite consistent and full of case studies and theoretical analysis. Most of the studies are focused on some specific enablers of mass customization. More complete views of all mass customization enablers can be found in literature surveys (Da Silveira, 2001; MacCarthy, 2003; Daaboul et al., 2009).

In terms of assessment, different levels are distinguished; first, the evaluation of the applicability of mass customization as a strategy (Daaboul et al., 2009). Second the evaluation of mass customization enablers through analysis of processes and/or design customizability, for instance (Yang and Li, 2002; Jiao and Tseng, 2004; Welborn, 2009), this stream involves the mechanisms of MC. Third; assessment may focus on the results of mass customization in terms of customer requirements satis-
faction (Jiao and Tseng, 2004). Accordingly the mass
customization evaluation involves stakeholders such as
suppliers, customer in addition to the enterprise pro-
cesses and products. This suggests that a modelling of
the enterprise meant to provide data for the assessment
must include all the above mentioned components.

In terms of sustainability, several authors highlighted
that such concept embraces different levels of the or-
ganization (Labuschagne, 2004; Laine, 2005; Jayal et al.,
2010). It can be concluded from the findings of the
aforementioned authors and sustainability literature re-
view that the levels are; product, process, and organiza-
tion and supply chain. In the following examples are
given to illustrate the need for these levels for each of the
sustainability dimensions.

Economically speaking, the product Bill-Of-Material
(BOM), production processes, suppliers cost, all impact
the overall cost of the final product. For the envi-
ronmental impact, let us take the example of resource use,
this latter depends on the product material, processes use
of auxiliary materials, etc. In terms of social sustainabil-
ity (which involves the labour and society), the organiza-
tion level (or company level) is the main driver of such
dimension. This has also been pointed out by authors
whose researches involve the social dimension of sus-
tainability such as Jørgensen et al. (2008) and Dreyer
(2009).

A consequence of this analysis is that product, process,
organization and supply chain levels are inevitable for
the indented meta-modelling. Moreover social, economic
and ecological environments of the enterprise need to be
considered, even indirectly; without being depicted as
parts of the meta-modelling.

3 MODEL COMPONENTS

This section presents the components of the meta-model
deducted from the previous section. For the sake of un-
derstandability, the components are depicted separately
in this section before presenting the complete meta-
model in section 4.

UML class diagrams have been used to depict the ob-
jects of the meta-model. Following indexes give short
explanation of the used associations’ meanings:

- `A` is comprised of `B`.
- `B` type is of type `A`.
- `A` is associated to 1 or more `Bs`.
- `B` is associated to 1 or more `As`.

3.1 Enterprise

This sub-section involves the enterprise objects and or-
ganizational level. Enterprise is depicted as a central
element of the model. In (Labrousse and Bernard, 2008)
enterprise objects include product, process, resource and
external effect (PPRE). The current model follows the
same logic except for the external effect object. This
latter has been extended to depict environmental, eco-
nomic and social environments constraints. In other
terms, the equivalent of “External Effect” is Enterprise
Environment which strongly impacts the Organization
Policy that will be described in section 3.1.1.

3.1.1 Organizational level

Being associated to the enterprise, organizational level is
not a physical object. It can be perceived through organi-
zation policies depicted by Organization Policy. This
latter refers to enterprise strategies and management
rules of labour, resources, investments, etc. (Fig. 1).

3.1.2 Product

In addition to the product itself, Product model com-
prises components and raw material, each of which is a
product in turn. This relationship between product and

![Figure 1: Organizational level](image1)

![Figure 2: Product](image2)
components and raw materials is depicted by the composition (Fig. 2). The Product is an Enterprise object.

3.1.3 Process

Process, as an enterprise object, is the set of activities involved in the production of a good. Processes range from the raw material extraction to the end of life of the product or delivery of the service (Fig. 3).

3.1.4 Resource

Resource is a generic enterprise object that may have different types namely, staff, material and financial resources. Staff refers to Employee. Material Resource can be Raw material, Energy, Technology or Equipment. Financial Resource refers to all money forms that enterprise possesses (Fig. 4).

3.2 Enterprise environment

3.2.1 Economic environment

Enterprise is a stakeholder within the supply chain; it can also play the role of Customer.

Supply Chain consists of all processes and flows involved in providing a product to the customer (Supply Chain Council, 2010).

Market is a place where Suppliers of a given product and Customers meet to make transactions.

Economic environment is comprised of both Market and Supply Chain stakeholders where relationships differ. In fact, in the former we speak about competitiveness between enterprises, while in the latter what counts is mainly partnership and coordination between supply chain actors (Fig. 5).

3.2.2 Social environment

Society is comprised of Individuals, Local communities and Governments (Fig. 6). Customer is a role which can be taken by any of society components (and the enterprise). Society with all its components urges the enterprise to carry out sustainable development, thus such impact is important for the SMC firm. Customer includes also the requirements that have to be fulfilled by the customized product. These requirements involve sustainability (i.e. emissions thresholds, cost, etc) and mass customization as well (i.e. required speed, size, etc).
3.2.3 Ecological environment

Ecological environment is considered as a set of resources namely Mined, Air, Land and Water resources (Fig. 7). This classification is inspired from the Life Cycle Assessment method (CML et al., 2001; Rebitzer et al., 2004) where environmental impact is often assigned to four Areas of Protection (AoP) namely; Air Resources, Land Resources, Water Resources and Mined Resources (Mangena and Brent, 2006).

Figure 7: Ecological Environment

3.3 Indicators

Indicators fall under the standardized models category used to evaluate sustainability (Todorov and Marinova, 2010) but they are also a very used technique in the field of mass customization assessment - even if this latter is not well established. Accordingly, an indicator allows measuring the performance of customization and / or sustainability. Indicator as a component of the model, measures the sustainability and/or mass customization performance for a given aspect (i.e. process customizability, emissions to ecological environment, etc). Indicator depends on Enterprise Environment that includes Economic, Social and Ecological ones. It depicts the impact of these latter on the Enterprise and vice-versa (Medini et al. 2011). Indicator is of different types, it can be associated to Organizational level (i.e. labour management) or enterprise objects including, Product (i.e. material cost, etc.), Process (i.e. process customizability, etc.) and Resource (i.e. energy consumption, etc.) (Fig. 8).

Figure 8: Indicator

4 META MODEL OVERALL SHAPE

The meta-model is depicted in Figure 9. It groups all the above mentioned components to provide a complete vision that spans enterprise components and stakeholders. To put together puzzles, following associations are required:

Product – Resource; Characterizes the resources used to provide a given product (that can also be a component or raw material).

Activity – Resource; Characterizes the resources used by a given activity that is a part of a process.

Product – Process; for a given product, only a definite set of process sequences is possible. This link defines the possible Processes and/or activities apt to perform a given Product. This is particularly important during the process planning for a product variant.

Individual – Employee; Employee of the enterprise is actually an individual in the society.

Environmental Resource – Material Resource; Material resource is a part of environmental resources.

Customer – Product; the product functionalities have to fulfil certain requirements of a given customer.

In Figure 9, associations are represented with the continuous line. The class Enterprise is depicted twice for the sake of clarity, it depicts the same object.

Social, Economic and Ecological environments fall all under the Enterprise Environment category. The impact of these environments is taken into account by introducing the Indicator object whose calculation uses information about the Enterprise Environment (i.e. characterization of the emissions, purchasing price, customer requirements, investments in society, etc.). The dependencies of Indicator and Organization Policy (mentioned before) on Enterprise Environment are depicted by the arrow broken lines.

5 CONCLUSIONS

In this paper a meta-model of the SMC-E has been built upon the requirements of a complete assessment of sustainability and mass customization performance. It was concluded that different components inherent to the enterprise and external stakeholders (i.e. Supply chain actors, Enterprise Environment) need all to be modelled. Each of these components has been described separately. Together, the meta-model components define the scope of an effective SMC-E assessment allowing the analysis and improvement of sustainability performance of a mass customization solution space. The specifications herein established provide the basis of following tasks:

- Development of sustainability and mass customized assessment model starting from instances of the present meta-model.
- Development of simulation models by adapting the proposed meta-model and creating instances for the simulation.
Analysis and improvement of sustainability performance of mass customized solutions.

Analysis of the links between mass customization and sustainability.

Nevertheless, the meta-model validation needs to consider several case studies by at least having interviews with or questionnaires to be filled by managers.

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