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Towards dynamic reference information models: Readiness for ICT mass customisation

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ABSTRACT

Current dynamic demand-driven networks make great demands on, in particular, the interoperability and agility of information systems. This paper investigates how reference information models can be used to meet these demands by enhancing ICT mass customisation. It was found that reference models for Production and Supply Chain Management do not yet sufficiently meet the requirements of a mass customisation approach. They have developed from isolated models based on pure standardisation and tailored customisation strategies, towards static repository-based models founded on segmented standardisation strategies. Existing models provide valuable knowledge for developing towards more dynamic reference information models, including the progress made by ERP vendors to make their reference models configurable. Important remaining challenges are setting up reference information models as generic models that define classes of architectures, and incorporating user-friendly means that guide users through the process of configuring specific information models.

1. Introduction

In response to today's increasingly volatile business environment, supply chains are in transition from chains pushing products efficiently to the marketplace, towards agile networks that sense and react dynamically to demand information. This makes great demands on, in particular, the interoperability and agility of supporting information systems [1,2]. Interoperability is the ability for two systems to understand one another and to use one another's functionality [3]. ICT agility is the ability to identify needed changes in the information-processing functionalities and to implement them quickly and efficiently [4].

The main challenge in meeting these demands is combining flexible customisation with efficient standardisation. In business literature, mass customisation is broadly advocated as a core approach to balance these seemingly contradictory notions [5,6]. Mass customisation relates the ability to provide customised products or services through flexible processes to the ability to produce in high volumes at reasonable costs [7]. This is by fabricating parts of the product in volume as standard components, while achieving distinctiveness through customer-specific assembly of modules [8].

Recent developments in ICT, particularly Service-Oriented Architecture (SOA), enable the application of mass customisation principles to information systems [9]. ICT mass customisation combines the advantages of standard and customised software. It enables on-demand configuration of information systems from standard components with standardised interfaces.

Information models (e.g. process and data models) support ICT configuration tasks since they provide systematic representations of the complex architectures to be configured. Specific information models could be developed from scratch for each configuration, but this would result in high costs and long lead-times. An alternative approach would be to use available 'best practices' captured in reference information models as a 'frame of reference' (i.e. blueprint, template).

The objective of this paper is to assess how reference information models can be used to enhance ICT mass customisation. Therefore, it respectively aims to: (i) identify the requirements to reference information models in an ICT mass customisation approach, (ii) investigate the extent to which existing reference models, in the domain of Production and Supply Chain Management, are useful for ICT mass customisation, and (iii) to explore trends in the development towards dynamic models.

The research started with a literature study to identify the requirements on reference information models in an ICT mass customisation approach. Therefore, a three-stage funnel approach was followed. First, the generic concept of mass customisation and the requirements on systems, enabling such an approach, were

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defined. Secondly, the approach and identified requirements were applied to mass customisation of information systems. Thirdly, the analysis concentrated on the role of reference information models in mass-customisable ICT.

After literature review, existing reference information models were investigated. Because user acceptance is an important characteristic of reference models, the investigation focused on reference models that are widely acknowledged and applied in the business community. The scope of our analysis was the domain of Production and Supply Chain Management, implying that reference information models which mainly focus on eCommerce processes (ordering, invoicing, catalogue exchange, etc.) and sector-specific reference models were not assessed.

The investigation was carried out through desk study and in-depth expert interviews with reference model developers, implementation consultants and managers (67%, 53% and 33%, respectively, multiple roles possible). In total, 15 experts were interviewed (9 persons from 7 software vendors and 6 people from 5 service providers) in-depth, based on a structured three-part questionnaire: (i) content and technology, (ii) model development, and (iii) implementation and usage.[1]

The structure of this paper follows the research approach. Section 2 defines the concept of mass customisation, the requirements on systems enabling such an approach, and applies this to information systems. Section 3 elaborates on the role of reference models and the requirements on such models for the enhancement of ICT mass customisation. Section 4 provides an overview of existing reference models for Production and Supply Chain Management and describes the extent to which these models meet the identified requirements. The paper concludes by describing trends towards dynamic reference information models and addressing future challenges.

2. Towards mass-customisable ICT

This section discusses the characteristics of a mass customisation approach, and identifies the requirements when such an approach is applied to ICT.

2.1. What is mass customisation?

The term 'mass customisation' was coined by Davis [6]. It was initially promoted as a broad visionary concept, putting together seemingly contradictory notions: customisation to produce tailored products or services through flexible processes versus standardised mass production to produce in high volumes at reasonable costs [5,6]. Around the turn of the century, mass customisation was mentioned in the debate about agility versus leanness as a core concept to bridge the gap between both approaches. Agile strategies focus on flexibility and customisation, while lean strategies focus on efficiency and standardisation. From the debate it emerged that leanness and agility are not mutually exclusive strategies, and that a hybrid strategy of both agile and lean approaches is required to meet the requirements of responsiveness [10]. In such 'leagile' approaches, the positioning of Customer Order Decoupling Points (CODPs) plays a central role. The CODP separates that part of the supply chain geared towards directly satisfying customers' orders from that part of the supply chain anticipating future demand [11]. Downstream products are differentiated to specific customers or markets, while upstream products are standardised based on demand forecasts.

Based on the CODP position, a continuum of control strategies is proposed in the literature, varying from strategies in which all processes are driven by customer order, to full anticipatory control in which all processes are based on demand forecasts. The main configurations are engineer-to-order (ETO), make-to-order (MTO), assemble-to-order (ATO) and make-to-stock (MTS). These strategies involve different levels of product differentiation, from fully customised in engineer-to-order (ETO) to fully standardised in make-to-stock (MTS).

Lampel and Mintzberg [12] argue that there is a dominant trend from both ends of the continuum towards the middle, namely towards mass customisation, or as they name it: 'customised standardisation'. Such a strategy offers the buyers the option of selecting their own set of components. Customers get their own product configuration but constrained by the range of available components. A mass customisation strategy is enabled by an assemble-to-order (ATO) production strategy, in which customer-specific products are assembled to customer order from standardised components that are fabricated to forecast.

Several authors stress that mass customisation imposes high demands on the enabling business systems. Pine et al. [5] argue that modularity and a linkage system are key factors to achieve mass customisation. Modularity allows parts of the product to be made in volume as standard modules, with product distinctiveness achieved through specific combinations of the modules [8]. A linkage system permits components to integrate rapidly in the best combinations or sequence required to tailor products or services [5]. Duray et al. [8] add that besides modularity, customer involvement in specifying the product is a key characteristic. Zipkin [13] states that mass customisation requires unique operational capabilities. He addresses four key capabilities: (i) a mechanism for interacting with the customer and obtaining specific information (elicitation); (ii) flexible processes that fabricate the product according to this information; (iii) the logistics to deliver the right product to the right customer; and (iv) powerful communications links that integrate these elements into a seamless whole. Tseng [14] identifies three basic requirements in design for mass customisation: (i) common building blocks that can be reused maximally, (ii) unified product architecture providing a structure of the defined building blocks that represent the capability of the enterprise to fulfil customers' needs in a unified manner; and (iii) a platform for meta level integration of the product realisation process. Huang et al. [15] focus on product platforms as a common success factor in achieving mass customisation, which encompass four strategies, i.e. commonality, modularity, scalability and postponement.

Synthesized from this literature, five key requirements for mass customisation systems are addressed:

1. *Generic product model*: mass customisation does not imply providing limitless choice, but it is restricted to available options. For quick product assembly, it must be clear what these possibilities are. Thus a product model is required that provides a standardised taxonomy representing different product variants and the underpinning structure [14]. Traditionally, product models are developed for every product or variant, which results in high complexity and component redundancy. Therefore, Hegge and Wortmann [16] introduced a generic product model that represents the set of all variants of a particular product family. It depicts all possible configuration options of product instances and the interdependencies that exist between components or features.
2. *Modularity*: products in a mass customisation approach consist of distinctive, autonomous and loosely coupled modules. These are independent components, each with its own single function and concentrated purpose [17]. These components can be used as black boxes, i.e. in order to use them, it is not necessary to know their inner structure, and changes in one component do

[1] The questionnaire can be obtained upon request from the corresponding author.