ERP Reference Process Models: From Generic to Specific

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Abstract. Generic reference models are based on the assumption of similarity between enterprises - either cross industrial or within a given sector. The research describes a validated reference metamodel, based on an empirical study of enterprises from various industrial sectors. Drawing on the metamodel, we suggest a methodology and tools for the design and generation of individualized business process models.

Keywords: industry blueprints, reference models, case studies and experiments.

1 Introduction

Modern enterprise operations and management are firmly based upon the principle of functionality and business processes supported by an enterprise-wide integrated IT infrastructure. Management focus has shifted to integrating and managing the process-centered enterprise – i.e. the chain of activities whose final aim is the "production of a specified output for a particular customer or market" [1] using tools such as Business Process Management (BPM) and Enterprise Resource Planning (ERP) [2]. These tools form the basis for enterprise activity design, operations, change and improvement.

The current main thrust of business process management research has focused on the study of structural frameworks and IT related execution patterns [6] putting little emphasis on the content layer that is supposed to populate these frameworks. "Real life" business process models, which contain practical content objects, have been somewhat disregarded except in illustrative examples. Few scientific publications have addressed the topic of designing business process content [9],[11],[10], opting to develop theories, empirical studies and supporting tools. The lack of suggestions for standard structure, terminology and tools for the process content layer has restricted the development of "reference modeling content science", leaving it mostly to vendors and commercial organizations [8].

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Presumably, professionals have developed business process repositories on the basis of experience accumulated through analyzing business activity and implementing IT systems in a variety of industries. This has led to a paradigm whereby these content frameworks are presented as generic – i.e. typical for an industrial sector (e.g. SAP's "aerospace industry" business solutions [5] or Oracle's "retail solutions" [12]). However, the existence of numerous "generic" reference models (or "best practices"), that vary significantly between ERP vendors, even for a given sector, indicates a lack of scientific systematization in developing such content models and raises the question as to whether these models actually constitute generic validated prototypes [6]. Another concern is the generation of individualized process models - conventionally based on customization of sectorial models. This approach overlooks the fact that sectorial classifications reflect the end-product of the enterprise, rather than its modus operandi [13].

Aiming to confront these concerns, the objective of this research is to: (1) demonstrate a generic, validated business process metamodel (2) suggest a structured methodology for the construction of enterprise-specific business process models based on the operational characteristics of the implementing organization.

After a review of related work (section 2), we present the validated metamodel (section 3), and a methodology for the design and generation of enterprise-specific process models (section 4). Section 5 includes conclusions and directions for future work.

2 Application of Reference Process Models

2.1 Commercial Reference Models

Commercial reference process models are usually developed by vendors such as SAP [5] and Oracle [4]; by system integrators such as EDS [16], IBM BCS (Business Consulting Services) [17], and Accenture [18]; and by BPM specific companies such as Staffware[20], Pegasystems [19], FileNet [21] and others.

ERP vendor reference process models include, for example, SAP's industry and cross-industry Business Solution Maps [5], Lawson-Intentia's ERM (Enterprise Reference Models) [14], and Oracle's OBM (Oracle Business Models) library [4]. In the SAP business solution maps, the top level "solution map" for an industrial sector presents names and descriptions of the high level functionalities for that industry (about 7), and the corresponding main processes (about 7) for each major process. From these categorizations vendors and integrators develop a suite of processes, reflecting what an enterprise does, or needs to do, in order to achieve its objectives [15].

These models are based on the assumption of significant similarity between enterprises that operate within a certain industry. Oracle corporation for example, offers process flows that cover 19 industrial branches [4]; SAP offers Business Solutions for 24 industrial branches [5]; and other ERP/SCM/CRM vendors similarly

base their business process models on a finite set of predefined business processes, that comprise "industry-specific" reference models.

In summary, research into commercial business process models has introduced the following concepts: (a) the idea of generic reference industry-related business process models (featuring industrial-sector or output genericity); (b) the idea that a specific enterprise process model is a sub-set of a generic reference business process model. The current research elaborates these concepts in the following ways: (a) suggesting a generic business process metamodel (functional or operational genericity); (b) applying quantitative statistical methods in validating the genericity of the reference process metamodel; (c) suggesting a structured method for generating derived individualized process models.

2.2 Derivation of Individualized Process Models

While academia has devised novel notions regarding model-driven structural process configuration of enterprise systems [24],[25], the prevailing practitioner procedure for generating individualized process models content is a top-down customization of generic sectorial models. When a vendor, integrator or BPM specialist approaches, say, two enterprises x, y within a certain industrial branch "α" (such as manufacturing, utilities, chemicals, healthcare, consumer goods products) both enterprises are first presented with an identical reference process model. The next stage would be a top-down customization of the reference model, by eliminating unnecessary functionalities or processes, so that it would best fit the needs of the enterprise (Fig. 1).

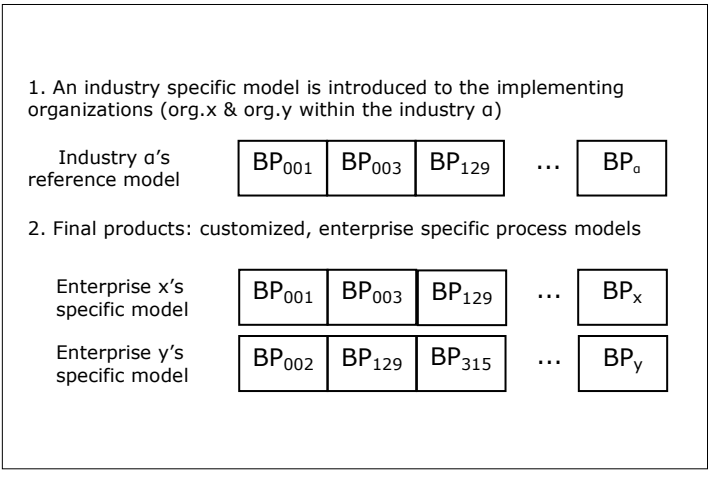

Fig. 1. Reference based content modeling: state of the art

This approach overlooks the fact that sectorial classifications reflect the end-product of the enterprise, rather than its modus operandi. Hence, focusing on *what* the enterprise produces (or supplies), instead of *how* this production is carried out, can be

misleading and may result in inappropriate business process models [6]. For example, an enterprise from the manufacturing sector may be based on fabrication processes – or assembly processes; or mass-production processes – or customized production processes. In each case the "production" and "logistics" functionalities are very different. A single "manufacturing" model would probably not cover all cases.

This research suggests an alternative approach for generating individualized process models, based on the correlation between the operational characteristics of the organization and a set of corresponding business processes.

3 Constructing a Validated Generic Metamodel

The current metamodel encompasses a hierarchy of over 2,000 processes gleaned from a survey of the content models published by SAP and Oracle, and further field surveys and student projects. These resulted in a sample of 101 enterprises from a wide range of industrial sectors. Top-level operational classifications were developed in two stages: a first partition into business-oriented functionalities and industry-oriented functionalities; and a further subdivision into basic and support functionalities on the one hand, and goods and services on the other. Thus processes are divided into five operational classes: (a) business functionalities: (1) basic business processes, (2) business support processes; (b) industrial functionalities: (3) basic manufacturing processes, (4) manufacturing support processes, (5) service processes. This top-level categorization is then decomposed into two further levels, following the lead of the breakdown presented in the Oracle business solution maps: each business process is subsumed under a main process; and each main process is subsumed under a major process.

Two attributes were considered necessary if the metamodel was to be regarded as meaningful at the major process (high) level:

- The set of major processes could be reproduced by performing clustering on the set of all main (lower level) processes over all enterprises (*separability*)
- Implementation of a major process implied implementation of all or most of the main processes it comprises (*genericity*)

Our analysis was carried out in two directions: bottom-up and top-down. First, all business processes were linked (a) to some main process and (b) to those industries in the sample in which they were found to be implemented. Then, clustering [22] was used to find significant groupings of main processes, based on the implementation findings. The clusters or groupings were found to correspond to a high degree with the 29 major processes empirically determined during metamodel construction by studying upper-level functionalities in the SAP and Oracle models and from conventional division of organizations into functional departments. It was found that (a) the probability is high that industries are significantly associated with the same number and content of clusters corresponding to the number of main processes in each class; and (b) the degree of separation between clusters is almost absolute. Thus the major processes can be considered separable (i.e. no overlapping of main processes within major processes). This completed the bottom-up partitioning

of processes at the major, main and operational levels. For example: Major: "procurement"; main: "procurement order"; basic: "authorization of procurement order".

As a first step to proving functional genericity, it was noted that the average probabilities of an enterprise implementing all the main processes within the five classes were: (a) business functionalities: (1) basic business processes (91%), (2) business support processes (59%); (b) industrial functionalities: (3) basic manufacturing processes (40%), (4) manufacturing support processes (51%), (5) service processes (59%). Thus, even at this level, the basic business processes can be considered common to almost all enterprises – i.e. functionally generic.

As a second step – top-down analysis – a major process was considered generic, at one of three levels, according to the following measure of "genericity":

- Strong genericity: all enterprises that implement the major process implement all of its requisite main processes – i.e. that a significant number of basic processes within the major-main hierarchy are implemented. This level was attained by all basic business processes, all business support processes (except "Information Service Management"), "Configuration Management", all manufacturing support processes, and all service processes.
- Intermediate genericity: the probability that a main process will be implemented in an enterprise, if the major process is implemented, is not less than 90% (i.e. 90% of the enterprises studied implemented the process). This level was attained by "Information Service Management" (91%) and "Product Engineering" (93%).
- Weak genericity: the probability that a main process will be implemented in an enterprise, if the major process is implemented, is not less than 65%. This level was achieved by "Research and Development" (76%) and "Production/ Operations" (65%).
- No genericity: the probability that a main process will be implemented in an enterprise, if the major process is implemented, is less than 65%. No major process exhibited this level of genericity.

Thus almost all the major processes show appreciable separability and genericity; and so are meaningful in general. These findings also enable two significant conclusions to be drawn: (a) an enterprise model can be constructed by a separable and additive set of business processes; (b) if an enterprise implements a major process, it most likely implements the corresponding main processes.

The metamodel thus possesses the following important properties:

- It encompasses 29 major processes, 169 main processes and some 2,000 processes.
- Its major processes are separable and generic, so that any derived model is composed of an *additive* set of major and main processes.
- Most business functionalities are common to all enterprises.
- Enterprises are differentiated mainly by their industrial functionalities – the degree to which each of the manufacturing and service sub-classes are implemented.

These properties enable us to utilize the metamodel in a systematic way for the design of individualized business process models.

4 Generating Individualized Process Models

This research elaborates a method that was presented in [6] as a possible solution to the above mentioned concerns. Instead of determining *what* organizations are producing and then tagging them according to their industrial classification, we determine in a general and then detailed way *how* organizations are operating, so that they are expressed by their operational characteristics. In order to establish an enterprise-specific business process suite, we analyze the existing or planned functionalities in the enterprise and create an enterprise-specific model. Each main process constitutes a generic building block, and incorporates a set of possible business processes exclusive to that main process. This course of action enables the construction of an "individualized" organizational model which itemizes the specific business processes of a given organization. The top-down approach is appropriate for two reasons. (a) Functional characterization of a specific enterprise is performed incrementally: first, major processes are analyzed; then, main processes, and finally basic business processes. (b) We apply the principle of separability (a particular business process is classified under one main process only; a specific main process is classified under one major process only) and additivity (as the major processes are separable, a model is formed from a conjunction of major processes, and thus main processes, and thus business processes).

4.1 Determining the Operational Classification of an Enterprise

Lincoln and Karni [15] proposed a general typological representation of enterprises, that overcame the necessity to distinguish between production and service industries, seeing that both types of activity occur in most organizations. Their typology characterizes industrial functionality by two codes: M(*) and S(*). M(*) defines goods production functionality (oriented along product development through manufacture) , whilst S(*) defines service provision functionality (oriented towards the proximity between the provider and customer. The scale of functionalities ranges from "pure goods production" (M(4)) through "pure service provision" (S(4)) (Table 1).

This presentation implies that an enterprise implementing "full production" functionality (R&D, product engineering, configuration management and production), with no service functionality, would be coded as M(1+2+3+4)S(0).

An enterprise implementing "full service" functionality (front office, contact office, mobile office and remote office), with no goods functionality, would be coded as M(0)S(1+2+3+4). All other enterprises can be characterized within this spectrum in accordance with their tendency to be oriented towards manufacturing or service. For example: a ticket sales office that is a "pure" service enterprise would be coded as M(0)S(1+2+3+4) (sales of tickets via the web, through agents in the field, via a call center, and person-to-person at the enterprise offices). A software company oriented both towards creating software and providing services would be coded as M(2+3+4)S(2+3) (development of customized software reusing modules; providing a help desk in the field and through a call center).

Table 1. The primary functional typology

Operational Characteristic	Code
Production/operations (MtS)	M(4)
Configuration management (AtO)	M(3)
Product engineering (EtO)	M(2)
Research and development (DtO)	M(1)
No significant goods production	M(0)
No significant service provision	S(0)
Remote office service (web/vending)	S(1)
Mobile office service (field)	S(2)
Contact office service (call center)	S(3)
Front office service (provider)	S(4)

4.2 Generation of Individualized Business Process Content Models

The procedure for generating an individual business process model is as follows, based upon the major-main-basic hierarchical tree within the metamodel:

a) Using a comprehensive questionnaire, identify the general operational characteristics of the enterprise (as described in section 4.1).
b) From the metamodel, select the major processes constituting the top-level operational characteristics of the enterprise.
c) Automatically generate a reduced model, encompassing only those major processes selected and incorporating all the main processes in the sub-trees below the major processes.
d) From this model, select the main processes constituting the second-level operational characteristics of the enterprise.
e) Automatically generate a further reduced model, encompassing only those major and main processes selected and incorporating all basic processes in the sub-trees below the main processes.
f) Using a general threshold probability given by the enterprise, automatically retrieve those business processes, for each main process in the condensed capstone, having a probability equal to or greater than the threshold value.
g) Automatically generate the initial model (all process levels) for the enterprise.
h) Fine tune the model – usually at the process (low) level – to ensure that all relevant processes have been included, and unnecessary processes eliminated. This may require some time, as the various "key users" in the enterprise become involved at this stage. However, they begin from the specific enterprise model as an initial input, rather than a generalized vendor offering. This focuses attention on the enterprise functionality, and can greatly shorten the time to reach agreement on the final model.

A summary of the steps is described in Fig. 2.

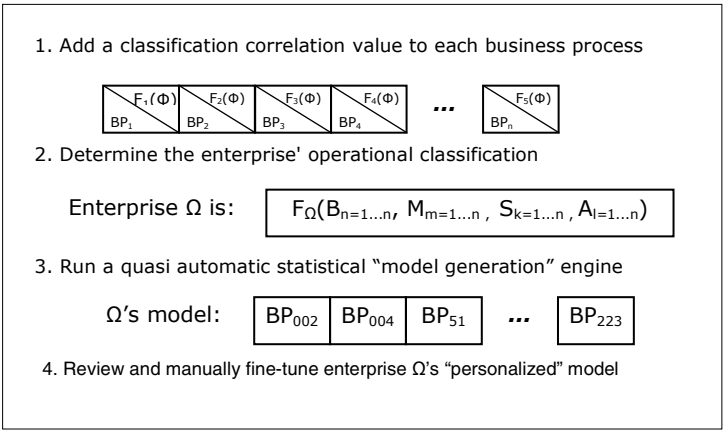

Fig. 2. Generating the enterprise specific model

For example, a confectionery manufacturer produces and markets a range of mass-produced candies for sale at the entrances to a chain of supermarkets. From the questionnaire we learn that its operations are characterized by make-to-stock production, a call center for customer orders, a fleet of refrigerated vans for distribution to the outlets, and refilling of candy vending machines outside the premises of each outlet. According to the categorization of operational characteristics (Table 1), the enterprise would be classified as M(3+4)S(1+2+3): managing the candy mix and distributing customer orders; and receiving the orders and maintaining vending machines. The corresponding set of industrial processes can be retrieved top-down from the business process repository, and, as a consequence of the additive property of the process clusters, the operational modules can be easily combined to rapidly establish the confectionery manufacturer's business process model. The next stage would be the fine-tuning of the model by the manufacturer. This model is then process as the launch pad for the blueprinting stages of the ERP project. This generation process has been carried out in several organizations in Israel, and has been found to be highly effective.

5 Conclusion

The business functionality and process aspects of ERP have, to a large extent, been overshadowed by IT perspectives of ERP software and vendor industry-based perspectives of functional commonality. However, business process modeling and design is distinctly different from information system process modeling [3], and a specific enterprise does not necessarily conform to the paradigm proposed for the sector under which it is classified. From a business viewpoint, it is implicit that the process approach is applicable to almost any industry or enterprise – at least at the nominal level (naming functions and processes). However, the correct process suite for a particular enterprise can only be assembled by careful consideration of operational characteristics;

if this is done correctly many classical customization problems can be avoided. Our investigation has demonstrated the tenability of this assertion, and has shown that such models can serve as rich tools for understanding enterprise functionality in general, and, specifically, those classed as business, manufacturing or service. It has been demonstrated that the method described in this paper significantly facilitates the design and construction of individualized process models, starting from the questionnaire, through focused model generation, and the fine tuning of the generated model. Each step has been found to contribute significantly to that following, so that a minimum of extraneous processes, at all levels, needs to be taken into account for elimination. The challenge for further research is to improve the predictive capabilities of the model (top-down stepwise generation) first by extending the metamodel representation level, and next by increasing the accuracy of the correlation between operational characteristics and corresponding business processes incorporated into the model.

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