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A Mass Customization Approach to Business Process Modularization

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***Abstract*—The capacity of organizations to deal with changing market and societal conditions becomes an important success factor. This property reflects on the way the modus operandi of an organization is organized. Based on a real-world case study, we outline a method that integrates mass customization as an organization concept from industry with an analysis of the foundational elements that constitute business processes. The purpose of this exercise is to explore if such method contributes to business process flexibility through a rigorous modularization of these processes. Its 'parts and patterns' approach results from a deliberate engineering attitude, whereby business operations, business information systems and information technology are operationalized based on a single architecture. The paper proposes a business process elements catalog as a facility to search and employ process constructs, thereby supporting their reuse. In doing so, the goal of this paper is to make the first step of a larger, three-step design science research effort into the support of business process modularization through mass customization.**

Keywords— business process engineering, business process flexibility, business process integration, foundational process elements, process constructs, mass-customization, modularity

I INTRODUCTION

Advancements in information technology and tele-communications take down barriers that traditionally separate market territories. As a consequence, the character of competition changes in its reach over geographies as well as over industry and knowledge domains. The value-generating capacity of many enterprises needs rethinking and their core competence needs new expression. The notion of core competence is linked to the quality of the output of the organization as well as to the capacity to deal with rapid changes in conditions. Market and distribution turbulence put new demands on this capacity, usually referred to as business agility. Agility [1], as a notion of flexibility, covers all aspects of the organization: human, digital, mechanic as well as organizational.

Lately, and again facilitated by technology advancements, commercial organizations not only want to improve internal flexibility but also enter into dynamic inter-company forms of collaboration presenting multi-vendor offerings to the marketplace [2, 23, 24]. Within this spectrum, business processes structure the value delivery activities of the networked offerings resulting in additional requirements to the capacity to maneuver in a flexible way. This capacity finds its expression in the ability to quickly change the structure of processes while maintaining integrity of execution. We refer to this property as modularity [3], a notion that we, in the context of our research, use exclusively for the capacity to deal with change as a dominant construction and engineering requirement in shaping the modus operandi of the firm.

Given the challenges that are experienced with respect to the operational structures of an organization, this paper develops an approach to business process design and construction that aims to improve operational flexibility. The basic idea is to enable process modularization, using foundational business function building blocks (BFBBs) and related engineering principles to construct business processes in a flexible yet rigorous way.

Concepts of mass-customization as employed in industrial organizations are used. There, the articulated use of standardized parts and patterns has supported intra- and inter-organizational resource-sharing [4]. Lessons learned there well apply in the design and construction of business processes supported by information systems. It is in this context that we name the method we develop Business Process Mass Customization (BPMC), "exploring essential elements of form and function" [5]. The method is the main artifact resulting from our work, developed to acquire and use knowledge and understanding of agile business process behavior.

Concepts of parts, of patterns and of a single engineering architecture stand central in this paper. Developing a parts concept starts with the identification of atomic process elements. We refer to these as primitives. Primitives are used to shape process constructs at different levels of aggregation. Primitives and constructs together are referred to as business function building blocks, abbreviated as BFBBs. The identification and elimination of functional redundancy is an important consideration here. BFBBs are standardized to support multi-applicability, behave domain-agnostic at the lower levels of aggregation, and are fit for sheer endless reuse. A conceptual model is the basis for structuring the design of our method.

Given the number of business process constructs that may appear in a business domain, the development of a catalog of these BFBBs is fundamental to the introduction of our concept. The catalog stores and structures the collection of building blocks to maintain integrity of application and to facilitate search and employment.

The structure of this paper is as follows. The way we position our knowledge area of interest is presented in Section II. We outline in a schematic way the content and boundaries of the elements that constitute the functioning of an organization, the role that business processes as formal structures play in this configuration of concerns as well as the boundaries of this research. In section III, we summarize well-knowns problems in aligning business operations, information systems and information technology and suggest an approach to de-complexing entangled structures. Section IV introduces our approach to the definition of atomic, reusable modular constructs. In Section V, we develop the concept of a catalog of reusable building blocks and constructs thereof. In section VI, the creation of a catalog prototype is illustrated by introducing a detailed, real-world business case. This case shows how a catalog of BFBBs grows while going through the design iterations of this case study. Section VII presents conclusions, the limitations that apply to our work at this stage, and a brief outlook onto future work.

II A CONFIGURATION OF CONCERNS

The eco-system surrounding organizations today is much influenced by changing technological capabilities and the ensuing enlargement of markets and distribution dimensions. This phenomenon does not only affect the immediate operations of the firm, but also affects the way lawmaking bodies, supervisory institutions and the general public look at the functioning of these organization. Hence the three main concerns for senior management in many organizations, for profit as well as not-for-profit, are:

- Value contribution,
- Quality of operations,
- Compliance with regulatory and supervisory stipulations.

As a consequence, issues like accountability and predictability are a major concern for senior management. Predictability requires formality and this means that more than in the past, the operations of the organization need to be organized in such a way that, next to desiderata with respect to performance (value delivery, agility), predictability gets valued as a necessary attribute. Predictability requires a structured way of working. And given the many factors that are involved, coming from many directions, more than ever the availability of a business operations architecture, a knowledge domain that supports clarity in complexity, is a board room concern. Not only the immediate operations of organizations are affected by technology and globalization, but also the institutions that regulate markets and exercise supervision over organizations and institutions have developed a level of sensitivity for the quality of management and operations, the lack of which can have a serious negative impact on standing and financial resources or organizations.

We understand business operations architecture to be the structured representation of all elements that are active in an organization's eco-system. Alter has used this eco-system in his work system method as a meta-model of these elements [6]. His work system includes formal as well as informal activities. Formal activities in an organization can be specified ex ante, rationalized and designed. As such they allow to be shaped according to system principles and can be addressed as a system. Unfortunately, informal activities cannot be formulated ex ante. They refer to the study of arguments in ordinary language about attitude and behavior of people, to elements of motivation and atmosphere, to culture and style and to the process of judgment and appreciation, all not easily captured in a systems definition. This holistic approach to the properties and boundaries of an organization is not new. Dietz et al infer "that a viable theory and methodology for enterprise engineering must be able to address all relevant aspects, even those that cannot be foreseen presently, in a proper integrated way, so that the operational enterprise is always coherent and consistent whole" [7].

Both formal and informal activities relate to the three main concerns for management as mentioned above and arguing about a business operations architecture needs to include these activities in an overall framework that positions the main elements of an organization's eco-system. Such a framework supports an overview of the organization in its major functions and allows zooming in and zooming out for purposes of analysis and design. Our overall framework is shown as a two-dimensional grid in Table 1. We discuss the two dimensions below.

The *views* dimension of the framework represents the three main operational aspects of the organization. *Formal operations* and *informal operations* represent all activities undertaken in the organization [6]. A value delivery view is added to ensure that at all levels of design and specification, the ultimate purpose of organizational activities, the contribution to the value delivery mission, is addressed.

Table 1: Framework for Analysis

		views		
		Informal operations	Formal operations	Value delivery
perspectives	Enterprise domain definition			
	Industry sector	1	2	3
	Mission	4	5	6
	Strategic definition			
	Context	7	8	9
	Strategy	10	11	12
	Tactical definition			
	Structure	13	14	15
	Application	16	17	18
	Implementation	19	20	21
	Operational definition			
	Management	22	23	24
	Operations	25	26	27
	Oversight & compliance	28	29	30

The *perspectives* dimension provides the main lenses and sub-divisions for analysis, design and, where applicable, for construction. The use of a sub-division in strategic, tactical and operational perspectives is well known as a way to distinguish between planning horizons of an organization [25]. We have added the *enterprise domain definition* perspective to ensure that all subsequent perspectives are applied considering the fundamental character of the organization, i.e., the direction that results from the *industry sector* (i.e., the *domain*) perspective properties as well as from the *mission* perspective properties of the organization.

The numbers in the cells of the grid are merely included for reference purposes. The construction mission adopted in this paper results in a focus on the *formal operations* view shown in Table 1. Formal operations are expressed as business processes (typically defined as tactical specifications). In natural language, this means that we analyze the structure, the application and the implementation of all formal structures in the organization with the purpose to design, construct and use business processes. This positioning defines the focus of our research on the Cells 14, 17 and 20 presented in Table 1. But we develop our research being aware of the full context that is given in the framework for analysis in its entirety, i.e., all cells of Table 1. Even in developing formal structures we remain aware of the many context factors that have an impact on the ultimate success of the organization.

III UNTANGLING KNOTS

Trends, summarized in the introduction to this paper, result in many opportunities for new businesses, but put strains on existing operations. These strains result from the complexities of a traditional way in organizing the modus operandi of the firm. In the context of this paper, it must suffice to state that the operational mechanisms in many organizations have trouble in coping with the depth and tempi of the current technology and market developments. Not seldomly, the inability to act resides in sub-standard information systems and technology. A root cause of this inability is the way the three knowledge domains in the heart of the operation interact. We illustrate this in Fig. 1.

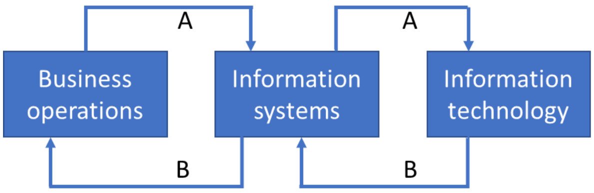

Figure 1: Knowledge domains interacting

In Fig. 1, *A* represents the transfer of requirement specifications and *B* represents the delivery of functionality. The problem is well known. Three knowledge domains, three problem languages, three professional attitudes do not get easily aligned. Next, in current practice, operational requirements, information systems and software constructs are to a large extent interwoven processes of mutually interactive objects and operations on objects. They are interwoven not only in the desired functionality but also in the actual design and construction of processes [8]. This interactivity is also referred to as combinatorial effects. Mannaert et al. qualify a "combinatorial effect to be the consequence of dependencies between multiple modules in an information system that cause a change to a specific module to have an impact on other modules that are – in principle – unrelated to the original change" [9].

Unfortunately, many information systems show these effects caused by:

- ambiguous, incomplete and inconsistent requirements specifications,
- the use of information systems and software languages not strictly separating objects from operations on objects,
- computer operating systems and support routines that create lock-ins,
- individual choices by designers and engineers with respect to IS and IT construction.

The resulting information system usually is difficult to operate and to maintain, which we refer to as *digital concrete*. If changes are required this results in costly and cumbersome software operations, untangling Gordian knots and introducing new ones [10]. Once changes have been made to the system, things get even more complicated and the effort required to further adapt such a system increases over time [11].

A novel approach to this problem is proposed by rigorously un-complexing the current way of working. This un-complexing results from three construction principles. The first principle is the identification of atomic process elements that are foundational to business process structures and can serve the requirements and particulars of the three interacting domains of Fig. 1. The second principle is to build all aggregations of functionality from the same atomic process elements. The third principle is to parameterize consequently all interactions between process elements. These principles together constitute the basis for the architecture and engineering principles of our BPMC method. In this paper we focus on the first principle, as this is the basis for the other two.

IV REUSABLE MODULAR CONSTRUCTS IN BPMC

In this section, we introduce the notion of reusable, modular business process constructs that form the basis of the BPMC method.

A The concept of BPMC

A cornerstone in developing BPMC is the recognition of a fundamental definition of the organization, emulated from General Systems Theory [12]. In this definition the organization is a system of input-transformation-output primitives with value creation as the unifying goal. Porter uses this concept of the value chain and his reference to the physical and distinct activities that a firm performs as a vehicle to explain the potential of differentiation to maximize the performance of the firm [13]. According to Porter, a value chain "disaggregates a firm into its strategically relevant activities to understand the behavior of costs and the existing and potential sources of differentiation". Activities drive the value generation mechanism of the firm and shaping activities for the construction of this functionality is the object of this paper. Business processes, then, are the formal expression of the value-generating activities of an organization.

A second fundamental concept in developing BPMC is the mass customization organization approach. The concept of mass customization [4] is an industrial organization concept, mostly applied in the process of physical production. It is generally known as an industrial organization concept that moves the coupling of client requests with specifications of the production process towards the point of delivery. The construction characteristics of this approach result in the identification of individual parts and the functional and physical interrelation between these parts expressed as assemblies. Parts, the engineering principles that result in patterns of functionality and an architecture that allows the build-up of more complex functionality, using these parts and engineering rules characterize this way of working. Standardized parts specifications and engineering principles find intra-company as well as inter-company application, and support specialization and economies of scale. A well-known example is found in the automotive industry where the end-product of a specific brand usually is a build-up of parts from a variety of suppliers that also deliver to the competition. The concept allows modularization in production processes and supports operational flexibility.

Business process design and construction in the traditional sense of expressing a domain and organization-specific way of working have difficulty in dealing with the current business dynamics. It is for this reason that the applicability of the mass customization concept in the structuring of business operations and related information systems gets attention.

Striving for 'near mass production efficiency' in an industrial environment implies a quest for economies of scale that can be reached by the production of sizable quantities of output units that are multi-applicable as a consequence of being standardized. Variety then is the result of combining standardized parts via the implementation of standardized engineering principles. Rigorously applied this means lower production costs and a better response to client demands. This mass customization concept, once applied in information systems construction, requires the availability of a similar standardized parts concept and similar standardized engineering principles. Its application addresses the requirements for flexibility and adaptability, properties of information systems that are much in demand.

There are useful communalities between the use of a mass customization approach between applications in physical industry and in information systems design and construction. One of these is the use of architectural concepts and tools as a means to properly deal with organizational complexities. A rigorous abstraction of products and/or services into foundational parts combined with the many instances of constructs (assemblies) from these parts results in a multitude of elements that need to be managed. The architecture knowledge domain offers insights and tools both to industry as well as to the organization of business operations.

But there are also differences that are noteworthy between mass customization in manufacturing and in information system development. For example, parts used in an industrial process get depleted. Parts used in an information systems process do not get depleted but can be used over and over again. This adds to cost efficiency that may stimulate organizations to consider this approach.

B The concept of primitives and constructs

Organizations undertake activities. An activity refers to work executed in a collaboration for a value contribution. An activity can be simple and singular but also complex and multi-faceted. As we want to avoid complexity and variance in the properties of individual process elements, we defragment process cases as demonstrated in Section VI. In this way we identify atomic process elements: elements that do not vary with the properties of a process configuration. For these elements, we identify three classes of parts:

- Activities, expressed as a verb in the present tense,
- Data-objects, expressed as nouns in natural language, either as key-value pairs or as compositions of data referred to as documents, and,
- Resource-objects, being human involvement, material assets and financial assets.

We also identify two different engineering tools:

- Logic sets, operators, that apply to parts as in business rules, parts logic, process logic and user interface logic,
- Flow directives, directional graphs that interconnect parts according to a defined sequence pattern.

We infer that the availability of these five classes of process elements suffices to enable the specification of business processes through the definition of reusable process-oriented modules. In Section VI of this paper, we describe a case study as a first iteration of our approach. The results of this real-world business case underpin this statement.

We base our way of working on the conceptual model shown in Fig. 2 (represented as a UML class diagram). This model illustrates the shaping of business functionality by the definition of primitives and the composition of constructs from these primitives. By 'elements of form' together with logic sets and flow directives as 'elements of function' [14], two essential ingredients of a design method are given. The three main classes in our conceptual model, shown in the top of Fig. 2, are explained below.

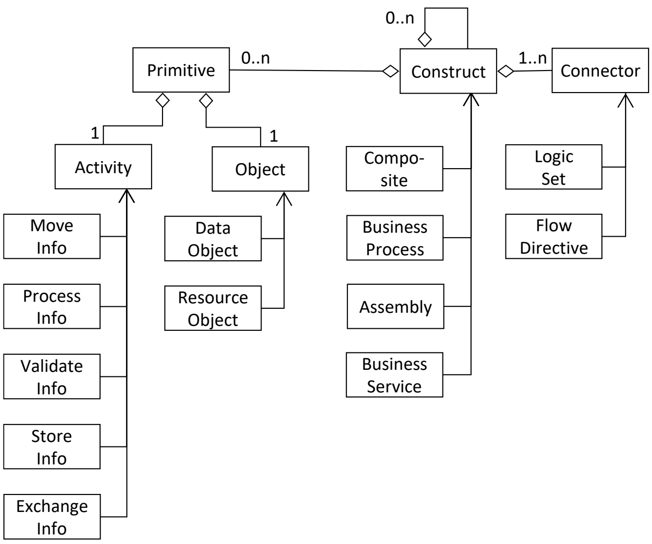

Figure 2: Conceptual Model

Primitives. Activities, specialized according to their role in the execution of a business function, get combined with either one data object or one resource object to constitute an atomic business function referred to as a *primitive*. This *primitive* is the atomic process element used to build all other compositions of functionality.

Constructs. More complex structures of functionality, referred to as *constructs*, are reusable process-oriented modules that express a pattern of functionality as required by the construction mission. These patterns are brought about by combining *primitives* with other *primitives* and/or *constructs* according to the design specifics, possibly using *connectors*.

Connectors. The connector elements *logic set* and *flow directive* are the instruments to bind individual process elements and to parameterize the functionality of the combinations (the patterns') of *primitives* with *constructs*. This structural parametrization enables dealing with the dynamics of business process operations.

C *The concept of architecture*

Although in practice, many different types of constructs may exist, four different levels of process complexity suffice to demonstrate the architecture of the granularity concept applied in BPMC. Fig. 3 shows how these four levels are layered on top of the basic level of the atomic primitives.

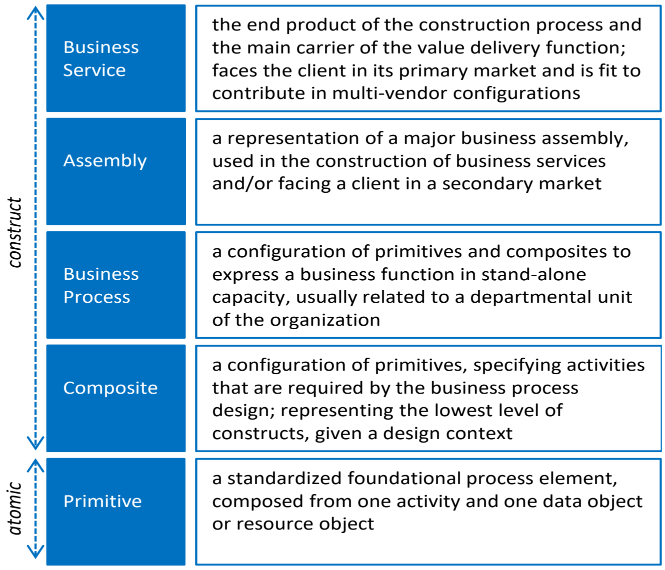

Figure 3: Granularity model

Table 2 shows in terms of cardinalities between element classes which aggregation rules apply in composing constructs. In natural language, the cardinalities that are listed in the table can be expressed as the following rules for proper composition of constructs:

- A *composite* contains at least two *primitives*.
- A *composite* contains no *business process*, *assembly* or *business service*.
- A *business process* contains at least two *composites*.
- A *business process* contains no *assembly* or *business service*.
- An *assembly* contains at least two *business processes*.
- An *assembly* contains no *business services*.
- A *business service* contains at least two *assemblies*.

Table 2: Relations between constructs in cardinalities

a ⇨ contains ⇩	primitive	composite	business process	assembly	business service
activity	1				
object	1				
primitive		2..n	0..n	0..n	0..n
composite	0		2..n	0..n	0..n
business process	0	0		2..n	0..n
assembly	0	0	0		2..n
business service	0	0	0	0	

In the BPMC method, all business process elements are eventually constructed from primitives. This means that one single architectural concept applies for all business processes that get constructed. Parts logic and process logic are logic types that parameterize the requirements from a business operations perspective with requirements from an information systems perspective and, ultimately, with requirements from an information technology perspective.

This is all used to the extent that is relevant for the process element under consideration. In that sense, this approach bridges the divides that traditionally occur between specifications from the business operations domain, the business information systems design and the information technology way of working (see Fig. 1). Conceptual and architectural differences that exist between these three knowledge domains are at the basis of information systems complexity in their construction as well as their application, quite often hampering modularity and the agility condition of an organization (i.e., forming the *digital concrete* that we have mentioned before).

D *Relation to existing approaches*

In developing business process research, the business process management knowledge community initially had its focus mostly on properties of business process design and construction issues for individual organizations. As in these organizations the number of structured processes grew substantially, the interdependencies between processes became relevant. In the research domain this resulted in numerous studies on interaction patterns and workflow modules [15]. Efforts were made to analyze and remedy interaction between different process modules with the aim to support interaction [16]. Delving deeper in process construction and behavior, issues like multiple instances, consistency checking, communication patterns, anti-patterns and error-handling [17] were covered.

The question arose if building and using these collections of processes could be economized by the re-use of process parts. This started a quest for multi-applicable process fragments, becoming visible as another research direction. In [18] process constructs are introduced as programmable entities that are multi-applicable over a range of process solutions. The work in [19] describes the use of proclets, weakly-connected interacting light-weight workflows as a method to overcome the limitations of monolithic workflows and to keep complex process structures understandable. The issue of sub-processes being collapsible and its contribution to understanding process models is the subject of [20].

The rise of multi-vendor platforms stimulated thinking about business process flexibility anew. These platforms combine vendors of individual services into an integrated client offering. This bundling of services requires bundling of operations and put new demands on business process construction and application. It represents another level of service engineering via the development of a service-dominant logic [21].

This development puts additional demand on the business process management profession, resulting in an increased demand for overview via process architectures. In [22] an analysis is given of the business process architecture landscape, which, in itself suggests an architecture of understanding.

V Organizing Modules into a Catalog

In this section, we show how we organize our reusable constructs in a catalog to make them usable in a structured design process.

A *The need for a catalog*

Central to the properties of the BPMC method is the development of a parts concept, referred to as business function building blocks (BFBBs), a pattern concept through the orchestration of parts in combination with engineering principles (logic and flow directives) and an architecture that shapes more complex business process modules from atomic parts (primitives).BFBBs come in all shapes and forms and that fact in itself asks for a structured approach to the issue of categorization. By definition, BFBBs are not only available for use and reuse by a single employee of a single organization. BFBBs can be employed cross-company, cross-industry, and cross-markets. This emphasizes the importance of structuring and managing the resulting collection of business process modules.

This BPMC design can be characterized as removing application-specific elements from atomic parts and moving the application specification to the pattern concept, i.e., to the orchestration formula to build functionality. The resulting effect is that atomic parts (primitives) are by nature application-agnostic and can be employed in whatever orchestration. As far as possible, we try to extend this even between application domains, such that primitives become domain-agnostic.

In traditional approaches to business process design, a domain-specific specification of business operations gets transformed into a domain-specific definition of activities and related items in a tailor-made ‘pattern’ of functionality to result in a unique and tailor-made business process construct. This is difficult to maintain and not easy to change. Buying business process modules in the marketplace can have advantages in this respect but may superimpose a certain way of working that not necessarily fits into the modus operandi of the buying entity.

B *The structure of a catalog*

Applying this way of working may well result in a substantial number of BFBBs. Not only this number of items asks for proper structuring. Selection and deployment must also be facilitated along search criteria that are multi-faceted, similar to the character of the patterns that result from design and construction. This asks for a well-structured design of a catalog.

C *Dimensions of the catalog*

In discovering and analyzing the spectrum of dynamic interaction between the BPMC artifacts, we use a cube model to depict the main dimensions of the catalog. This catalog cube is set up as a space in which we place the three main dimensions of specification. These dimensions relate to the perspectives of Table 1. They are shown in Fig. 4.

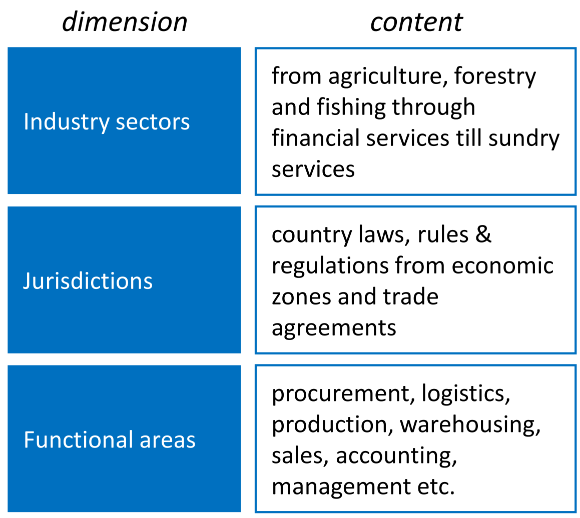

Figure 4: Dimensions of the catalog

The *industry sector* dimension describes in general terms the characteristics of the operations of all types of organizations. For The Netherlands, this is the SBI code (standard enterprise classification). With this classification comes the transfer of industry specifics to individual organizations. Some of these have an impact in business process specification.

The *jurisdiction* dimension represents laws, rules and regulations that apply on organizations within a specific legal domain. Stipulations from overarching authorities like the European Union or international trade agreements are supposed to be applied via the country laws and rules.

The *functional areas dimension* gives, per industry type, a general classification of functional domains within an organization.

We visualize our concept in a three-dimensional cube where each cell contains specific BFBBs, as shown in Fig. 5. Each cell in this cube contains the attributes of the BFBBs.

An important attribute is the building block identity. Each building block has a unique identification code that gives access to this item. The second important attribute classifies the building block according to its information processing characteristics. In our approach, we distinguish between five information processing class types:

- Information mover
- Information processor
- Information validator
- Information storage
- Information exchanger

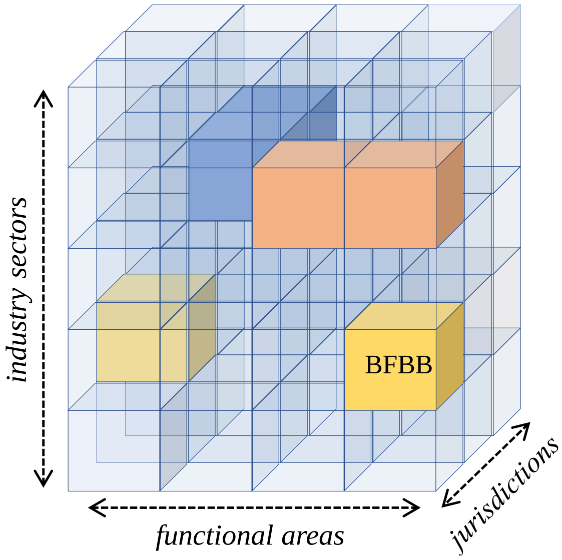

Figure 5: Catalog cube (adapted from [23])

Another attribute of the cell contains the building blocks as ready-made components, fit to be used in construction operations. The cell further contains attributes for the specification of the building blocks in a graphic form, the specification of the operational pattern of the blocks as in BPMN or a similar language to demonstrate its functioning including the applicable algorithm specification, as well as a manual that supports design, maintenance, and employment in business process constructs.

Users of the catalog will now be able, guided by the parameters of the cube's dimensions, to peruse through this virtual warehouse of modules for those building blocks they want to select for inspection, to use in construction or to adapt in a design process. The cube also facilitates the components' life cycle management.

VI CREATING A PROTOTYPE CATALOG

In this section we introduce a real-world business case that has provided the opportunity to observe and analyze the practical application of the BPMC concept. In Subsection A, we outline the application area of the business case. In Subsection B, we summarize the findings of the first exercise in discovering atomic process elements. We have matched our findings with domain experts to deepen our initial analysis in desk study 2, as discussed in Subsection C. This additional analysis includes our first study into the inter-company applicability of the atomic process elements identified. Subsection D summarizes our findings.

A The problem domain

In the Netherlands, national government operates a law (WMO-law) to regulate and fund the support for the elderly and citizens with handicaps. The purpose of the law is to enable people to keep control over their own life and to stimulate participation in social activities. This law allocates the execution of this citizens' service to municipalities. These are responsible for the provision of material support to citizens that qualify under the regulations. To facilitate the application of this law, operational manuals were distributed to the municipalities together with a set of architectural guidelines on operational matters and suggestions on handling IS and IT aspects[1].

At the introduction of the WMO-law, the government decided to issue a grant to a Dutch research group, composed of scientists and consultants, to study the experiences gained during the introduction and functioning of the new law. The briefing of this research party initially focused on aspects of software mass customization but was later on adjusted to concentrate on aspects of business process design and construction. The research mission was to search for, to identify and to categorize business process building blocks, fit for reuse and standardization. From the multitude of services that were covered by the new law, the research team decided to concentrate its work on the analysis of one specific service, being the delivery of wheelchairs to people with mobility handicaps.

Following the suggested structure as given by the national government, the research group started its work by studying the national guidelines to find that this wheelchair provisioning service was composed of 7 individual business processes. These were broken down in detail in a quest to understand the structure of these business processes. We looked at these from an activity perspective: what activities needed to be executed to deliver the required wheelchair service and what other process elements were involved to constitute a functioning process? From the, at that time, 400 municipalities in The Netherlands, 4 municipalities, varying in size and location, were selected to be involved in our case study. The case study was organized as part desk study and part interviews with managers and staff of the municipalities involved.

B Construction of the catalog step 1

The first desk study involved de-factorizing each of the 7 wheelchair business processes in the specification given as the national standard. In decomposing these, we made a distinction between single elements of functionality (primitives) and composites, process elements that have a more complex structure and contain more than one primitive. In total we found 84 primitives and 14 composites. Next, we analyzed each activity element to better understand its functionality and to compare this with apparently similar activities to be able to eliminate redundancies. Table 3 illustrates the results of this initial analysis.

Process elements were considered redundant when differences in wording in fact represented identical functionality. The table demonstrates that 1 composite and 46 primitives were found redundant. This means a substantial redundancy factor of 54%, which can be attributed almost completely to replicated primitives.

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[1]- EGEm , Architectuur Model gemeentelijke E-Dienstverlening, (www.vng.nl)
- NORA, Dutch Government Reference Architecture, (noraonline.nl)
- Startarchitectuur WMO 1.0 (kick-off architecture WMO) (Ministry of Public Health/CapGemini, www.nl.capgemini.com/publieke-sector)

Table 3: results of desk study 1

Business process	Desk study 1		Redundancy check 1	
	composite	primitive	composite	primitive
Intake	3	18	3	14
Screening	4	17	3	6
Indicating	1	8	1	4
Allocating	1	12	1	5
Application	1	8	1	2
Delivering	2	16	2	4
Man. Accounting	2	5	2	3
Totals	14	84	13	38

C Construction of the catalog: next steps

The next step in the case study was to meet management and staff of the municipalities selected to present our findings and ask for their comments. Although all municipalities involved were aware of the national standards issued, some of these municipalities decided, mostly for political reasons, to deviate from these standards and to apply proprietary business process specifications.

These alterations applied in the business processes *Screening* and *Allocating* (see Table 3). Based on this information, a new set of business process specifications for these two business processes was constructed, resulting in an overall picture of the wheelchair delivery processes as presented in Table 4.

Again, a substantial level of redundancy was found: the actual number of primitives used can be reduced by 58% by removing functionally replicated primitives.

Context bound

Analyzing the desk study, we found that the qualification of an activity as a primitive at this stage of our research is context-bound, i.e. depending on the view taken during decomposition.

Table 4: results of desk study 2

Business process	Desk study Feature preference		Redundancy check 2	
	composite	primitive	composite	primitive
Intake	3	18	3	14
Screening	5	25	4	2
Indicating	1	8	1	4
Allocating	2	12	2	6
Application	1	8	1	2
Delivering	2	16	2	4
Man. Accounting	2	5	2	3
Totals	16	92	15	39

For example, *MakeDelivery*, a primitive that appears in the wheelchair delivery business process, may well consist of subordinate activities. This detailed level of specification, however, was not required in the design of the *MakeDelivery* activity as it was observed at that time. It does not add functional meaning at the required level of specification. A change in context, in this case meaning a more detailed lens in analyzing the *MakeDelivery* activity, could well result in the identification of smaller activities like *check entitlement of client*, *check specification of wheelchair allotted*, *check storage position*, *get wheelchair from storage* and *get client to sign for receipt*. In this way, we demonstrated that the qualification of a primitive as atomic depends on the point of view taken. It also became clear that many business process elements either carried different names for a similar process step or carried identical names for quite different action.

This situation did not comply with our ambition to identify those atomic elements of functionality (primitives) that under no circumstance would vary with a view of the beholder or a change in functional environment (another business process). To avoid confusion about the character of a primitive we make a distinction between the use of primitives in a design environment and their use in a construction environment. In a design environment the use of primitives as a notion is context bound as explained above. The use of primitives during the construction of a business process or parts thereof is interpreted in its absolute sense as atomic process elements that cannot be dissected further without losing their functionality.

Broadening the scope

As a last step in this quest for process elements properties, we compared three business processes from the banking industry with three processes from the WMO wheelchair business case and three processes from a trading firm. The purpose of this investigation was to explore if primitives from one specific industry could also be applied in other industries.

Table 5 shows the results of the comparison. We depict three processes for each of the three industries. The first business process (Bank GSP) uses 10 primitives and, as a consequence of being the first case in the analysis, 10 of these are new primitives in this survey. The second business process requires the availability of 11 primitives, 7 of which are new ones. The other 4 primitives were already available from the first process. The third banking business project uses 10 primitives of which 5 are not previously used. We observed a decreasing pattern.

Table 5: inter-industry redundancy analysis

Industry sector	Business process	Total primitives	New primitives
Bank GSP	staff support	10	10
Bank GMP	process modif.	11	7
Bank GIP	implementation	10	5
WMO	screening	13	6
WMO	allocation	10	2
WMO	delivery	9	1
Trading Cy	procurement	15	7
Trading Cy	complaint	12	4
Trading Cy	distribution	9	2
Totals		99	44

The next business process (WMO Screening) uses 13 primitives. Of these 13 primitives, only 6 are new and 7 primitives were already available as they were being used in the banking business processes.

This pattern applies similarly through the other WMO business processes and continues also for the trading company's processes. Analyzing more business processes indicates that fewer BFBBs that are found can be classified as new. We also conclude that on the level of primitives, process elements "travel" over barriers of function and of industry. To what extent they also would be applicable in other jurisdictions (see Fig. 4) needs further investigation.

D Analysis and learning

Working on this research topic in a hands-on situation was useful in understanding the practicalities that one experiences in implementing a generic approach to business process design in an organization. We made several observations.

The first observation is general in character and relates to the use of guidelines, instructions and policy directions as issued by the national government. It shows from our interviews that local management and local employees only used these guidelines when they fitted into their perception of local adequacy and at the levels of professionalism available. Also, the policy directions given by local management on the level of individual communities played an important role in the level of adoption experienced. We concluded that bringing the local expertise on a level that would allow to deal with process structures in conformance with national standards would require a substantial upgrade of local skills and expertise. It was beyond the brief of the research group to deal with this issue.

Our second observation is that, although the problem area is similar in all municipalities, tradition and local preferences influence the modus operandi in the problem domain in a substantial way. Hence we see the need to offer tools that allow modularity on the levels required (and allowed) by local circumstances.

Our third observation is that, notwithstanding local differences, there is, below these layers of (pretended) domain specifics, a substantial amount of communality in parts and patterns used, resulting in a substantial redundancy factor. This observation stimulated us to pursue this issue to be the focal point in our research.

The availability of fully operational process systems that offer enough flexibility to cater to local requirements would potentially un-lock a threshold of process efficiency that other factors in this case prohibit to expose and use. It is the awareness of those non-formal or 'softer' conditions next to the 'hard' specifics of a formal business process specification that makes us advocate (Section III) to consider those other factors that influence the ultimate results of a design and construction investment. Hence we advocate the inclusion of business operations goals next to these from the IS and IT domains.

VII CONCLUSIONS AND FUTURE WORK

In this paper, we have investigated the use of reusable, atomic business function building blocks for constructing business processes. In the context of a design science research effort, we have taken a first step in the development of an artifact that, ultimately, as a method should contribute to de-complexing entangled process structures that hamper business agility. The quest for atomic building blocks (both in intention, i.e., the structure of building blocks, and extension, i.e., concrete sets of building blocks) requires an adequate level of abstraction of organizational processes – abstraction therefor is a main technique in the development of our approach.

We found in our case study that these atomic process elements can be identified and that the use of these does indeed result in reducing redundancy in both the intra-company as well as the inter-company scopes. The first contours of an industry-specific smallest common denominator of building blocks appeared in our analysis. The level of redundancy that showed in our case study indicates a substantial level of overlap in current designs of business processes. This overlap is manifest on the level of primitives and as primitives in this method-to-be are the atomic elements from which all other constructs are built its properties also dominate process architecture. As such, they may develop as a foundational element in the foreseeable internet toolbox of business process design and construction. This development stimulates the construction of process modules that, speaking the same engineering 'language', are either already multi-applicable or are easily adjusted to be so. If so, intra-company and inter-company application of our approach may enable new levels of collaboration and flexibility.

This paper is the start of a broader project that deals with the limitations that apply in the above. The interaction between process elements resulting in patterns needs to be explored in depth as is the question of domain-specific orientation. In what elements does this process property reside? Although the notion of a single and comprehensive architecture to build modularized business functionality is briefly mentioned, this topic needs to be expanded before grounded conclusions with respect to validity and utility can be made. Future work will focus on the limitations mentioned above. Ultimately, our objective is to explore the possibility to combine an "open" process architecture with a dedicated application in business operations. To that end we will include additional case studies and the involvement of practitioners to ensure a real-world-oriented method.

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