*Enterprise Information Systems*
Vol. , No. , , 1–30

# RESEARCH ARTICLE

# Business Process Architectures: Overview, Comparison, and Framework

(*Received 00 Month 200x; final version received 00 Month 200x*)

With the uptake of business process modeling in practice, the demand grows for guidelines that lead to consistent and integrated collections of process models. The notion of a *business process architecture* has been explicitly proposed to address this. This paper provides an overview of the prevailing approaches to design a business process architecture. Furthermore, it includes evaluations of the usability and use of the identified approaches. Finally, it presents a framework for business process architecture design that can be used to develop a concrete architecture. The use and usability was evaluated in two ways. First, a survey was conducted among 39 practitioners, in which the opinion of the practitioners on the use and usefulness of the approaches was evaluated. Second, 4 case studies were conducted, in which process architectures from practice were analyzed to determine the approaches or elements of approaches that were used in their design. Both evaluations showed that practitioners have a preference for using approaches that are based on reference models and approaches that are based on the identification of business functions or business objects. At the same time, the evaluations showed that practitioners use these approaches in combination, rather than selecting a single approach.

**Keywords:** Business Process; Business Process Architecture; Business Process Model; Enterprise Model; Case Study

## 1. Introduction

Despite relentless advances in IT (Chui *et al.* 2013), organizations struggle to create value and improve their business processes. Process models turn out to be a helpful tool to improve the understanding of current business operations and are often used as a foundation for improvement initiatives (Indulska *et al.* 2009). Yet, any organization that engages in modeling its business processes, inevitably encounters questions. Which processes exist in my organization? Where does one process end and the other begin? At what level of detail should these processes be modeled? These questions are especially relevant when an organization's interest in its processes results in a collection of hundreds of process models. Consider, for example, the SAP Reference Model (Curran and Keller 1999), which consists of 604 process models, the reference model for Dutch municipalities (Sdu Information Solutions 2013), which consists of over 400 process models, and the IBM Insurance Application Architecture process models (Huschens and Rumpold-Preining

ISSN: 1751-7575 print/ISSN 1751-7583 online

DOI: 10.1080/1751757YYxxxxxxxx
http://www.informaworld.com

2006), which currently consists of over 250 models. Several authors have proposed the notion of a *business process architecture* to address questions like the ones we mentioned, including Green and Ould (2004, 2005), Joosten (2000), Koliadis *et al.* (2008) and Scheer and Nüttgens (2000). Such an organized overview of the processes that exist within an organizational context, along with the guidelines on how the related models should be organized, is what can help individual modelers to arrive at a consistent and integrated collection of process models. However, the introduction of a business process architecture clearly begs the question of *how* in any given situation it should be established.

Given the variety of views on how to design a business process architecture, we identify a lack of understanding of the differences between these views and uncertainty among business users to make the right choices. Yet, it has been recognized that not any business process architecture is equally effective. In a recent blog post, for example, Derek Miers notes how some process architectures may actually impede on the process-centered line of thinking that was behind the initiative to model process in the first place[1].

This paper aims to fill the identified gap by investigating which approaches and guidelines to create a business process architecture exist, which of these are considered most useful in practice and how they are actually applied in practice. In pursuing this aim, we focus on the conceptual, modeling-related, challenges involved in organizing a business process architecture, rather than the organizational or socio-political issues that play a role in the effective use of process models. More precisely, the paper offers the following contributions:

(1) An overview of the design approaches and guidelines that can be used to design a business process architecture.
(2) An exploratory comparison of the use and usefulness of these design approaches and guidelines in practice.
(3) A framework that is aggregated from existing approaches and that can be used as a basis for structuring a process architecture.

To arrive at these contributions, first, a structured review of existing literature has been conducted. This review led to an overview of the design approaches, as well as an overview of the guidelines and structuring principles that these approaches propose to create a process architecture. Next, the use and usefulness of the different design approaches in practice has been explored through a survey that was conducted in a workshop session with 39 practitioners. This collection of opinions illustrated that practitioners rely on a hybrid combination of approaches, rather than a single approach. This result led us to investigate the particular combinations of approaches, guidelines and structuring principles that are mostly used in practice, by investigating process architectures from practice in four case studies. Based on an analysis of the results from the evaluation, an overview of the most commonly used structuring principles is presented in the form of a framework. This framework can be used as a basis for structuring a new process architecture. Although the guidelines and the developed framework remain to be proven in practice, we argue that they are more than subjective statements because they are derived from literature and two more in-depth studies.

The remainder of this paper is structured as follows. Section 2 presents a precise description of what a business process architecture is. Section 3 presents and compares the approaches to designing a business process architecture, as identified in literature. Section 4 presents a survey-based evaluation of the use and usefulness of these approaches

[1]See `http://bit.ly/fBnfzI`, Accessed January 31, 2014

and the guidelines and structuring principles that they propose. Section 5 presents a case study-based evaluation of how approaches and their related principles are used to design process architectures in practice. Section 6 analyses the results of the empirical evaluations and proposes a framework for structuring process architecture, based on this evaluation. Finally, Section 7 presents related work and Section 8 concludes this paper.

## 2. Business Process Architecture

We define a business process architecture as an organized overview of business processes that specifies their relations, which can be accompanied with guidelines that determine how these processes must be organized.

A business process architecture can serve as a tool to design a structure for the processes that exist in an organization, before those processes are designed in detail. In this way, it can be used to help determine which processes exist and where one process ends and the next process starts. For that reason, it is typically designed before the processes themselves, however, if it is kept up-to-date with changes to the individual processes, it can also be used as an overview of all the processes that exist in an organization.

Purely for illustrative purposes, Figure 1 shows an example of a business process architecture in the ArchiMate notation (Lankhorst 2005). The figure shows a collection of business processes, represented by the rounded rectangles with the arrow icon, as well as the various relations that exist between these business processes.

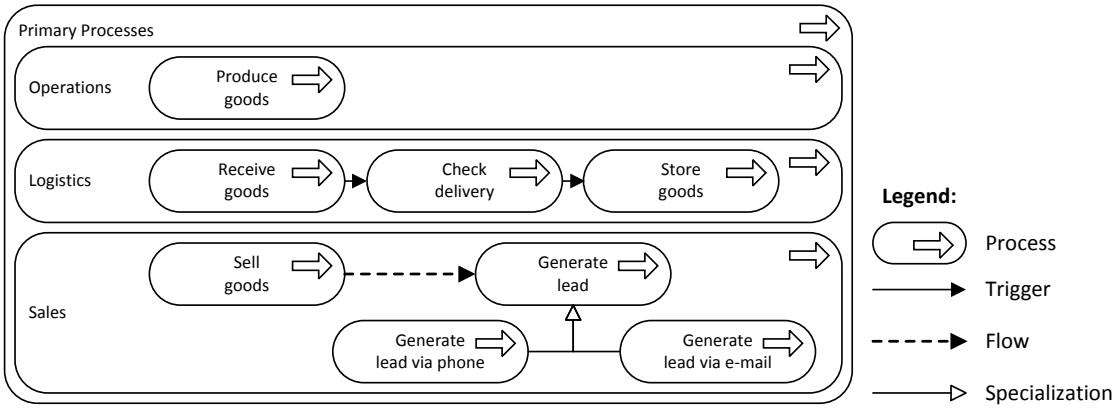


Figure 1. Example Business Process Architecture

There is no consensus about all the potential relations that exist between business processes. However, as Section 3 will show, the following types of relations are frequently used throughout the literature. The *decomposition relation* expresses that a process is decomposed into multiple subprocesses. In Figure 1 this relation is represented by the graphical containment of subprocesses within the parent process. The *specialization relation* expresses that one process is a specialized version of another. In Figure 1, this relation is represented by an arrow with an open arrowhead. The *trigger relation* expresses that the execution of one process can trigger the execution of another. In Figure 1, this relation is represented by an arrow with a filled arrowhead. The *use relation* expresses that one process provides services that are used by another. In Figure 1, this relation is represented by a regular arrow.

A business process architecture can be enriched by 'containers', such as layers or

columns, along with guidelines for which processes can be contained in a particular container. For example, a distinction can be made between containers for primary and support processes (Porter 1985). The container for primary processes can only contain processes that directly add value for the client; the container for support processes can only contain processes that do not directly add value, but are necessary for the effective operation of the primary processes.

## 3. Business Process Architecture Design Approaches

There are a number of approaches to design a business process architecture. This section presents a classification of the different approaches that we identified through a literature study.

The literature study was performed using the keywords 'business process architecture' and combinations of the words 'business process' and 'identification', 'delimitation' or 'demarcation'. *Google Scholar* was used initially as a source. For each approach that was found, references and citations were used to further identify approaches. As a result, 45 approaches were identified. Of these approaches 30 originated from a survey by Fettke *et al.* (2006) specifically aimed at the topic of using reference models to design a business process architecture. We validated the completeness of our results by using additional sources, in particular: *Scopus*, *Web of Science*, *Inspec*, *ABI/Inform*, *IEEE Electronic Library*, *ACM Digital Library* and *Springer* (in that order). *Scopus* and *Inspec* both returned one additional approach, but after that no other candidates were found. Reference and citation analysis of the two additional approaches returned one more approach, leading to a total of 48 approaches to design a business process architecture. The precise protocol is given in Appendix A.

The approaches that were collected in this manner were subsequently classified by answering the question: 'On what basis are processes and their relations identified according to this approach?' This led to five classes of approaches: goal-based, action-based, object-based, reference model based, and function-based. Table 1 shows this classification. In each approach (or class of approaches), a business process architecture is designed by first designing another structure, e.g. a goal structure. Such a structure should be designed in terms of the concepts and the relations prescribed by the respective approach. A business process architecture is subsequently designed based on that structure.

In the remainder of this section we discuss each of the five classes of approaches in more detail.

Note that the approaches are not necessarily mutually exclusive. For example, a reference model-based approach can group business processes according to the business functions that they implement. Thus, it essentially combines a reference model-based and a function-based approach. In particular the approach by Damij and Damij (2009) proposes a combination of different structures as a starting point for identifying business processes, see. When an approach fit into multiple classes, we used the class that best described the approach. This was possible, because, except for the reference-model based approach, all approaches started from a single structuring principle.

### 3.1. *Goal-based*

**Brief description.** In goal-based approaches (Antón *et al.* 1994, Koubarakis and Plexousakis 2002, Lee 1993, Kavakli and Loucopoulos 1998, Yu and Mylopoulos 1994, Lunn

Table 1. Classification of Business Process Architecture Design Approaches

| **class approaches** | **structure** | **organizing concept** | **concept relations** |
|---|---|---|---|
| **goal-based**<br>Antón *et al.* (1994)<br>Koubarakis and Plexousakis (2002)<br>Lee (1993)<br>Kavakli and Loucopoulos (1998)<br>Yu and Mylopoulos (1994)<br>Lunn *et al.* (2003) | goal structure | goal (various subtypes) | various associations including:<br>- realization (inclusive, exclusive)<br>- influence |
| **action-based**<br>Medina-Mora *et al.* (1992)<br>Lind and Goldkuhl (2003)<br>Lind (1997)<br>Dietz (2006)<br>Auramäki *et al.* (1988)<br>Johannesson (1995) | action structure | action loop (various subtypes) | various associations including:<br>- decomposition<br>- triggering<br>- phasing<br>- specialization |
| **object-based**<br>Green and Ould (2004)<br>Joosten et al. (2002) | object model | business object (various subtypes including:<br>- permanent object<br>- case object) | various associations including:<br>- decomposition<br>- state transition<br>- specialization |
| **reference model based**<br>survey: Fettke *et al.* (2006) | classification | class (various subtypes including:<br>- business function<br>- industry segment) | decomposition specialization |
| **function-based**<br>Scheer and Nüttgens (2000)<br>Aitken *et al.* (2010)<br>Eertink *et al.* (1999)<br>Aronson (2008) | function hierarchy | function | decomposition |

*et al.* 2003) a goal structure, which consists of business goals and relations between those goals, is designed first. Subsequently, a business process architecture is derived from it, based on the definition of a business process as a collection of related activities to achieve a certain *goal*. Figure 2 shows an example of a goal structure and a business process architecture that is derived from it. The benefit of using the goal-based approach is that associating goals with processes also helps to determine *why* certain processes are important or at all needed.

**Organizing concept.** The main organizing concept in goal-based approaches is the 'goal', but different approaches distinguish different types of goals. Antón *et al.* (1994) provide an extensive discussion of different types of goals that can be identified. Subsequently, they show that focusing on different types of goals leads to a different goal structure and, therefore, potentially to a different business process architecture. In addition, different types of goals may be translated differently into processes when a business process architecture is constructed (Yu and Mylopoulos 1994).

**Concept relations.** Different goal-based approaches also distinguish different types of relations between goals. Four of the approaches within this class consider a *realization* relation between goals, which expresses that a (higher level) goal can be achieved by achieving the (lower level) realization goals being related to it (Antón *et al.* 1994, Koubarakis and Plexousakis 2002, Lee 1993, Kavakli and Loucopoulos 1998). Kavakli and Loucopoulos (1998) also distinguish the *influence* relation between goals, which expresses that one goal influences another goal. Lee (1993) allows the modeler to freely

define the types of relations that can be considered within a goal structure.

**Deriving a process architecture.** Goal-based approaches differ significantly in how they relate a process architecture to the goal structure. Lee (1993) defines a relatively strict relation between goals and sub-goals and processes and subprocesses, stating that if goals are related, the processes that help realize those goals must be related too. Koubarakis and Plexousakis (2002) and Kavakli and Loucopoulos (1998) state that goals can be used to identify processes, but do not make statements about how relations between goals influence relations between processes. Antón *et al.* (1994) and Yu and Mylopoulos (1994) relate processes only indirectly to goals (i.e. via other concepts).

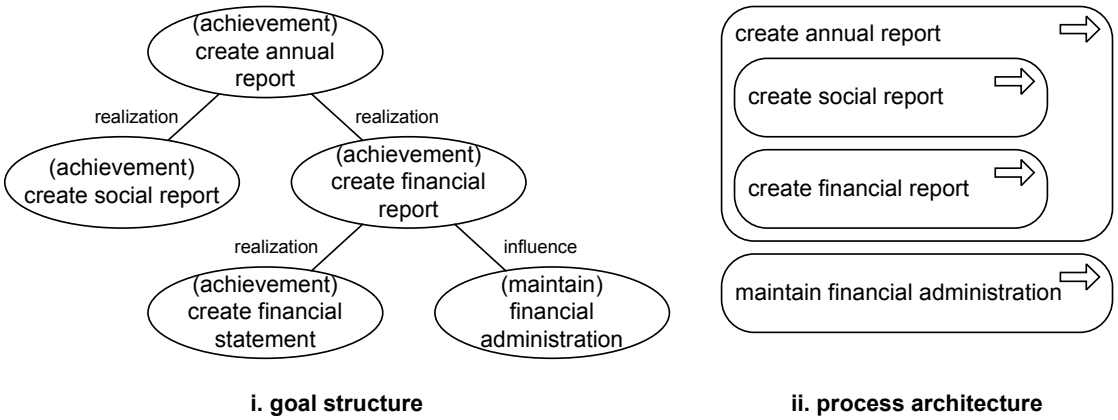


Figure 2. Example of Goal-based Design of Process Architecture

## 3.2. *Action-based*

**Brief description.** In action-based approaches (Medina-Mora *et al.* 1992, Lind and Goldkuhl 2003, Lind 1997, Dietz 2006, Auramäki *et al.* 1988, Johannesson 1995) an action structure, which consists of business actions and their relations, is designed first. A business action is an activity loop in which a provider completes some work for an internal or external customer. Thus, by definition, it is very similar to a business process. The main difference between a business process and a business action lies therein that business action theory assumes that all human action, and therefore also business action, follows certain standard patterns and phases. This makes business action theory particularly suitable for identifying processes, delimiting those processes (i.e. determining where one process stops and the other starts) and dividing a process into subprocesses and/or variants (Lind and Goldkuhl 2003, Lind 1997); the patterns and phases help determine which (sub-)processes should exist according to a pattern and where a (sub-)process ends and another begins, because of a transition from one phase to another. Once an action structure is designed, a business process architecture can be derived from it, using the strong similarity between business processes and business actions. Figure 3 shows an example of action structure and a business process architecture that is derived from it.

**Organizing concept.** The main organizing concept in action-based approaches is the 'action' and different approaches distinguish different types of actions. Nonetheless, all action-based approaches use the idea that each action goes through a number of phases. However, the exact number and definition of these phases differ per approach.

**Concept relations.** Different action-based approaches distinguish different types of relations between actions. All of the action-based approaches that we studied have a

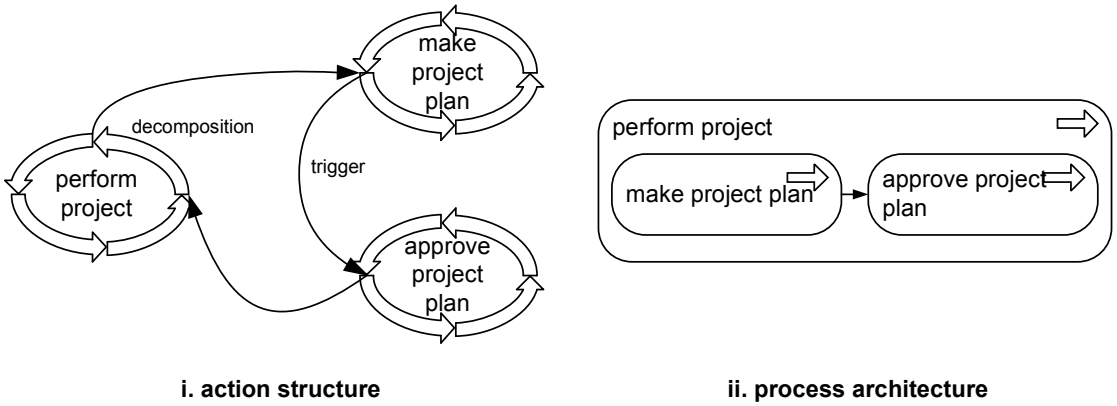


Figure 3. Example of Action-based Design of Process Architecture

decomposition, a triggering and a phasing relation. A decomposition relation between actions represents that an action can be decomposed into multiple more detailed actions. A triggering relation represents that the completion of one actions triggers the start of another. A phasing relation represents that one phase of an action is completed and that the next phase starts. Lind and Goldkuhl (2003) and Lind (1997) also discuss a specialization relation, in which actions such as 'apply for car insurance' and 'apply for home insurance' are specializations of a more general action 'apply for insurance'.

**Deriving a process architecture.** Action-based approaches differ significantly in the way in which a process architecture relates to the action structure. First, the approaches differ with respect to how they perceive the role of the business process concept. Most approaches do not distinguish between actions and processes and develop an overview of the actions that are performed in an organization in terms of an 'action structure' (Medina-Mora *et al.* 1992, Dietz 2006, Auramäki *et al.* 1988, Johannesson 1995). One approach makes a distinction between actions and processes and discusses the relation between them (Lind and Goldkuhl 2003, Lind 1997). Second, the approaches differ with respect to the scope of the action structure that is designed. Where a business process architecture focuses on structuring all business processes within a certain scope, the scope of an action structure can vary. Case studies are performed for high-level business functions, such as purchasing (Dietz 2006), or workflow processes, such as hiring new personnel (Medina-Mora *et al.* 1992).

### 3.3. *Object-based*

**Brief description.** In object-based approaches (Green and Ould 2004, Joosten et al. 2002) a business object model is designed first, for example in the form of a UML class diagram. Subsequently, a business process architecture is designed by studying the business objects that exist in the organization, as well as their inter-relations. Figure 4 shows an example of an object model and a business process architecture that is derived from it.

**Organizing concept.** The main organizing concept in object-based approaches is the 'business object' and both identified approaches consider three types of business objects: 'permanent objects', 'case objects' and 'other objects'. *Permanent objects* are business objects that have a relatively long life cycle in the organization, such as the 'client' in most organizations. Processes can be identified from permanent objects by determining the operations that can be performed on these objects and defining processes to support

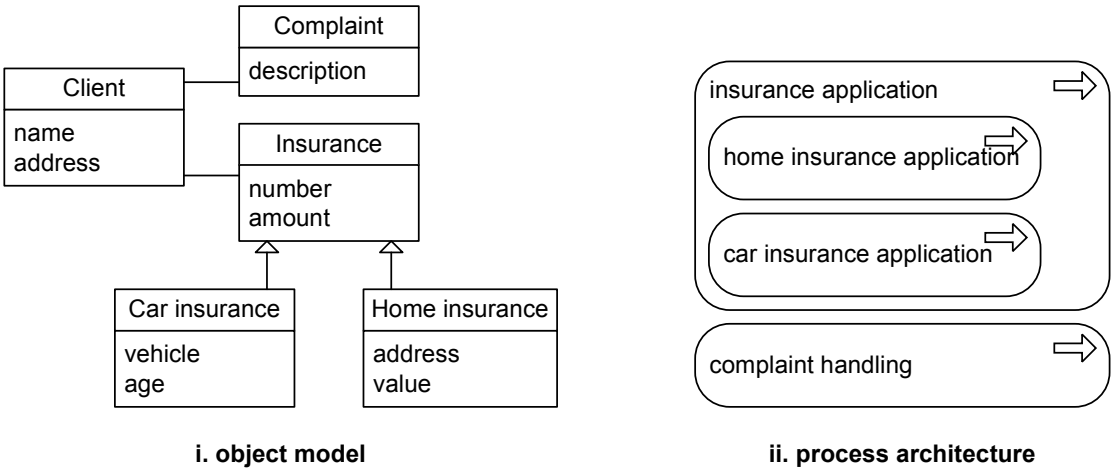


Figure 4. Example of Object-based Design of Process Architecture

these operations. For example, a new client can arrive or buy something, thus leading to the need for a process to register new clients and a sales process. *Case objects* are objects that guide the execution of a business process and thus directly identify a business process. An example of a case object is an 'order' or an 'application'.

**Concept relations.** Object modeling is a discipline in itself and the many object modeling techniques that exist distinguish many different types of relations between business objects. Some of these relations are of particular interest in the context of designing a process architecture. The relation between permanent objects and case objects can be used to identify a logical group of processes. A relation between states of one or more business objects can be used to delimit or relate business processes. For example, a state-change of an object from 'ordered' to 'shipped' can be used to delimit and relate the 'order' and 'shipping' processes. A decomposition relation between objects can be used to identify a decomposition relation between business processes. For example, the decomposition of a 'mortgage application' into 'client details', 'mortgage details' and 'securities' can lead to different subprocesses in the mortgage application process. Finally, a specialization relation can be used to identify a logical group of processes. For example, a specialization relation between 'apply for car insurance', 'apply for home insurance' and 'apply for insurance' can be used to identify a logical group of insurance application processes.

**Deriving a process architecture.** A process architecture is not directly derived from an object model. However, different types of objects and relations can be used to identify processes and relations between processes, as described in the previous two paragraphs.

## 3.4. *Reference Model Based*

**Brief description.** In reference model based approaches, an existing business process architecture (the reference model) is re-used and adapted to design a new business process architecture. Figure 5 shows an example. The benefit of this approach is that much time can be saved by starting from an existing model. Also, the reference model is meant to present best practices and may thus lead to better designs. There exist a large number of business process reference models. Fettke *et al.* (2006) published a survey that covers 30 of these. However, the focus of these reference models is on presenting a collection

of business process models, not on the business process architecture that structures the collection itself. In most cases, the business process architecture is a by-product of the reference model, although in some it is considered and published separately (APQC 2011, Aitken *et al.* 2010, Malone *et al.* 1999). In the context of business process reference models, the business process architecture is commonly referred to as a business process (architecture) framework (Koliadis *et al.* 2008) and takes the form of a classification. What distinguishes the classifications are the concepts that are used for classification, the relations between elements in the classification, and the specification of abstraction levels in the specification.

**Organizing concept.** Fettke *et al.* (2006) found that the two most-used concepts to classify business processes in a business process architecture are *business function* and *industry segment*. In addition to that, a classification can be done based on a predefined classification that is based on consensus rather than a single concept. APQC's Process Classification Framework defines such a classification (APQC 2011).

**Concept relations.** The most prominent relations between business processes in reference models are those of specialization and decomposition (Malone *et al.* 1999), which have been explained in Section 2.

**Deriving a process architecture.** In a reference model based approach, the reference model itself *is* a process architecture. An instance of that process architecture that is specifically developed for a company, is derived by adapting the reference model.

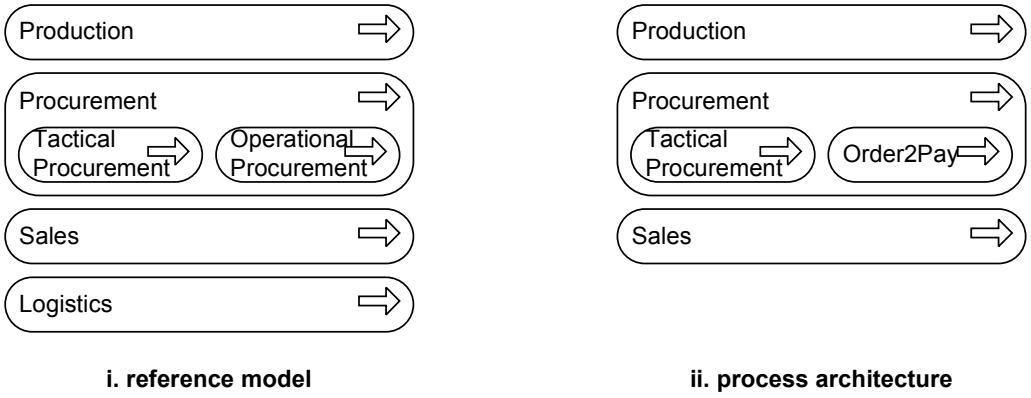


Figure 5. Example of Reference Model Based Design of Process Architecture

## 3.5. *Function-based*

**Brief description.** In a function-based approach a function hierarchy is designed, which represents the decomposition of business functions into more detailed business functions. A process architecture is derived from the function hierarchy by either considering the functions at a certain level in the hierarchy as processes, or considering functions and processes as orthogonal and using processes to represent the flow relations between functions.

**Organizing concept.** The main organizing concept in the function-based approach is the 'business function', which is defined as a capability of an organization, such as 'production' or 'procurement'.

**Concept relations.** The sole relation that is considered in a function hierarchy is the decomposition relation, which represents the decomposition of a function into a set

of more detailed functions.

**Deriving a process architecture.** There are roughly two ways in which a function hierarchy can be related to a business process architecture. Firstly, the function hierarchy can be the primary way of organizing the business processes. In that case, functions are decomposed into more detailed functions until a chosen level of decomposition is reached from which the functions are further decomposed into processes (Aitken *et al.* 2010, Aronson 2008). In this case, business processes are organized according to the functions to which they belong. Secondly, functions and processes can both be organized into hierarchical structures through decomposition relations, which should be closely aligned (Scheer and Nüttgens 2000, Eertink *et al.* 1999).

Figure 6 shows an example of a function hierarchy and a business process architecture that is derived from it. The benefit of using business functions to identify processes is that, compared to business processes, business functions are relatively simple to identify and stable, because they focus on *what* an organization does rather than *how* the organization accomplishes that. Consequently, they arguably form a good starting point for designing a business process architecture.

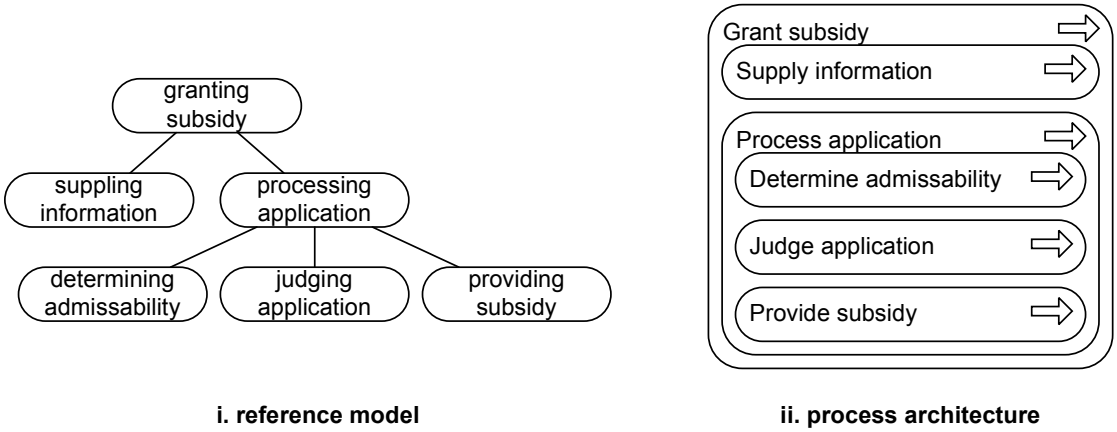


Figure 6. Example of Function-based Design of Process Architecture

## 4. Survey Based Comparison of Approaches

As has been hypothesized and empirically proven, the intention to use an IT artifact is mainly a function of two pervasive beliefs: perceived ease of use and perceived usefulness (Maes and Poels 2007). This is the reason that, for our exploratory evaluation of the business process architecture design approaches that have been described in the previous section, we centered on these notions. We extended this view by also acquiring the perception of respondents on the popularity of these approaches in practice. The outcomes of the survey should be interpreted as an inventory of opinions and an illustration of the use, usefulness and popularity of the presented approaches in practice. It is not intended to prove any hypotheses with this. In this section, first the evaluation setup is presented, followed by a discussion of the results.

### 4.1. *Setup*

The evaluation of the five main classes of approaches was done among a group of 39 Dutch practitioners in the area of Business Process Management. They were invited as members of the BPM Round Table [1], a free forum for Dutch BPM professionals that organizes regular meetings at which a BPM topic is discussed. Currently, the BPM Round Table has 334 members, making for a response rate of around 12%. Demographic information of the respondents is provided in Table 2. The demographics show a rather homogeneous group of respondents. The 'average' respondent is an experienced advisor working in a large professional services firm. This is a good group of respondents to give an opinion on popularity of process architecture approaches in practice, because this group has seen much of the industry, both because of their experience and because of their employment as advisors at professional services firms. A threat to the external validity of the survey, however, is the fact that all respondents were Dutch. We will comment on that in the conclusions.

Table 2. Demographics of respondents

| **experience (years)** | **number of respondents** | **percentage** |
|---|---|---|
| $< 1$ | 5 | 13% |
| 1 - 4 | 6 | 15% |
| 5 - 10 | 7 | 18% |
| $> 10$ | 21 | 54% |
| **industry sector** | **number of respondents** | **percentage** |
| professional services | 15 | 38% |
| research | 9 | 23% |
| financial services | 7 | 18% |
| healthcare | 4 | 10% |
| software | 2 | 5% |
| logistics | 1 | 3% |
| government | 1 | 3% |
| **company size** | **number of respondents** | **percentage** |
| small | 6 | 15% |
| medium | 3 | 8% |
| large | 30 | 77% |
| **job function** | **number of respondents** | **percentage** |
| advisor | 23 | 59% |
| manager | 8 | 21% |
| student | 5 | 13% |
| researcher | 2 | 5% |
| developer | 1 | 3% |

The evaluation consisted of three parts. The first part focused on the ease of use, usefulness, and popularity of the approaches in general, while the second part aimed to investigate the usefulness of specific guidelines, as they exist as part of an overall approach. A discussion of the results completed the session, which overall lasted for two hours.

During the first part of the evaluation the participants received a brief explanation and some examples for each type of approaches, similar to the explanations given in the

[1] `http://bpmroundtable.nl/`

previous section. After each explanation of an approach, the participants were asked to give their opinion on the following three statements: (i) this approach is easy to apply, (ii) this approach is useful to design a business process architecture, and (iii) this approach is popular in practice. We used an electronic voting system to record the scores 'agree', 'neutral , 'disagree', or 'don't know' on each of the statements. This operationalization of the usefulness of business process architecture design approaches is based on the (empirically validated) observation that the intention to use an IT artifact is mainly a function of two pervasive beliefs: perceived ease of use and perceived usefulness (Maes and Poels 2007). In total, 15 evaluation scores were stored per participant (5 classes of approaches times 3 questions).

Table 3. List of specific guidelines

| **number** | **guideline** |
|---|---|
| 1 | Identify logical units within a process (unit of time, place, resource,...), determine which of these logical units form a sub process. |
| 2 | Identify 'consists of' relations between documents, derive from that 'consists of' relations between business processes. |
| 3 | Use a reference model to describe processes completely. |
| 4 | Identify the start and end of a process by identifying the start and end of the corresponding transaction. |
| 5 | Identify the business goals, then identify the business processes that accomplish these business goals. |
| 6 | Each process belongs to at most one business function. |
| 7 | Identify the documents and files that exist in an organization, then identify the processes that describe what is happening to these documents. |
| 8 | Identify 'executed within' relations between transactions, derive 'executed within' relations between business processes from that. |
| 9 | Identify the value that is created for clients, then identify the processes that describe how this value is created. |
| 10 | Identify the business functions, then identify the processes that are executed within these business functions. |
| 11 | Identify transactions (which are executed by a provider for satisfaction of a consumer), then identify the business processes that accomplish these transactions. |
| 12 | Use a reference model to identify processes. |
| 13 | Identify 'consists of' relations between business goals, derive 'consists of' relations between business process from that. |
| 14 | Identify artifacts that flow through an organization, then identify the processes that belong to these flowing artifacts. |
| 15 | Graphical properties and relations between processes in a process architecture model have to have a clear meaning. |
| 16 | Identify 'consists of' relations between business functions, derive 'consists of' relations between business process from that. |
| 17 | A business goal has to be achieved by a business process, or should consist of sub goals that are achieved by a business process. |
| 18 | Use a reference model to identify relations between processes. |

In the second part of the evaluation, the participants were presented 18 specific guidelines as taken from the literature (see Table 3). For each of these guidelines, the participants were asked to give their opinion on the hypothesis that the guideline is *useful*

for designing process architectures, by indicating whether they would agree, be neutral, would disagree, or did not know. Each of the five identified classes of approaches was represented by three guidelines, e.g. guidelines 5, 13, and 17 were taken from goal-based approaches. In addition, we added three guidelines (i.e. 1, 9, 15) that could not be classified under one of the five main classes of approaches. The participants were neither told which guideline belonged to which of the presented approaches, nor were they aware of the fact that there were three additional, unclassified guidelines.

## 4.2. *Results*

The results for the first part of the evaluation can be found in Table 4. It can be derived from this table that the reference model based approach is considered the most easy to use, useful and popular; 67% of the participants agreed with the statement that the approach is easy to use, 62% with the statement that the approach is useful, and 56% with the statement that the approach is popular in practice. In a similar way, it can be seen that the goal- and action-based approaches are considered the least easy to use, useful and popular approaches (highest percentage of participants who *dis*agreed with these statements).

Table 4. Overview of Business Process Architecture approaches. Each statement is scored on whether the participants agree with it (A), are neutral (N), disagree (D), or don't know (?).

| **approach** | **ease of use** | | | | **usefulness** | | | | **popularity** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | N | D | ? | A | N | D | ? | A | N | D | ? |
| goal-based | 30% | 43% | 22% | 5% | 39% | 25% | 28% | 8% | 6% | 19% | 33% | 42% |
| action-based | 41% | 24% | 32% | 3% | 42% | 26% | 21% | 11% | 19% | 5% | 35% | 41% |
| object-based | 37% | 29% | 29% | 5% | 57% | 24% | 19% | 0% | 29% | 18% | 18% | 34% |
| reference model based | **67%** | 21% | 8% | 5% | **62%** | 16% | 8% | 14% | **56%** | 13% | 10% | 21% |
| function-based | 45% | 34% | 16% | 5% | 50% | 32% | 8% | 11% | 38% | 21% | 13% | 28% |

The second evaluation focused on the usefulness of specific guidelines as taken from the literature. Table 5 summarizes the results and shows some surprising outcomes. First, the guidelines that are identified as being the most useful are guidelines 9 (89% of the participants find it useful) and 15 (84%). Both are guidelines that cannot be classified within one of the approaches. Apparently, separate rules of thumb exist that are not part of a bigger approach to design a business process architecture, but are nonetheless considered highly useful when designing and defining business processes. Second, the guidelines that have been evaluated as the least useful (highest percentage of participants that disagree) are guidelines 3, 6 and 18. Two of them are from the reference model based category and the other one is from a function-based approach. This is remarkable, since actually the reference model based approaches were classified most often as useful in the first part of the evaluation (67%, see Table 4). Third, one guideline (6) was found useful by none of the participants, while all other guidelines found at least some support. Finally, guidelines taken from the same approach are not perceived as equally useful, e.g. guidelines 6, 10, and 16 are expressed to be useful by 0%, 47%, and 26% of the participants respectively.

These observations fit in the overall pattern that guidelines do not receive the same evaluations as the approach of which they are a part; individual guidelines may be evaluated as more useful or less useful than the approach of which they are a part and different guidelines belonging to the same approach may be evaluated differently. For example, of the guidelines that are related to the goal-based approach (guidelines 5, 13, and 17),

Table 5. Overview of Business Process Architecture Guidelines. Each guideline is scored on usefulness by asking the participants whether they agree (A), are neutral (N), disagree (D), or don't know (?)

| **no.** | **approach** | **source** | **usefulness** | | | |
|---|---|---|---|---|---|---|
| | | | A | N | D | ? |
| 1 | not classified | Lankhorst (2005) | 51% | 14% | 24% | 11% |
| 2 | object-based | Joosten et al. (2002) | 36% | 23% | 31% | 10% |
| 3 | reference model based | Fettke *et al.* (2006) | 29% | 26% | **39%** | 5% |
| 4 | transaction-based | Lind (1997)<br>Lind and Goldkuhl (2003) | 51% | 16% | 22% | 11% |
| 5 | goal-based | Koubarakis and Plexousakis (2002)<br>Lee (1993)<br>Yu and Mylopoulos (1994) | 63% | 26% | 11% | 0% |
| 6 | function-based | Aitken *et al.* (2010)<br>Aronson (2008) | 0% | 3% | **95%** | 3% |
| 7 | object-based | Joosten et al. (2002) | 38% | 26% | 33% | 3% |
| 8 | transaction-based | Lind (1997)<br>Lind and Goldkuhl (2003) | 11% | 26% | 24% | 39% |
| 9 | not classified | Lankhorst (2005) | **89%** | 6% | 3% | 3% |
| 10 | function-based | Aitken *et al.* (2010)<br>Aronson (2008)<br>Scheer and Nüttgens (2000)<br>Eertink *et al.* (1999) | 47% | 32% | 18% | 3% |
| 11 | transaction-based | Lind (1997)<br>Lind and Goldkuhl (2003) | 44% | 31% | 15% | 10% |
| 12 | reference model based | Fettke *et al.* (2006)<br>Koliadis *et al.* (2008) | 69% | 21% | 10% | 0% |
| 13 | goal-based | Lee (1993) | 26% | 32% | 24% | 18% |
| 14 | object-based | Joosten et al. (2002)<br>Green and Ould (2004) | 68% | 16% | 16% | 0% |
| 15 | not classified | Lankhorst (2005) | **84%** | 3% | 3% | 11% |
| 16 | function-based | Scheer and Nüttgens (2000)<br>Eertink *et al.* (1999) | 26% | 33% | 18% | 23% |
| 17 | goal-based | Lee (1993) | 59% | 24% | 14% | 3% |
| 18 | reference model based | Fettke *et al.* (2006)<br>Koliadis *et al.* (2008) | 32% | 24% | **37%** | 8% |

guidelines 5 and 17 are evaluated as more useful than the goal-based approach itself. Guideline 13 is evaluated differently from guideline 5 and 17, its evaluation is on-par with the evaluation of the goal-based approach itself.

After the evaluation with the voting system, the resulting patterns were discussed with the participants. In this discussion it became very apparent that companies often do not use one of the identified approaches fully or even exclusively. Rather, a mixture of ideas from different approaches are applied. For example, one participant explained that the approach followed within his institute was to first follow a functional decomposition of processes, followed by an approach to identify the most important objects. The attractiveness of a hybrid approach may explain at least to some extent how it is possible that individual guidelines can be evaluated differently from their encompassing approach. It was also interesting that despite the broad appreciation of the reference model based approach, its usefulness was further qualified by several participants. One of them remarked: "Reference process models certainly provide a tangible starting point, but it should not be underestimated how much time must be spent on appropriating them to a specific setting. It's terrible!". Also, since we established the relative poor evaluation of the goal-based approach, a participant noted that this score is caused by the fact that

"management becomes very quiet when asked for the actual goals that need to be fulfilled". This points to a practical barrier of linking goals to process models, as proposed by this class of approaches. From the approaches that were holding the middle ground between the most popular and the least popular approaches, the approach that attracted most discussion was the object-based approach. In particular, the "explosion of objects" was considered troublesome and affecting its ease of use negatively.

In conclusion of the discussion, we invited the participants to identify approaches that were not covered by the five main classes of approaches that were the subject of the session. The most important addition here may be coined as the *service oriented approach*. Based on the identification of important business services an organization provides, the main processes and their relations can be established as well. Business services were in particular mentioned as being more concrete than goals by some participants, even though the approach could also be seen as subsumed by the object-based approach according to others.

The above observations and the results of the exploratory evaluation illustrate that the reference model approach is considered most useful, easy to use, and popular; the goal-based and action-based approaches score lowest. However, none of the evaluated approaches to business process architecture is considered by practitioners as the perfect or even a dominant solution to structuring the process landscape in a company. Rather, the hybrid combination of guidelines seems to best represent the state-of-the-art. While such a position may have its appeal, it also points at a lack of any approach to satisfactorily deal with the demands of practitioners to define business process architectures.

## 5. Case Study Based Comparison of Approaches

Since the survey-based evaluation from Section 4 shows that practitioners do not use a single approach to design a process architecture, we conducted further research to determine popular combinations of approaches, guidelines and structuring principles. To this end we took four business process architectures from practice as case studies and determined the structuring principles that were used to create them. The case studies concern theory building (Eisenhardt 1989), where we are interested in answering the research question: "which elements of design approaches are used in practice to design a process architecture". The case study protocol that we followed contains the elements described by Runeson and Höst (2009).

We selected the cases, using the maximal variation principle Runeson and Höst (2009), in order to produce a set of cases that is as representative as possible. In doing so, we assume that process architectures will primarily differ with respect to the goal with which they are created, and the industry sector for which they are created. Therefore, we varied the cases with respect to these characteristics. We strictly selected process architectures for which the authors were not involved in the development, because that would create a bias in the case selection. Table 6 shows an overview of these characteristics and the general characteristics of company size, measures in terms of the number of employees, and company age, measured in terms of the number of years in existence. The characteristics of the first three cases are approximated to maintain the confidentiality of the organizations.

We used the literature study from Section 3 as the theoretical frame of reference for our case study. In particular, we use the elements of the design approaches, as they are classified in Table 1. Consequently, for each of the four cases we determined:

- which basis was used to construct the process architecture;
- which instances of organizing concepts are part of the process architecture; and
- which relations are part of the process architecture.

These questions were answered through a document analysis.

Each of the process architectures is described in a document, such as the publicly available document that describes the process architecture for the municipality (Kwaliteits Instituut Nederlandse Gemeenten (KING) 2011). In the document analysis, the authors studied these documents. In addition, unstructured interviews were held by the authors with people in the organizations in order to improve the authors' understanding of the process architectures. Since the documents can be assumed to represent a consensus between the different people in the respective organizations, no intra-case comparison was needed.

Each of the process architectures consisted of several 'groups' of processes. The authors identified the names of these groups. These names are presented in more detail further on in this section. The authors then used the names to determine the structuring principles behind the groups of processes. This requires a creative step, but that step can be verified by the reader. Finally, the authors identified the relations between the groups of processes that were presented in the process architecture.

In the remainder of this section, we will present the document analysis of each of the process architectures, by presenting the 'groups' of processes that were identified in the documents, the structuring principles that were derived from those groups, and the relations that we identified between the groups of processes. We will also present strongly simplified versions of each of the process architectures, to clarify the structuring principles and relations by example. The last subsection then does an inter-case comparison of the structuring principles that underlie the four process architectures.

Table 6. Case characteristics

| **case study** | **sector** | **purpose** | **size (nr. employees)** | **age (years)** |
|---|---|---|---|---|
| harbor | transport | creating an overview of processes | approx. 100 | approx. 10 |
| electronics | manufacturing | identifying processes to model | approx. 200 | approx. 10 |
| bank | services | re-engineering processes | approx. 25,000 | approx. 25 |
| municipalities | public | re-engineering processes | 134 | 3 |

## 5.1. *Harbor Process Architecture*

The first process architecture is from a department of a large Dutch Harbor and concerns the primary processes of the harbor as a whole. The process architecture was developed primarily to provide an overview to all stakeholders of how the different stakeholders (e.g.: harbor master, transporters, terminals, and customs) and their processes are related. The processes that are organized in this way are not explicitly related to the process architecture.

Figure 7 shows a strongly simplified view of the process architecture. We classified the structuring principles that were used to design this process architecture as shown in

Table 7. We argue that the process architecture organizes processes in two dimensions: according to mode of transportation and according to business function. The business functions induce a function-based decomposition on multiple levels. First, a distinction is made between an 'import' and an 'export' function. These functions are further decomposed, e.g. into 'departure harbor', 'transshipment' and 'hinterland transportation' for 'export'. These functions are again further decomposed, e.g. 'create manifest' is part of 'departure harbor'. The modes of transportation induce an object-based organization, where each of the modes of transportation is a business object. The arrows that are associated with the modes of transportation provide some information on the order in which business functions, and consequently, processes can be performed. Note that the ordering relations were not originally identified in literature as potential relations between processes. Triggering relations are indeed identified, but these are more strict than ordering: a triggering relation implies an order between the related processes, but processes can be ordered in time, without having a triggering relation.

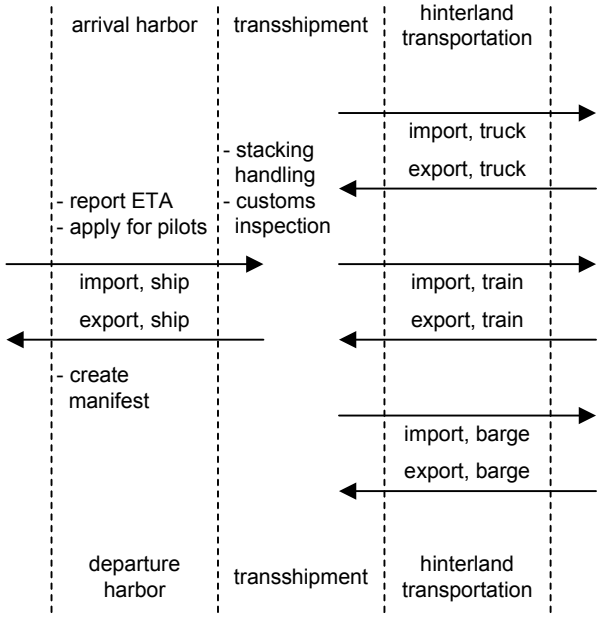


Figure 7. Harbor Process Architecture

## 5.2. *Electronics Manufacturer Process Architecture*

The second process architecture is of a single department within an internationally operating electronics manufacturer. The process architecture was developed as a starting point in a project that involved the development of models of all processes in the organization. The process architecture aims to organize all processes in the organization (both primary and secondary). At the time of writing, 213 primary processes are identified, of which 212 are also modeled in detail, but only 19 secondary processes are identified, of which 11 are modeled in detail.

Figure 8 shows a strongly simplified view of the process architecture. The process architecture consists of two separate models: one that represents the hierarchical decomposition of the processes and one that represents information that flows between the main processes. We classified the structuring principles that were used to design this

Table 7. Concepts used in process architectures from practice

| case study | structuring basis | concept instances | relations |
|---|---|---|---|
| harbor | function-based | import, export<br>phases of import, export<br>functions related to phases | decomposition<br>ordering |
| | object-based | modalities | |
| electronics manufacturer | function-based | primary, secondary<br>common business functions | decomposition<br>ordering<br>flow |
| | object-based | product type | |
| bank | function-based | management, support, customer<br>common customer functions | decomposition<br>ordering<br>specialization |
| | object-based | product type<br>sales channel<br>customer type | |
| municipality | function-based | steering, primary, supporting | decomposition |

process architecture as shown in Table 7. We argue that the processes are primarily organized using a functional decomposition. A first-level decomposition into 'A' and 'B' processes is made, which can be equated to a decomposition into primary and supporting processes. Processes are then further decomposed. For the processes of the second-level decomposition, separate models exist that represent trigger relations between processes from the third-level decomposition. Therefore, we say that ordering relations are expressed between processes. In addition, looking at the decomposition of the 'production' process, we argue that an object-based decomposition of this process into sub-processes is used, where each production process is classified according to the type of product that it aims to produce. Interestingly, general-purpose processes, such as 'packaging', are also identified on this level. These processes are the same for each of the different types of products.

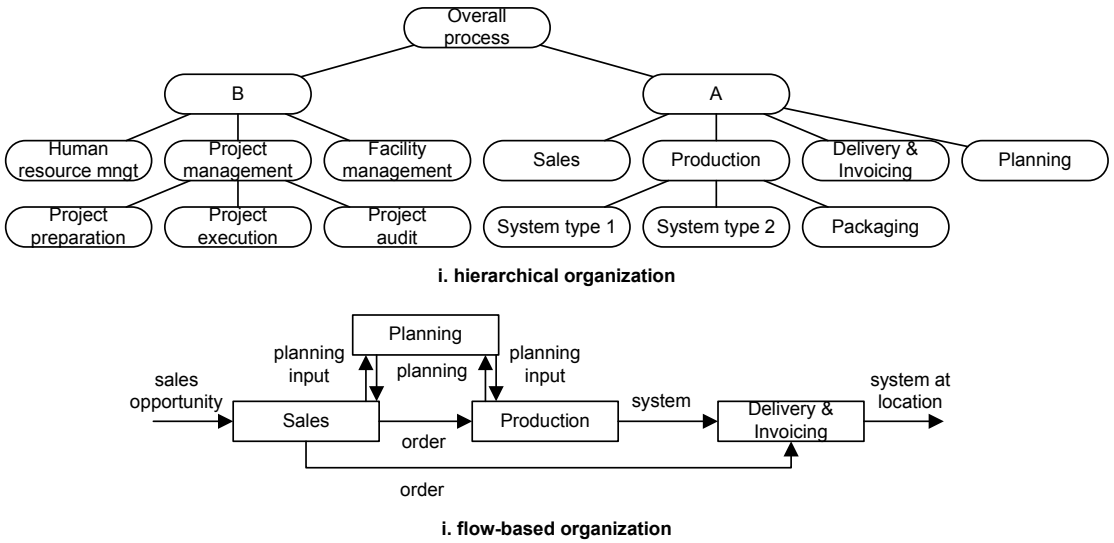


Figure 8. Electronics Manufacturer Process Architecture

### 5.3. *Bank Process Architecture*

The third process architecture is that of an internationally operating bank. It was developed as part of a project to re-engineer the bank's existing business processes in such a way that they become more standardized. The bank runs 360 primary processes and different variants and sub-processes exist for each of them.

Figure 9 shows a strongly simplified view of the process architecture. The bank organizes its processes in 'process families'. A process family is a process that represents the tasks that are generally performed in a family of similar processes. Within each process family, a number of variants can exist. Variants are distinguished for different products, different sales channels, and different types of clients. For example, the 'advise customer' process family represents a general process for providing advice to customers. A possible variant of this process is advising customers about checking accounts. Ideally, the variant re-uses as much of the general process family as possible, but it can also specialize, remove and add elements. Both process families and process variants consist of steps and steps consist of tasks. We classified the structuring principles that were used to design this process architecture as shown in Table 7. There are three classes of process families: management, support and customer process families. We argue that these classes and their subsequent elements constitute a functional decomposition. Process families and steps are related by means of ordering relations. In addition, there exist specialization relations between process families and their variants and also between the elements of process families (general steps and tasks) and their counterparts in process variants. Finally, we argue that process variants are classified in an object-based manner, according to product type, sales channel and customer type.

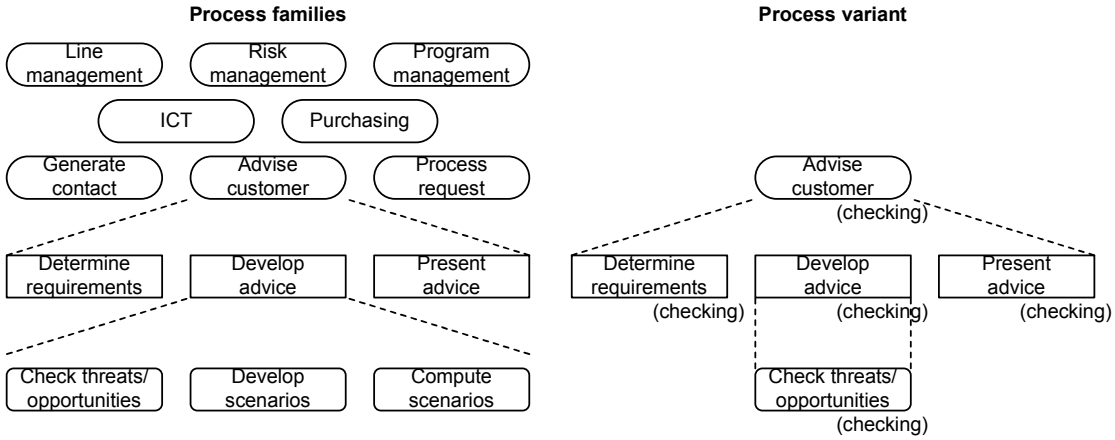


Figure 9. Bank Process Architecture

### 5.4. *Municipalities Process Architecture*

The fourth process architecture is a general process architecture developed by the quality institute for Dutch municipalities (KING). The Netherlands have 415 municipalities that perform similar tasks. The process architecture by KING was developed as a reference process architecture for local governments and aims at improving process quality and efficiency. It does so by setting an example on how to structure and streamline processes.

Figure 10 shows a simplified version of this publicly available reference process architecture (Kwaliteits Instituut Nederlandse Gemeenten (KING) 2011). The processes

are divided into steering (strategic), primary and supporting processes, based on their nature. Within each of these categories, a number of clusters of processes is defined. We classified the decomposition of the processes in the reference architecture as a solely functional decomposition as shown in Table 7. The division in categories (based on the nature of the processes) and clusters is driven by the functions that are performed in the various groups. Processes with a similar function are grouped into one cluster. Arguably, the decomposition of 'provide products & services' is object-based, but this decomposition only plays a minor role in the whole. We decided that this role was not sufficiently prominent to claim that an object-based decomposition was used as a structuring principle.

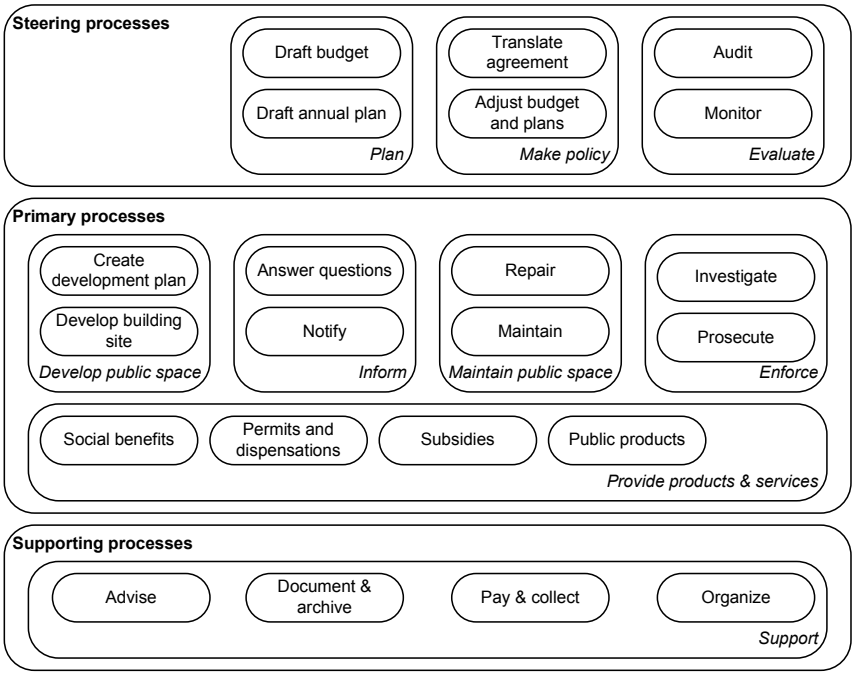


Figure 10. Process Architecture for municipalities (adapted from Kwaliteits Instituut Nederlandse Gemeenten (KING) (2011))

## 5.5. *Results*

Table 8 shows a comparison of the types of structuring principles and relations used in the different cases. The cases are referred to by their first letter H(arbor), E(lectronics manufacturer), B(ank), and M(unicipality).

The comparison shows that three of the four cases use a combination of a function-based and an object-based approach and one case uses a purely function-based approach. This observation is in line with the previous evaluation (see Section 4), which showed that, in practice, organizations rely on a combination of several approaches to develop a process architecture. However, interestingly, in the previous evaluation, the reference model based approach was deemed the most usable and useful, while none of the cases used that approach. The reason for this was that the authors of the process architectures were not aware of the existence of process architecture reference models in their particular domain (which is not the same as saying that they do not exist). For the municipality, the developed process architecture was meant to serve as a reference model.

All cases use decomposition relations in the function and/or object dimension to organize their processes. The decomposition in the function dimension is hierarchical and between two and seven levels deep, but three of the four cases have a low number (two or three) of levels. Looking in more detail at the concepts that are used in the cases, as they are presented in Table 7, three of the four cases have a first-level decomposition into primary processes (also called customer processes) and secondary processes (also called support processes), which is indeed a common distinction to make **??**. Two of these cases add management processes (also called steering processes) to the primary and support processes. The object-based decompositions are orthogonal rather than hierarchical and based on a low number (one to three) of object classes.

Ordering relations are used in all cases, except in the municipality process architecture. The ordering relation indicates temporal relations between processes without a direct triggering of one process by the other. This kind of relation seems to be an important element of a process architecture in practice, while it is not present in any of the approaches found in literature. Of the 'other' possible relations, which are presented exhaustively in Table 1, only the specialization and the flow relations are used and only by single cases.

While the specialization relation is only explicitly used in one case, two of the other cases identify a form of specialization, as described in more detail in the previous sections. The harbor process specializes its functions for three of the four different modalities and the electronics manufacturer specializes its functions for the different product that it develops. This specialization principle can easily be explained by a desire to achieve economies of scale, by enabling resources to be shared between processes as much as possible.

Based on an analysis of the four cases, we conclude that a process architecture is often developed based on a decomposition of processes in both the function and object dimension, using a hierarchical decomposition at approximately three levels in the function dimension and an orthogonal decomposition in the object dimension. In addition, ordering relations between the functions at selected levels are often used as well as some form of specialization. We also conclude that these rules should merely be interpreted as guidelines, as they already differ for the four cases and, consequently, can be expected to differ further for other cases.

Table 8. Comparison of process architectures from practice

| **approach** | **relation** | | | | |
|---|---|---|---|---|---|
| | decomposition | ordering | specialization | flow | other |
| goal-based | | | | | |
| action-based | | | | | |
| object-based | H: 1 dimension<br>E: 1 dimension<br>B: 3 dimensions | H | | | |
| reference model based | | | | | |
| function-based | H: 3 levels<br>E: up to 7 levels<br>B: 2 levels<br>M: 3 levels | H<br>E<br>B | <br><br>B | <br>E | |

## 6. Process Architecture Framework

Based on the results of both the survey-based comparison of the process architecture design approaches and the case studies, we created a framework that consists of structuring principles that are commonly used when designing a process architecture. The framework is developed by creating a structure that adheres to the most commonly used structuring principles as they are identified in the previous sections. In particular, the framework was developed in such a way that the process architectures from the case studies in section 5 can be structured according to the framework. Figure 11 shows the framework.

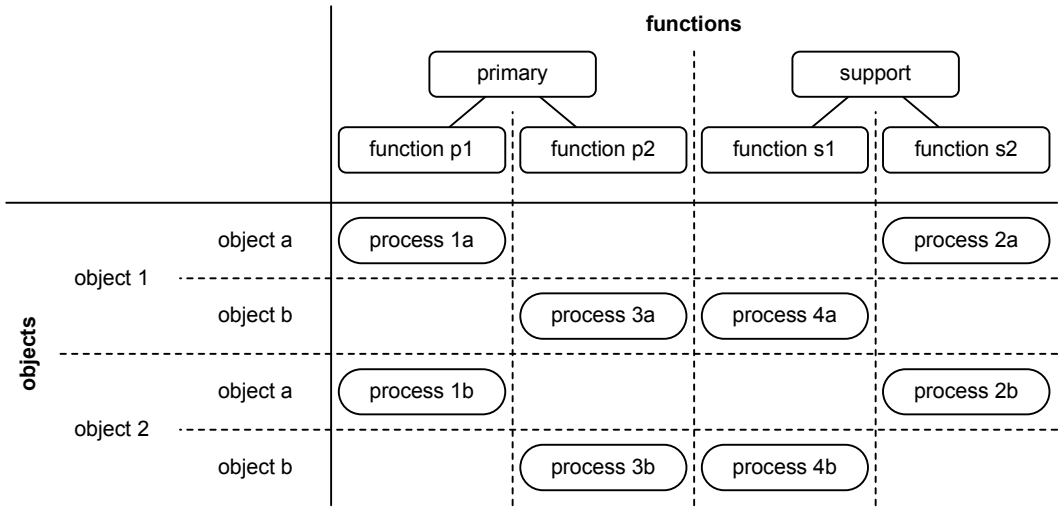


Figure 11. Process Architecture Framework

In the framework, processes are both organized and can be identified by (a) the creation of a hierarchical decomposition of the business functions that exist in an organization and (b) a classification of the most important, permanent business objects. A common first-level decomposition to use is the decomposition into primary and support business functions, potentially enriched with management business functions. The decomposition of business functions does not go deeper than two or three levels. The classification of business objects is also based on a small number of business objects, say one to three. Processes are then categorized by the business functions that are involved in executing the processes and the business objects that are affected by the processes. When processes are executed by the same business functions, but affect different business objects, they are typically designed in such a way that they are as similar as possible and only differ with respect to essential differences between the business objects.

Figure 12 shows an example of how the framework could be used to structure the processes at the harbor (also see Figure 7). The figure shows the decomposition of business functions on two levels and a classification of permanent business objects, in this case: modes of transportation. Processes that address the same function for different business objects are variations of each other, i.e. transshipment to the different forms of hinterland transportation, the subsequent paperwork and leaving the harbor is dealt with in a similar manner for the different modes of hinterland transportation. This does not mean that the processes are exactly the same, but rather that an effort is made to keep them as similar as possible. For example, the manifest can be created in the same way for the

different modes of transportation. Even docking at a terminal can be done similarly, announcing arrival and reserving a place can be handled the same, but the actual docking will differ.

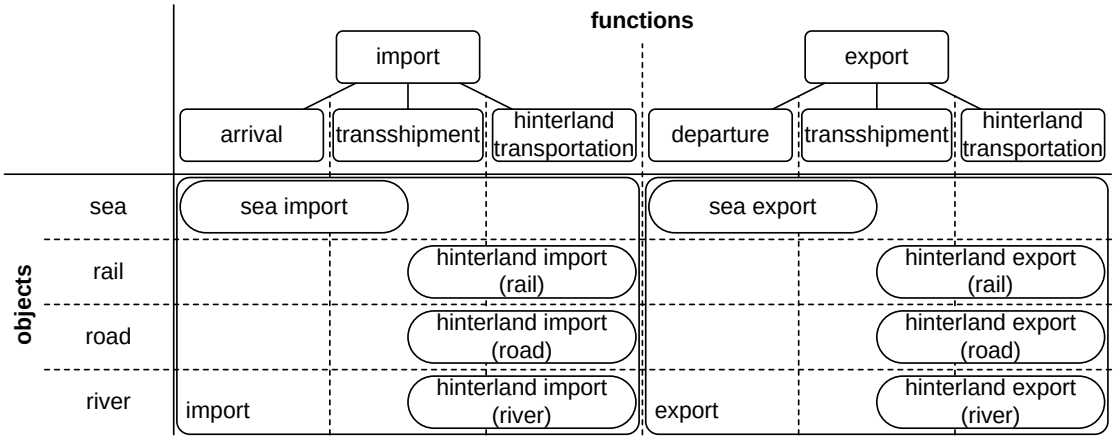


Figure 12. Example Use of the Process Architecture Framework

There are a number of alternatives when creating a process architecture according to the framework. As explained in Section 3.5 the process architecture can either be developed such that the processes only apply to a single (high-level) business function or such that they apply to multiple (high-level) business functions. Figure 11 illustrates the first case, while Figure 12 illustrates the second case. This choice is associated with a choice as to what level the functional decomposition will drill down to. If the functional decomposition goes deep enough, processes *have* to apply to multiple functions, because processes are specifically meant to relate functions. The same choice that holds for business functions also holds for business objects. Processes can apply to a single business object or to multiple business objects. A distinction between different (similar) processes, depending on business objects can also be made only for specific functions. For example, in the process architecture of the electronics manufacturer (see Section 5.2) a distinction between different processes for different product types is only made for the production function, not for the other functions. Finally, a choice can be made with respect to additional relations that are added to the process architecture.

It is possible to include hierarchical relations between business process models as part of the process architecture. These hierarchical relations can be inspired by (hierarchical) relations between functions, objects or both. Figure 12 shows such relations, showing an 'export' and an 'import' super process that are decomposed into subprocesses. While it is possible to include such a decomposition in a business process architecture, the semantics of the decomposition must be carefully considered. In particular, the decomposition can represent either that the child processes together realize the part process (aggregation) or that one of the child processes can be selected to realize the parent process (specialization). A combination of both these types of relations is also possible. For example, in Figure 12 it can be expected that a combination of 'sea import' and one or more of the processes 'hinterland import (rail)', 'hinterland import (road)', and 'hinterland import (river)' realize the super process 'import'. Consequently, the super process is realized by an aggregation of the subprocess 'sea import' and the specialized'hinterland import' subprocesses. When representing a super process as an aggregation, there are again two options, and special care must be taken concerning the semantics of the aggregation relation. The first option is that the super process is an aggregation of sub processes that

run relatively independently of each other. The second option is that the super process is an aggregation of sub processes that run consecutively and together form an end-to-end process that realizes the goal of the super process. In Figure 12, it can be expected that the second option is meant; a container flows end-to-end first through the sea import process and then onward through a hinterland import process in order to realize the goal of 'import'.

This implies that hierarchical aggregation and specialization relations are part of the framework as well as ordering relations that represent the sequence in an end-to-end process. Indeed such relations were also identified in the case studies that are presented in Section 5. The way in which these relations are (graphically) represented remains open. Modeling languages exist that can be used to graphically represent different relations between business processes (Lankhorst 2005) and the companies from the case study all used their own proprietary notations to represent their business process architecture.

## 7. Related Work

In comparison to the way we ordered the various approaches for business process architecture design, three alternative classifications exist. Two of these focus on a subset of the approaches that we consider, namely the reference model based approaches (Fettke *et al.* 2006, Koliadis *et al.* 2008). By begin reference model based, these approaches have a scope that differs from the one in this paper. In particular, this paper covers an additional 18 approaches and provides an empirical evaluation of the use and usefulness of all these approaches. The third classification (Green and Ould 2005) focuses on presenting the classification itself, according to which it discusses 4 approaches. The classification looks broadly at the area of business process architecture, presenting a plethora of aspects to classify them. Our paper looks specifically at means to design a business process architecture (an aspect that is also covered in (Green and Ould 2005)) and provides a more detailed discussion of that aspect. In addition, our paper provides an empirical evaluation of the use and usefulness of the approaches and covers a larger set of approaches.

In comparison to the process architecture framework that is presented in this paper, there exist other process architecture frameworks as well as enterprise architecture frameworks.

Existing process architecture frameworks are included in the literature review that is presented in Section 3. While not every process architecture design approach includes a framework, many do (Scheer and Nüttgens 2000, Fettke *et al.* 2006, Joosten et al. 2002, Aitken *et al.* 2010, Aronson 2008). These existing frameworks use a specific type of approach (goal-based, action-based, object-based, reference model based, or function-based), or in rare cases a combination of two types of approaches. In that respect, the framework presented in this paper is more generic.

Enterprise architecture frameworks and design approaches address the design and subsequent use of an enterprise architecture, which is a description of the components of the enterprise and their interrelationships. Depending on the approach that is used, business processes may be included. For example, TOGAF (The Open Group 2009), Zachman (Zachman 1987) and DYA (Wagter *et al.* 2001) consider business processes as part of an enterprise architecture. Although, an enterprise architecture approach's ability to address the relation between a business process and other components of enterprise architecture (such as business goals or functions) would help to design a business process architecture, enterprise architecture approaches do not primarily aim to assist in the design of

a business process architecture. In that respect enterprise architecture frameworks and design approaches differ from the framework that is presented in this paper. Enterprise modeling languages can be used (possibly in combination with an enterprise architecture approach) to graphically represent an enterprise architecture and, consequently, a business process architecture. The distinction between an enterprise modeling language and an enterprise architecture is not strict. Sometimes enterprise architecture approaches come with an enterprise modeling language (e.g.: ARIS (Scheer and Nüttgens 2000)) and sometimes enterprise architecture approaches are closely related to an enterprise modeling language (e.g.: TOGAF (The Open Group 2009) is closely related to ArchiMate (Lankhorst 2005)). We use the distinction here to talk about enterprise architecture design approaches and graphical means to represent the results. An enterprise modeling language can be used to represent business processes, their relations, and their relations to other concepts. Consequently they can help with, but are not primarily focused on, the design of a business process architecture.

An area that is related to business process architecture is that of service oriented architecture, in which processes are typically expressed as service orchestrations or service choreographies. This is especially interesting, because the design of . However, the design of a service oriented architecture is typically considered from a more technological perspective.

## 8. Conclusion

In this paper, we provided an overview of the current approaches to design a business process architecture. We identified five different classes of approaches from the literature: (i) goal-based; (ii) action-based; (iii) object-based; (iv) reference model based; and (v) function-based approaches. By means of an exploratory survey that involved 39 practitioners, we explored the actual use and perceived usefulness of the various approaches. Surprisingly, a hybrid combination of guidelines turned out to be most popular among our respondents. To study the characteristics of real-life process architectures in more detail, we examined four cases across different goals and industry sectors. On the basis of their organizing concepts and coverage of relations, we proposed a process architecture framework that can be used to support the development of a concrete process architecture.

The unique contribution of our work is that it proposes a concrete approach to design a process architecture on the basis of both a theoretical and an empirical understanding of the topic. A solid theoretical basis is provided by an extensive literature study, while an empirical understanding is provided by an exploratory survey and case studies.

Both the exploratory survey and the case studies suggest that a business process architecture should combine different structuring approaches, where the function-based and object-based structuring approaches appear to be the most useful. The practical evaluations disagree on the usefulness of a reference model as structuring principle, because it is judged as one of the most useful approaches in the survey, while it does not appear in the case studies. The case study based evaluation further suggests that decomposition of processes in multiple dimensions should be possible in a business process architecture and that processes should be as generalizable as possible. The proposed framework is designed based on the theoretical finding and accommodating for these features derived from the practical evaluations.

Our findings should be seen against a number of limitations. First, the research should

be seen as exploratory and, therefore, the conclusions that are drawn from it, should be used with the necessary caution. While the conclusions are based on literature and exploratory empirical work, they remain to be validated more rigorously. In particular, while the coverage of the different types of approaches through our classification can be considered as fairly inclusive, this is certainly not the case for the empirical evaluation. The fact that the respondents of the survey were all Dutch, is a risk to the external validity of the results. However, there is reason to assume that our findings for a Dutch sample also hold for other Western populations. In particular, because we see that there is no strong preference for one particular approach to business process architecture. If this already holds for a relatively small community of Dutch business process experts, many of whom know each other and are taught by the same lecturers or consultants, it is likely that it also holds for larger and less connected communities. While it would be interesting to repeat the survey in a broader (geographical) context, we do not expect that this will lead to new insights. The survey-based evaluation of the existing approaches can be considered as rather high-level and context-free. To some extent, this limitation is addressed by the in-depth case studies we carried out, which specifically dealt with the particular goal behind the development of a process architecture and its industrial context. Finally, the results presented in this paper and the use of process architecture approaches in general can be considered to be primarily of interest to large organizations, with a large number of processes (i.e.: more than 100). This is also illustrated by the fact that the respondents of the survey were mainly (77%) from large organizations. Apparently, small organizations did not consider the topic to be of interest.

Taken the noted limitations into account, we identify a clear match between our contribution and the interest in approaches to design business process architectures among practitioners. However, as the research presented in this paper is exploratory in nature, a first direction for future work should be further testing and validating of the use and usefulness of the guidelines, as well as applying, validating, and refining the proposed framework in practice. An attractive way to go forward would be to carry out field experiments that aim to investigate whether the proposed framework helps to design an industrially useful process architecture in an efficient way. Another venue is the development of tool support to ease the framework's application and tie instances of process architectures to actual process model collections.

The guidelines for business process architecture design that are presented in this paper are only presented to get a more detailed understanding of the business process architecture design approaches themselves. However, developing guidelines for business process architecture design is an interesting research topic in its own right. Especially considering that an important conclusion of this paper is that practitioners compose their own design approach with guidelines from different approaches. Of particular interest are guidelines that define the level of detail or aggregation at which a business process in a business process architecture should be described.

While we aim to present an exhaustive account of the business process architecture design approaches that exist in literature, it should be noted that there may exist business process architecture design approaches that are not covered in literature and, therefore, not included in this study. Of particular interest is a service-oriented approach to business process architecture design, because the absence of such an approach was also mentioned in the survey. The development of a service-oriented approach to business process architecture design is therefore a possible topic for future work.

## References

Aitken, C., Stephenson, C., and Brinkworth, R., 2010. Process Classification Frameworks. *Handbook on Business Process Management 2*. Springer, 73–92.

Antón, A., McCracken, W., and Potts, C., 1994. Goal decomposition and scenario analysis in business process reengineering. *Proc. of CAiSE.*, 94–104.

APQC, 2011. APQC Process Classification Framework (PCF) - Version 5.2.0. Technical report, APQC.

Aronson, B., 2008. *Enterprise Designer - Building a Conscious Organization*. Raleigh, NC, USA: Lulu.

Auramäki, E., Lehtinen, E., and Lyytinen, K., 1988. A speech-act-based office modeling approach. *ACM Trans. Inf. Syst.*, 6, 126–152.

Chui, M., Manyika, J., Bughin, J., Brown, B., Roberts, R., Danielson, J. and Gupta, S., 2013. Ten IT-enabled Business Trends for the Decade Ahead: Updated Research. McKinsey Global Institute.

Curran, T. and Keller, G., 1999. *SAP R/3 Business Blueprint*. Bonn, Germany: Addison-Wesley.

Damij, N. and Damij, T., 2009. Business process identification technique. *Proc. of Conf. on Cooperation and Promotion of Information Resources in Science and Technology*. IEEE, 31–34.

Dietz, J.L.G., 2006. The Deep Structure of Business Processes. *In*: *Communications of the ACM*, Vol. 49, 59–64.

Eertink, H., *et al.*, 1999. A Business Process Design Language. *In*: *Proc. of FM*, 76–95.

Eisenhardt, K.M., 1989. Building Theories from Case Study Research. *The Academy of Management Review*, 14 (4), 532–550.

Fettke, P., Loos, P., and Zwicker, J., 2006. Business Process Reference Models: Survey and Classification. *BPM Workshops.*, 469–483.

Green, S. and Ould, M., 2004. The Primacy of Process Architecture. *In*: *CAiSE Workshops (2)*, 154–159.

Green, S. and Ould, M., 2005. A framework for classifying and evaluating process architecture methods. *Software Process: Improvement and Practice*, 10 (4), 415–425.

Huschens, J. and Rumpold-Preining, M., 2006. IBM Insurance Application Architecture (IAA) - An overview of the Insurance Business Architecture. *Handbook on Architectures of Information Systems*. Springer Berlin Heidelberg, 669–692.

Indulska, M., Recker. J., Rosemann, M., and Green, P., 2009. Business process modeling: Current issues and future challenges. *Proc. of Conf. on Advanced information systems engineering*. Springer, 501–514.

Johannesson, P., 1995. Representation and communication - a speech act based approach to information systems design. *Inf. Syst.*, 20, 291–303.

Joosten, S., 2000. Why Modellers Wreck Workflow Innovations. *Proc. of BPM.*, 119–131.

Joosten et al., S., 2002. *Praktijkboek voor Procesarchitecten*. Assen, The Netherlands: Koninklijke van Gorcum B.V.

Kavakli, E. and Loucopoulos, P., 1998. Goal-Driven Business Process Analysis - Application in Electricity Deregulation. *In*: *Proc. of CAiSE*, 305–324.

Koliadis, G., Ghose, A., and Padmanabhuni, S., 2008. Towards an Enterprise Business Process Architecture Standard. *In*: *IEEE Congress on Services* IEEE, 239 –246.

Koubarakis, M. and Plexousakis, D., 2002. A formal framework for business process modelling and design. *Inf. Syst.*, 27, 299–319.

Kwaliteits Instituut Nederlandse Gemeenten (KING), 2011. GEMMA process architec-

ture 2.0. Technical report, Den Haag, The Netherlands (in Dutch).

Lankhorst, M.e.a., 2005. *Enterprise Architecture at Work - Modelling, Communication and Analysis*. Springer.

Lee, J., 1993. Goal-based process analysis: a method for systematic process redesign. *In*: *Conf. on Organizational computing systems* ACM, 196–201.

Lind, M., 1997. Reconstruction of Different Business Processes - A Theory and Method Driven Analysis. *In*: *Workshop on Communication Modelling*, 87–104.

Lind, M. and Goldkuhl, G., 2003. The constituents of business interaction - generic layered patterns. *Data and Knowledge Engineering*, 47 (3), 327–348.

Lunn, K., *et al.*, 2003. Traceability in requirements through process modelling, applied to social care applications. *Information and Software Technology*, 45 (15), 1045 – 1052.

Maes, A. and Poels, G., 2007. Evaluating quality of conceptual modelling scripts based on user perceptions. *Data & Knowledge Engineering*, 63 (3), 701–724.

Malone *et al.*, 1999. Tools for Inventing Organizations: Toward a Handbook of Organizational Processes. *Manage. Sci.*, 45, 425–443.

Medina-Mora, R., *et al.*, 1992. The action workflow approach to workflow management technology. *In*: *Conf. on CSCW* ACM, 281–288.

Porter, M.E., 1985. *Competitive Advantage*. The Free Press.

Runeson, P. and Höst, M., 2009. Guidelines for Conducting and Reporting Case Study Research in Software Engineering. *Empirical Software Engineering*, 14 (2), 131–164.

Scheer, A.W. and Nüttgens, M., 2000. ARIS Architecture and Reference Models for Business Process Management. *In*: *Business Process Management, Models, Techniques, and Empirical Studies* Springer, 376–389.

Sdu Information Solutions, 2013. *Documentair Structuurplan* [online]. Amsterdam, The Netherlands: Sdu Information Solutions. Available from: http://www.model-dsp.nl/ [Accessed 14 August 2013].

The Open Group, 2009. The Open Group Architecture Framework Version 9. Technical report, The Open Group.

Wagter, R., *et al.*, 2001. *DYA: Speed and cohesion in business and ICT architecture*. Den Bosch: Tutein Nolthenius (in Dutch).

Yu, E. and Mylopoulos, J., 1994. Using goals, rules, and methods to support reasoning in business process reengineering. *In*: *Proc. of HICSS*, Vol. 4, 234 –243.

Zachman, J., 1987. A framework for information systems architecture. *IBM Systems Journal*, 26, 276–292.

## Appendix A. Structured Literature Review Protocol

| **review step** | **procedure** |
|---|---|
| Primary search | Automated search using Google Scholar<br>Terms used:<br>-"business process architecture"<br>-"business process identification"<br>-"business process delimitation"<br>-"business process demarcation"<br>-"business process architecture"<br>Investigated first 5 pages of results.<br>104 papers found. |
| Primary selection | Select papers based on title and abstract.<br>Inclusion criterion:<br>Paper describes approach for architecture design.<br>15 papers selected. |
| Secondary selection | Scan references and citations in 15 selected papers.<br>Select papers based on title.<br>Inclusion criterion: as above.<br>30 additional papers selected. |
| Search verification | Automated search using: Scopus, Web of Science, Inspec, IEEE-IET, ACM-DL<br>Terms used: as above.<br>102 papers found.<br>Select papers based on title and abstract.<br>Inclusion criterion: as above.<br>2 additional papers selected.<br>Scan references and citations in 2 selected papers.<br>Select papers based on title.<br>Inclusion criterion: as above.<br>1 additional paper selected. |
| Data extraction and analysis | Extract:<br>- basis for identifying processes and process relations in the architecture.<br>- concepts used for organizing processes in the architecture.<br>- types of relations identified between these concepts.<br>- relation between concept structure and process architecture. |