Empirical-Based Construction of Reference Models in Public Administrations

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Abstract: This paper introduces a tailored procedure model to construct reference models by using rich empirical data. The procedure model has been built based on requirements from the public administration domain and has been applied in two case studies. Public administrations are currently confronted with the challenge of demands for an increased service level and an efficient handling of requests from citizens and companies. Therefore, there is a strong need to identify common and best practices for business processes. This knowledge is crucial in order to guide reorganisation efforts. Reference models have been established as an important mean to document process knowledge that applies to more than one organisation. To empirically acquire process knowledge in public administrations we propose a tailored procedure model and exemplify its application.

1 Introduction

The public sector exhibits many characteristics that set it apart from private organisations (e.g. [NC05, SGH04]). As one important difference the common public administration service portfolio is significantly more diversified. Municipal processes include over 1,000 interconnected and interdependent services and underlying workflows [Be06]. In many European countries EU directives, federal, and state laws exert significant influence on the organisational structures of public administrations. Within these restrictions municipalities, however, have the right to shape their business processes independently. Consequently, public administrations not only manage huge process portfolios, the individual processes also vary significantly between these organisations.

Currently, public administrations are facing new challenges like cost reduction, new organisational work concepts [SP06, TR00] as well as an increased service level demand. Political pressure is exposed on public administration to support the current economic revival in the European Union by offering improved public services and providing them more efficiently. Therefore, public administrations are forced to rethink their resource allocation, to reduce costs and processing times. This situation urges the identification of common practice and best practice processes for public decision makers. However, cross-organisational process catalogues or registers with common or best practices do not exist.

Conceptual modelling has proven to be an efficient way to gain process knowledge and support process improvement [Da04, DB95]. Business process models are semi-formal, mostly graphical descriptions of the business processes of an organisation. Common and efficient structures within process models can be documented in form of a reference model. A reference model is a robust yet flexible model which comprises universal facts that suit more than one scenario of application [BDK06]. The information within a reference model may be applicable to several organizations of a certain class or type (e.g. branch, business type, size). Reference models represent common or best practices and, often, offer a normative suggestion on how to solve a certain problem. However, the construction of reference models is very time-consuming and expensive. To date, literature provides little guidance on how to efficiently create them.

The aim of this paper is to develop a procedure model for the construction of empirical based reference models. The procedure model is derived based on requirements from the public administration domain. It is applied in two case studies within the public sector. The paper will proceed as follows: Firstly, we will derive the domain specific requirements on reference models and the respective methods for their construction (Section 2). In a second step we analyse the state-of-the-art in reference modelling research and derive research needs to meet the identified requirements for the public sector (Section 3). Then we will introduce and discuss our proposed procedure model in detail (Section 4) and show an example of how to derive reference models from empirical data (Section 5). The paper closes with a brief conclusion and outlook to further research (Section 6).

2 Requirements for Reference Models in Public Administrations

Reference models can be defined as abstract descriptions of a domain, i.e. a particular type or class of organizations [FL03, RA07]. They are reusable artefacts that can be applied in information modelling projects [De06, Sc98]. In contrast to modelling from scratch the use of reference models aims to reduce modelling expenses. Within its predefined scope of application a reference model can guide the creation of an organisation specific model and thus decrease its development costs. Two general requirements can be derived from the purpose of reference models

2.1 General Requirements of Reference Models

A reference models must consist of comprehensive, reusable information of an application domain [BT06]. The value of a reference model is based on the fact that it contains explicit facts that otherwise had to be costly elaborated and reconstructed. To achieve such a collection of relevant domain information, *empirical data* from different organisations has to be gathered, consolidated and generalized [JS07]. To build up a suitable abstract knowledge base, domain experts need to externalise their understandings of an organisations processes [AG07].

We differentiate two notions of empirical influence on reference models:

- Firstly, to represent common or best practices of a domain, a reference model should be an abstraction of a sufficient number of comparable real-life processes. The knowledge must be gathered in a form that allows for analysis and comparison of the processes in order to derive a useful abstraction. This requirement is what we refer to as *empirical foundation* of a reference model.

- Secondly, a reference model needs to be evaluated to ensure its applicability and validity [Fr07]. This requirement can be met by surveying domain experts or by applying the reference model in practise. Therefore, the modelling process must allow for feedback and refining of the model in an iterative manner. We refer to this requirement as the *empirical validity* of a reference model.

Conclusively, we require both a pre- and post-constructive empirical basis of reference models, which leads to our first general requirement:

R1: Empirical Basis: To represent common or best practice, reference process models must be based on rich empirical data *(empirical foundation)*. Additionally, reference models must be evaluated and iteratively refined *(empirical validity)*.

For the practical use of a reference model it is crucial that its application is efficient. This means the efforts to adapt it to a particular organisational context must be lower than building an organization specific model from scratch [BT06]. Thus, the reference model must provide means for efficient application and *adaptation* to organisation specific conditions [Fr07]. It is important that this process is reliable and traceable. Customisation parameters can be e. g. specific legal requirements in the application context or the size of an organisation. Hence, the following second requirement can be derived:

R2: Applicability and traceability: To be a useful tool in organisation specific contexts, reference models must support adaptation while ensuring traceability of customisation.

2.2 Assumptions about Reference Modelling in Public Administrations

Based on the general requirements above, we derive in this section four domain specific assumptions about the process of reference model construction.

A1: In public administrations the collection of empirical data within process models is feasible. By contrast, the acquisition of information about business processes in private companies is regarded as a severe problem. Domain experts and decision makers are often reluctant to reveal this exclusive knowledge as it has a (potential) competitive value. Therefore, it is difficult to establish a sufficient and traceable *empirical foundation (R1)* for reference models. In public administrations, however, the transfer of processes knowledge is less problematic. As governmental bodies do not compete against each other (in a market sense) [Se98], there are no general strategic objections against the collection and use of process data. Therefore, in public administration process modelling techniques can be used to collect the empirical data. Along with the business processes performance data can be acquired (e.g. processing time, required resources).

A2: A thorough evaluation of a reference model is required before it can be applied to a public administration. The services and business processes of public administrations are affected by a comprehensive catalogue of legal regulations [Br00, Wa92, WK05]. The implementation of a new or adapted business process is, therefore, not only influenced by the question whether and to what extent it implies an economic improvement. The business process must also meet technical, legal, and organizational requirements. The complex interdependency between these factors requires ensuring the *empirical validity (R1)* of the model. Consequently, multiple iterations will be necessary prior to approving the reference model and its corresponding adaptation rules.

A3: In the public sector adequate adaptation rules can be identified for reference models. Public administrations offer a great variety of common services. Due to different sizes, deviating competences, and a limited autonomy of the organisations, the process structures of these services may vary considerably [Wa92]. Therefore, a reference model has to be adapted to specific conditions of a public administration. In the private sector such an adaptation is a difficult task. Each company independently defines its service and product portfolio. Therefore, it is hard to specify appropriate adaptation rules that meet the requirements of a multitude of companies. This fact impedes the reference model *applicability (R2)* for private enterprises. In contrast, domain the number and the kind of *public services* is defined by a legal framework. [Br00, RO06] The derivation of application rules is therefore much more feasible in this particular domain.

A4: In public administrations it is crucial that the derivation of a reference model from process data is traceable. Public decision making is based on the principles of transparency and *traceability* (R2) [We22]. Hence, the construction of a reference model in the public sector must be driven by according criteria. The identification of common and best practice needs to be guided by a rigorous and comprehensible procedure. The deviation of common practice, i.e. procedures that have been adopted by a predominant part of the public administrations, must be based on a comparison of the collected process models. Through an analysis of similarities between the different process models common practice can be derived. A comparison procedure that guides the search for common practice must, therefore, in order to be traceable, be documented in detail or additionally be implemented in a tool. Best practices, i.e. process designs with an outstanding performance, additionally require the examination of process *performance indicators*. Thus, a procedure model has to support the collection of such indicators. Furthermore, it necessarily comprises detailed descriptions of how to use these indicators to identify best practice. Again, tool support improves the traceability of this procedure.

3 Related Work on Reference Modelling

An extensive body of research work on reference modelling has been published in recent years (see [FL04, FL07] for further references). The first of two major categories of publications in this area is dedicated to *methods and techniques* for reference modelling. The second category comprises work where specific *reference models* are suggested. These latter publications commit themselves not only to a particular domain (i.e. a particular class of systems or businesses) but also to specific means of description

[BS04, BR03, Sc02, St93]. However, reference models addressing the particular organisational issues of the public sector are still rare (for one of the few examples see [HTP05]). Current publications on reference models for specific domains reveal little if any insights on how the respective domain knowledge has been acquired. In the following we will analyse to what extent existing work on reference modelling methodology supports compliance with the requirements R1 and R2.

3.1 Support for an Empirical Basis of Reference Models

Current reference model construction methods lack support for the acquisition of empirical process data. Process models for reference modelling commonly separate the construction tasks from the application and adaptation process [De06, Sc98]. Schütte focuses on ensuring reference model quality by defining guidelines of reference modelling that are neutral towards application domains and utilised modelling languages [Sc98]. Central issue of the process is the *consensus* of multiple domain experts by means of argumentation. An empirical acquisition of process information is not supported (R1/A1). Given the high diversification of processes in public administrations, argumentative consolidation seems not feasible for reference model construction.

Ahlemann and Gastl additionally take into account the necessity of an empirical grounding for reference models [AG07]. Their approach comprises a two-step empirical inquiry with experts of the domain at hand. The first step utilises structured interviews that aim at extracting domain knowledge by a predefined questionnaire. The strength of the method is the iterative accumulation of domain expertise. This is done to improve the *empirical validity* (R1/A2) of the model. However, the approach is not based on a collection of process models (R1/A1). Methodical guidance for model consolidation based on the empirical results is not provided.

Vom Brocke explicitly facilitates the distribution of reference model construction [BT06]. He introduces a value chain that both includes distribution via sharing and discussion of reference model components as well as supports their application. While his approach supports the continuous refinement of the models, it does not offer guidance for the derivation of the reference models based on empirical data (R1/A1). The strength of the approach is the explicit consideration of a market view on reference models, which is, however, a minor issue in the context of public administration.

3.2 Concepts for Applicable and Traceable Reference Models

The modelling language support for reference model adaptation has extensionally been discussed in literature during recent years [BDK06, De06, KJR06, RA07, BT07]. In fact, the majority of publications on reference modelling methodology are concerned with the support of adaptation mechanisms. These works develop language constructs, which allow for the traceable modification of generic reference models dependent on their respective context of application.

Rosemann and van der Aalst [RA07] develop formal configuration mechanisms for event driven process chains. The method aims for providing model driven adaptation of off-the-shelf software. The main focus is to ensure syntactical correctness and semantic integrity of process models by automatically consolidating changes that are carried out manually by removing model parts. Becker, Delfmann et al. [De06, KJR06] specify configuration mechanisms that allow for a configuration of reference models based on specific business scenarios. Within this approach, integrated reference models are adapted by *model projection*. Furthermore, research in reference model application has addressed *generative adaptation mechanisms* such as aggregation of reference model building blocks, instantiation or specialisation of defined model parts, or derivation of specific models by analogy [BT07]. Within both approaches additional model information needs to be provided for the customisation process (R2/A4).

Conclusively, there is a rich body of research work on adaptation mechanisms to ground our method on, while methodical guidance for an empirical basis of reference models is a hardly developed field. Hence, in the remainder of our paper, we will focus on closing this gap.

4 Procedure Model for Empirical-Based Reference Modelling

The last section of this paper has shown that there is no procedure model for reference model construction, which satisfies the requirement of an empirical basis (R1). In the following a procedure model is presented that addresses this requirement and considers the specific assumptions of the public administration domain. The procedure model is depicted in Figure 1.

Step 1: Empirical acquisition of business process knowledge: The creation of a reference model starts with the collection of empirical data about a business process. This requires the following steps:

- *Choose and define the process:* Initially, an adequate process must be chosen that can be transformed into a reference model. A process is adequate when it is non-specific to a particular organisation and might be of interest in multiple contexts. The boundaries of this process must be fixed in order to define the scope of the reference model.

- *Select public administrations:* Representative governmental bodies must be chosen where the selected process can be modelled. Relevant criteria can be for example the size of the organisation, its competences, or its regional and political affiliation. Also, organisations with a particular internal process structure or an outstanding performance should be considered.

- *Record process data:* The process data can be acquired in interviews, questionnaires, or through document analyses. The modelling of the process data can be conducted in a distributed manner. However, since *comparable* process models are essential to our method, strong modelling guidelines as well as a common terminology need to be agreed on prior to modelling. We suggest using a domain-specific modelling language (cf. Section 5) to address these requirements

[Pf07]. Beside the mere order of tasks, additional information such as responsibilities, resources and performance figures need to be recorded. Performance indicators are in particular important as they can be used later to identify best practice.

Step 2: Construction of the reference process model: Based on the empirical data collection the reference model can be derived. Two types of reference models can be created from the data inventory. Firstly, a reference model can be constructed that comprises the *common practices* of the process:

- *Compare Process Structure:* The collected processes need to be *comparable* in order to apply an automated matching. The common elements of the process models can be identified and declared to parts of the reference model. Specific process steps can be erased or hidden and annotated with their organisation's specific outline data for adaptation purposes.

- *Integrate Common Structures:* The parts identified as common process structures can now be integrated into the reference model. However, conflicts such as different order of processing steps can arise. These conflicts need to be resolved.

Secondly, processes with outstanding performance figures can be elaborated to identify *best practices*. Starting point for this task are the measures for process performance such as processing time or resources spent. This data has been collected with the processes. If a manual, experience-based analysis indicates causality between good performance and process structure, the process or parts of it can be included into the reference model. However, the decision on a causal relation requires excellent knowledge about the corresponding domain, especially if certain measures are to be prioritised. However, it is not always feasible to derive a best practice process from the available data. If it is not possible to construct the reference process from the existing information a jump back to the data collection phase is required.

Step 3: Integration into a reference process model catalogue: The procedure model represented here initially focuses on a single process only. However, ultimately it aims at iteratively covering the typical process landscape of a public administration. To achieve a coherent representation, the individual models need to be integrated into a framework, e.g. in a process catalogue. Therefore, links and dependencies must be identified and possible conflicts need to be resolved. The result of this step is a comprehensive structure which comprises all reference processes, shows their interdependencies and allows for efficient retrieval within the process repository.

Step 4: Annotation of the reference process model: To enable the transformation of the reference model into an organisation specific model, the annotation of adaptation attributes is helpful. Under consideration of the empirical data collected it is possible to derive placeholders for instantiation and markers for specialization or analogy construction. Components of the reference model can be highlighted as appropriate elements for aggregation. With the annotation of configuration attributes and the definition of corresponding configuration rules the reference models can be adapted specifically to the requirements of a certain situation or organisation. For example a configuration rule could filter out all activities that are related to electronic payment if

such a system is not available in a small public administration. The intended scope of the reference model influences the specification of configuration rules.
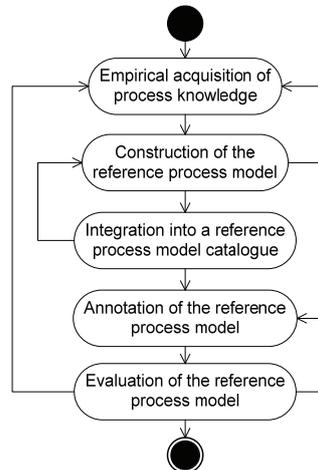

Figure 1: Procedure model for the empirical data based construction of reference models.

Step 5: Evaluation of the reference process model: The quality of a reference process model can be tested empirically in a specific project situation. The value of the model can be assessed based on the utility it provides within the project. Before the evaluation can start it is crucial to make sure that the intended scope of the reference model matches the project situation at hand. For the assessment of the quality of the reference model it can be differentiated between, firstly, the correctness and the utility of the model itself and, secondly, the support for efficient adaptation. The quality of the reference model depends on whether it can be transformed into a meaningful organisation specific model. The quality of its adaptation support, however, relies on the usefulness of the annotation with attributes and rules. If weakness in the reference model are identified it must be returned into the construction phase or the annotation phase respectively. This construction / evaluation cycle leads after a couple of iterations to an empirically founded and confirmed reference process model. It terminates when a stable version of the reference model is reached.

5 Evaluation of Empirical-Based Reference Modelling

Two case studies in the public sector have been performed to evaluate the procedure model. In these two projects we have applied the PICTURE-process modelling method to collect the processes. The PICTURE method has specifically been designed for the public administration domain. The case studies took place in two different organisations. The ultimate goal of these two and additional subsequent case studies is to constitute a reference model for the entire public sector. In this paper we present the first preliminary results based on the first two steps of the procedure model.

Altenberge (A) is a municipality in the Münsterland region in Germany with about 10,000 inhabitants. Around 35 officials are working in the core administration. The modelling project goal in this municipality was to verify the existing service catalogue from Altenberge. For that purpose we identified 461 services. We captured the services with the PICTURE-method using the corresponding tool. The process collection was performed over a period of six month with a team of 14 modellers.

Münster (MS) is a county-free city in Northrhine-Westphalia in Germany with about 280,000 inhabitants and around 4,000 officials in the core administration. The project goal in Münster was the documentation of all citizen-centred processes. The modelling project was limited to six offices in three departments of the administration. Within six months 14 modellers identified and modelled 172 processes with the PICTURE-method.

Step 1: As an exemplary process we selected the preparation of a marriage. We chose this process for its moderate size and its commonness. The reference model intends to abstract from size or location of municipalities. Thus, Altenberge and Münster have been selected for their different size and organizational structure. The processes have been collected using the PICTURE-method which supports strong involvement of the officials in the modelling project. Their active participation in the project helps to efficiently acquire the process knowledge.

Modelling with PICTURE is performed in a coarse granular form with standardized modelling elements, so called *Process Building Blocks (PBB)*. These standardized elements simplify modelling and allow for greater comparability of the models (for a detailed description of the PICTURE-method cf. e.g. [Be07a, BPR07]). The PICTURE language characteristics allow for an efficient acquisition of processes. Figure 2 shows the marriage preparation process of the two organisations in PICTURE-notation.

Step 2: After collecting the empirical data we analyzed the models with regard to common process segments. A tool-based comparison identified mutual PBBs, which where integrated into the reference model accordingly. Whereas type and naming conflicts are basically avoided by the utilised modelling method, ordering conflicts still occurred as seen in the use of the PBB "Printing". The arrangement of the marriage date is done before printing in the MS-process and after printing in the A-process. The resolution of this conflict has been conducted manually – in this case the order of fixing the date and printing the information is arbitrary and therefore not a subject for the subsequent annotation in step 4.

PBBs that solely occur in some of the process instances recorded will be transferred to the reference model depending on the predefined threshold. Since we have two processes to compare in this example the threshold of occurrences of the PBBs is set to two. Hence, the automated analysis identified five PBBs that were contained in only one of the process instances (marked grey). In a subsequent manual analysis the PBB "Encash" has been marked to be retained, the remaining four (marked grey) were not included. The decision to keep the "Encash"-PBB was due to the finding that the respective activity actually did exist in both organisations. It appeared that Altenberge modelled a separate encash process according to their organisational structure. Since the reference model aimed to represent the full marriage preparation process, the respective PBB was integrated.
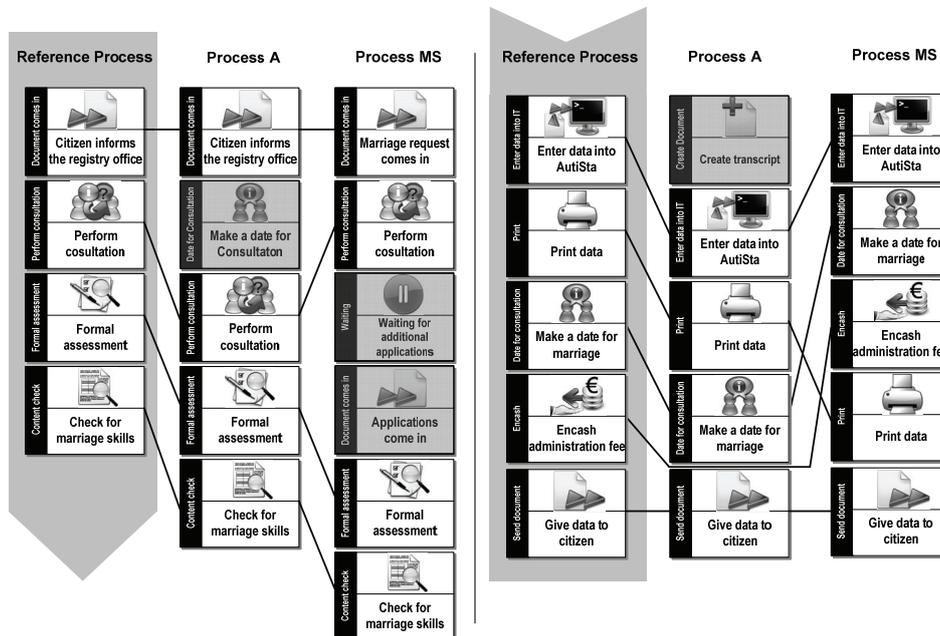
Figure 2: Process of preparation of a marriage.

Currently, we are continuously collecting additional empirical process data. For this purpose, PICTURE-projects in other cities are currently under way or more are planned. Steps 3 to 5 of the procedure model will be applied as soon as sufficient process data is available to make reliable statements about the constancy of the reference processes and their context-dependent variants. As more data is available, manual interventions within the reference model derivation process will become less important. Our long term objective is to create a catalogue of reference models for public administration based on our procedure model.

6 Summary and Outlook

Currently, many public administrations in Europe are facing a high reorganisation pressure. However, knowledge about common or best practices is not available in the public administration domain. In this paper we have proposed a reference modelling method that seeks to analyse and reconstruct domain knowledge by eliciting empirical processes data. We have pointed out that the utilisation of a modelling language combined with strict modelling guidelines or domain-specific constructs supports the efficient derivation of reference models. Furthermore, we exemplified our procedure model by using the PICTURE-method as a strictly standardized language for the public administration domain. Based on two case studies we have demonstrated how a reference process can be derived from the recorded data. Currently, modelling projects with municipalities all over Europe seek to gather more process data based on the PICTURE-method and the procedure model. The objective is to enrich our data base of

public administration processes. Along with the elicitation, the process catalogue is empirically validated and perpetually refined. Future research will be necessary to evaluate the reference model catalogue once it has reached a stable state. In principle an adoption on other domains is also possible. This is feasible by a change of the domain-specific constructs within the PICTURE-method.

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