Evaluation of ICT Investments in Public Administrations Based on Business Process Models

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Abstract. Within the public sector domain there is great potential for business process optimization through ICT. However, until today these possibilities remain largely unexploited. To measure the impact of ICT-investments all processes of a public administration have to be taken into account. The PICTURE modelling method has been proposed as a way to efficiently model the whole process landscape of a public administration. Based on the processes captured, the impact of certain ICT functionalities can be analyzed. ICT investment decisions become more transparent towards the political leadership which are the decision makers in the public sector. This paper has two research objectives: First, an architecture for an semi-automated evaluation of ICT investment decisions is introduced. Second, the practical feasibility of the architecture is shown based on an investment decision for a document management system.

Keywords: E-Government, Public Administration, Process Landscape, ICT Investment, Decision Support.

1 ICT Investments in Public Administrations

Process reorganization and optimization through ICT bears great potential for public administrations (PA) [1, 2] in Europe. Infrastructure oriented software products like workflow management systems (WFMS), document management systems (DMS), or optical archives (OA) play a particular important role in this context. These systems have been established as good solutions for back-office reorganization because of their impact on multiple business processes.

Especially in PAs these potentials remain largely unexploited due to missing transparency. Municipal administrations often hesitate to invest into new or bigger ICT components. Due to this missing transparency ICT investment decisions cannot be justified towards the political leadership and the public. Therefore, often only few processes which are easy to assess are reorganized [3].

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The full impact of ICT investments can only be assessed when considering the complete process landscape of a PA [4]. For example a DMS is not only able to support the process "handle building application" but also the processes "handle application to run a restaurant" or "handle application for housing allowance". Therefore, all of these processes should be taken into account, when deciding on ICT investments. To consider the process landscape of a PA means to refer to its complete set of processes.

Transparency about the process landscape can be achieved by using the PICTURE modelling approach. The PICTURE-method is a domain specific approach [5-8] designed for process modelling [9, 10] in PAs. It enables capturing the whole process landscape by fixing the level of detail of the models [11]. This is important due to the various potential contributors to models in PAs [12]. The PICTURE-method is easy to understand and it enables the involvement of employees of a PA into the modelling process. This allows for an efficient acquisition of a large number of processes. PICTURE has been chosen in this paper as it is to our best knowledge the only PA-specific modelling approach that focuses on the representation of the entire process landscape [13].

The contribution of this article is to present an architecture for a semi-automated evaluation of ICT investments. Basis for this analysis are PICTURE process models. These models explicate the implicit knowledge [14, 15] about the process landscape and, therefore, provide the information needed to assess the impact of ICT-investments on the processes. By using the whole processes landscape as foundation for the analysis, investments decisions become more transparent and justifiable.

The reminder of the paper proceeds as follows: The second chapter outlines the core elements of the PICTURE modelling language. Chapter three describes the architecture of the ICT investment evaluation approach. It explains how the impact of ICT investments can be evaluated on the basis of PICTURE process models. The fourth chapter presents an implementation of the evaluation methodology and illustrates its application. The paper concludes with a summary of its core contributions and an outlook to future research areas.

2 The PICTURE Process Modelling Approach

PICTURE is a domain specific modelling method with a corresponding web-based tool. The PICTURE-approach consists of two core components: The *process landscaping module* and a *reporting framework*. In section 3 the support of ICT investments decisions by the reporting framework is described. In the following the process landscaping module with the PICTURE modelling language is presented.

The two fundamental constructs of the PICTURE modelling language are process building blocks and attributes. Additional constructs that rest upon these basic ones are processes, sub-processes, variants, and anchors. To structure the different elements, the PICTURE-language distinguishes different views on the process landscape.

Views: Like many other process modelling approaches PICTURE uses views in order to handle and effectively reduce complexity. PICTURE consists of four different views (Fig. 1):

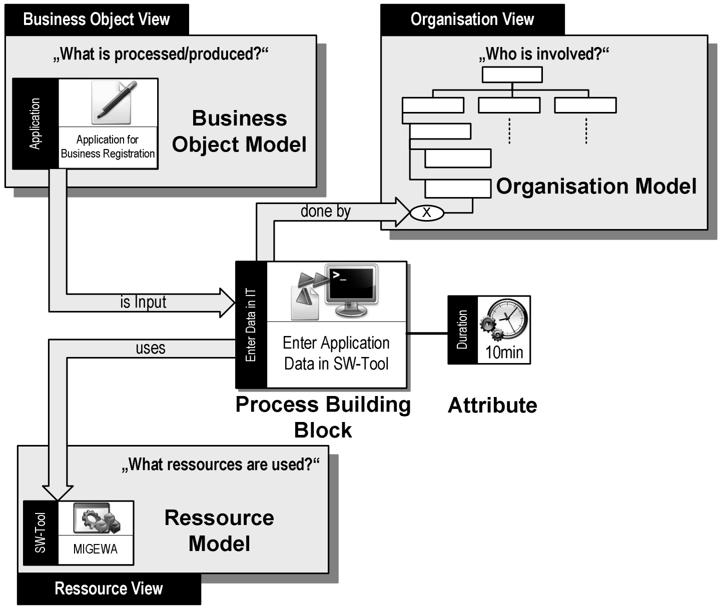


Fig. 1. Views, Building Blocks, and Attributes within the PICTURE-Method

- Process View ("How is a service delivered?")
- Business Object View ("What is processed/produced?")
- Organization View ("Who is involved in the modelling process?")
- Resource View ("What resources are used?").

Process Building Blocks: A main construct of the PICTURE modelling language are *process building blocks (PBB) [16].* A PBB represents a certain set of activities within an administrative process. The name of a PBB is taken from the vocabulary of the PA domain [17]. PBBs are atomic, have a specific level of abstraction, and are semantically defined by a domain concept. Therefore, in an analysis of the models problems like *naming conflicts* [18] are avoided. As the type of the PBB defines the semantics of the model element such conflicts do not occur. Examples for PBBs are "Incoming Document", "Formal Assessment", "Enter Data in IT", or "Archive Document". PBBs belong to the process view.

Attributes: Additional facts about the processes can be collected with the help of *attributes* assigned to the PBBs. These attributes specify the properties of the corresponding building blocks in detail. For example, an attribute of the PBB "Enter Data into IT" is "Duration". Attributes provide the core information for the subsequent process analysis. They establish a connection from the central process view to the business object, organization, and resource view.

Processes: A process performs a certain administrative service. In PICTURE processes are represented as a sequential flow of PBBs. A process can further be described by attributes. It can be connected to organizational units or employees.

Sub-Processes: Many processes are quite complex and run through several different organizational units. In order to simplify the modelling of processes the concept of sub-process is introduced. A sub-process in PICTURE is defined as a part of a process that is covered by only one employee.

Variants: As modelling with the PICTURE-language is strictly sequential a construct is needed to describe contextually important ramifications in the process flow. For that purpose PICTURE offers two possibilities: On the one hand attributes can be used to specify different cases with percentage values, e.g. for different contact channels (mail, email, phone, or personal). On the other hand it is possible to specify process variants. A *process variant* defines an alternative sequence within a sub-process. The frequency of a variant is captured by percentage values.

Anchor: An anchor allows for establishing connections between PBBs in different sub-processes and variants. For example the PBB "Outgoing Document" from variant A in sub-process II can be connected to the PBB "Incoming Document" from sub-process III. The exchanged document is for example a change request. In this case an anchor is established between the two corresponding PBBs. Thus, the anchor connects different sub-processes to form a process. Fig. 2 shows how processes, sub-processes, variants, and anchors work together.

With the PICTURE-language similar activities are modelled by the same type of PBB. The PBBs limit the degree of freedom during modelling. This leads to reduced

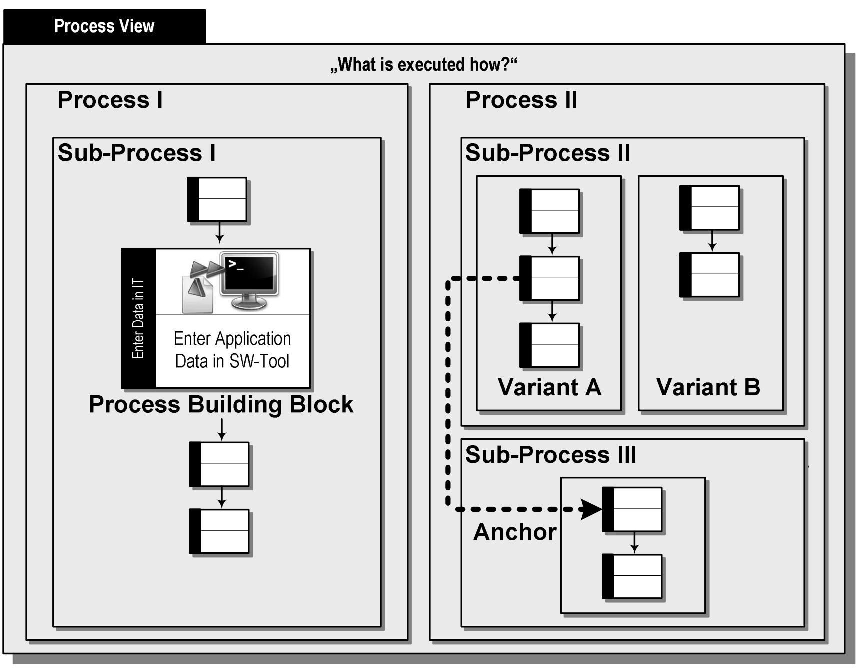


Fig. 2. Processes, Sub-Processes, Variants, and Anchors within the PICTURE-Method

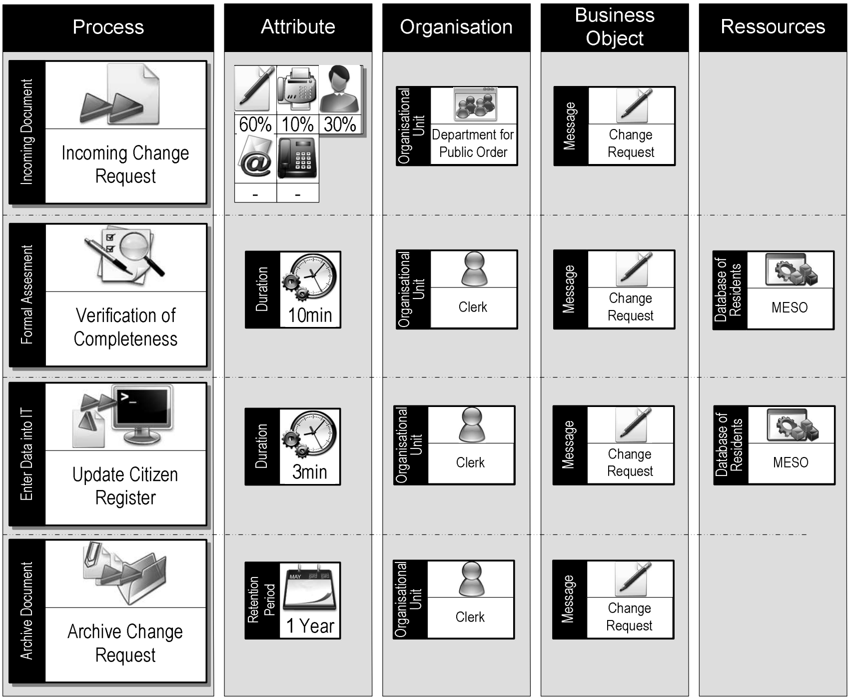


Fig. 3. Example Process "Update Citizen Register" in PICTURE-Notation

deviations when different modellers are involved in a project. Additional information is collected in a structured way and by a standardized set of attributes per building block. Thus, the occurrences of specific combinations of PBBs with certain characteristics can be identified by a simple syntactic search. The analysis algorithm does not need to use natural language processing to capture the semantics of a PBBs, which avoids analysis problems like naming conflicts or structural conflicts [19].

Fig. 3 shows the process "Update Citizen Register" as an example of a PICTURE-model. The process is triggered when a citizen moves to a new address. By law a citizen is required to inform the government by handing in a change request. This fact is visualized by using the PBB "Incoming Document". Within the following four columns additional information are given regarding attributes, the organization responsible, the business object, and the resources used in order to process the building block. This information is relevant for an analysis of the process model. The next step within the process depicted by the next PBB is "Formal Assessment". In this PBB the completeness of the change request is verified. Afterwards the citizen register database is updated and the change request is archived for at least one year.

As the example shows, the focus of modelling with PICTURE lies on an easy capturing of the PA's process landscape. The models are annotated with facts that are relevant for ICT investments decisions. The use of PBBs and corresponding attributes prepares an automated analysis of the models. In the following the corresponding reporting framework is presented.

3 An Architecture to Evaluate ICT Investments

An ICT component such as a DMS, a WFMS, or an OA can have several optimization effects on the process landscape. The main quantifiable benefits are reductions of processing, transport and waiting times, elimination of errors, or a decreased material consumption. Due to legal regulations and the involvement of a large number of external agents reorganization in the public sector is highly constricted. It is difficult and time-consuming to provide a realistic forecast of these benefits. Therefore, it is helpful when the examination of the process landscape can be performed in a semi-automated form. Unlike traditional process modelling approaches the PICTURE-language allows for such a semi-automated analysis of the process landscape. The information that has been captured by the *modelling component* is saved in a *process model repository*. The corresponding architecture of the framework is described in Fig. 4. The PICTURE reporting framework is based on the following elements (c.f. Fig. 5):

Process building block pattern: Basis to analyze PICTURE-models in an automated form are the so called *process building block patterns (PBBPattern)*. A PBBPattern represents a specific weakness, inefficiency, or potential improvement in the process landscape. It consists of a sequence of PBBs with specific corresponding attribute values. A PBBPattern can contain required and/or unwanted PBBs as well as placeholders for arbitrary PBBs. A PBBPattern is used to search the process landscape for specific (sub-) processes that fit to its specification. The PBBPattern comprises all requirements a (sub-) process has to meet to be counted as a match. An example for a PBBPattern is the sequence of the PBBs “Enter Data into IT” and “Print Document”. A PBBPattern is connected to a key figure. PBBPatterns together with its key figures are stored in the *PBBPattern / key figure repository*.

Key figure: A key figure is the basis to quantify the specific effect of an ICT component on a PBBPattern. It is applied to evaluate the occurrences of the PBBPattern in a quantitative form. The key figure is defined by a formula that is based on the attributes of the *Pattern elements* (e.g. “number of pages”), and (sub-) process attributes (e.g. “number of cases per year”). The data to calculate the key figure is derived from the attribute values of the (sub-) processes where the PBBPattern matches. An example for a key figure is the number of printed pages per year. It is calculated by a multiplication of the attribute “number of pages” in all the instances of the PBB “Print Document” with the corresponding (sub-) process attribute “number of cases per year”. For this computation all (sub-) processes where the PBBPattern is found are considered. Consequently, a key figure refers to a *PBBPattern* and a *savings rate*.

Savings rate: The savings rate estimates the effects of the introduction of a specific ICT product. It is used to calculate a monetary savings potential of an ICT component based on a key figure. For instance it can be assumed that the introduction of a DMS saves 0.02 Euro per page printed in the organization. In the example of the key figure “printed pages per year” and with a savings rate of 0.02 Euro per page for a DMS an annual saving potential can be derived. Based on that data an investment decision for the DMS can be made. The savings rate is a project specific monetary value. A

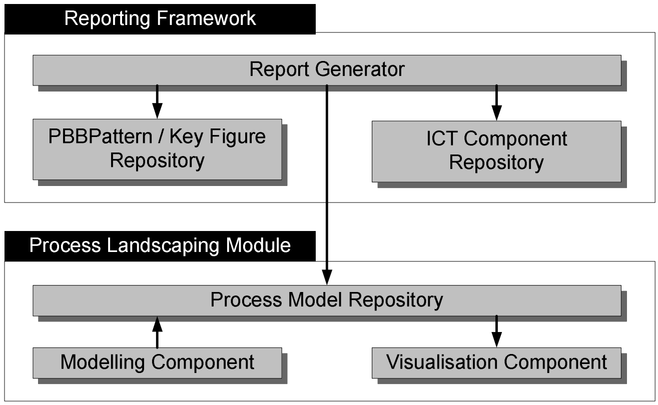


Fig. 4. Logical Architecture of the Reporting Framework and the Process Landscaping Module

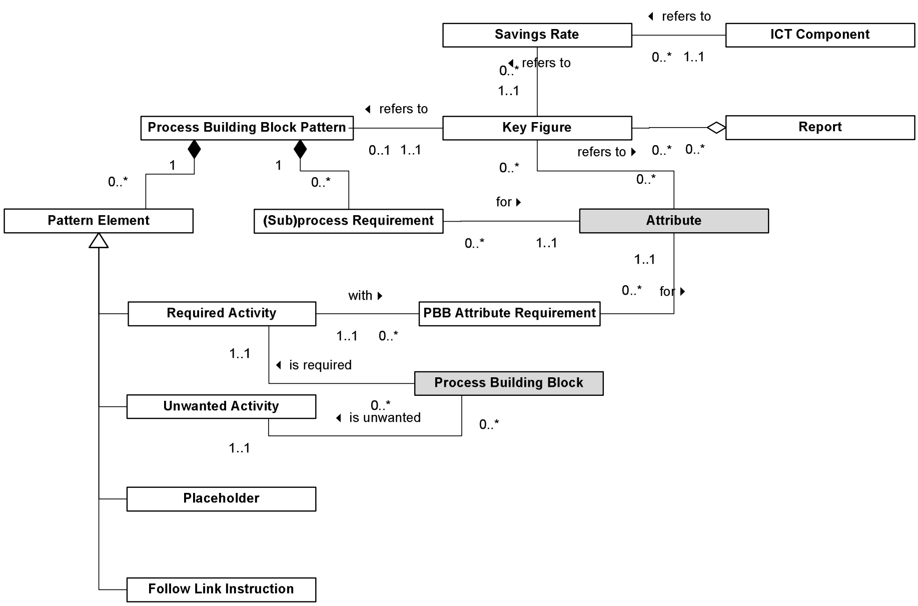


Fig. 5. Metamodel of the Pattern-based Analysis

possible source for savings rates is the cost accounting of the organization. The savings rates are stored in the *ICT component repository*.

Report: A report contains all relevant information for an ICT investment decision. It comprises a single or multiple key figures. For each key figure the corresponding savings potential is displayed and visualized in a chart. Reports can be designed for specific ICT components. For example there can be a report for the introduction of a DMS, with the number of "printed pages per year" and the corresponding savings potential. The reports are created by the *report generator*. The report generator uses data from the *process model repository*, *the PPBPattern / key figure repository*, and the *ICT component repository*.

Pattern element: A pattern element represents a PBB which is required respectively unwanted in a (sub-) process with respect to a PBBPattern. A PBBPattern consists of a sequence of pattern elements. A PBBPattern matches a (sub)-process if all pattern elements have a corresponding (*required activity*) and have no (*unwanted activity*) counterpart in form of a PBB in the (sub-) process. A *placeholder* stands for a number of PBBs that are ignored in a (sub-) process. It defines the maximum number of PBBs until the next required activity has to be found in the (sub-) process when the PBBPattern matches. The f*ollow link instruction* requests the analysis algorithm to continue its search in the next connected sub-process. This allows for more intelligent patterns that span over the borders of a sub-process.

PBB attribute requirement and (sub-) process requirement: Beneath a sequence of pattern elements also specific attribute values are relevant in order to make a PBBPattern match. The *PBB attribute requirements* define for each *required activity* the value ranges for its attributes so that a PBBPattern applies. The *(sub-)process requirements* contain all attributes of a process or sub-process which are relevant for the pattern. Similar to the *PBB attribute requirements* a specific value or value range can be specified for the PBBPattern.

When the analysis algorithm is executed the *process repository* is scanned sub-process by sub-process and variant by variant for a specific PBBPattern. Whenever a match is found the corresponding key figures are derived based on its calculation formula. By using the savings rates the results are computed for each process and aggregated for every organizational level of the PA. An aggregation of the data at different stages allows for a drill-down and roll-up analysis. Hence, based on the key figures and the savings potential relevant processes for reorganization can be identified. By following the organization chart the user can identify processes with abnormal values.

PICTURE is able to forecast the potential benefits of an introduction of a single ICT or even a group of ICT components. Based on different scenarios potential savings can be forecasted. Due to an automated pattern-based analysis of the process models this process is less time-consuming than a manual analysis. To derive ICT-investment strategies from the analysis results the potential benefits (considered to be realistic) have to be compared with the introduction and maintenance costs of an ICT component. A forecast of these costs is usually much less time-consuming and more reliable than the forecast of the potential benefits.

4 Implementation and Use of the Reporting Framework

The reporting framework has been implemented as a module of the web-based PICTURE-tool. The module provides a construction kit for PPBPatterns, key figures, and reports. Similar to the process landscaping module it is designed to enable a simple and intuitive construction of these elements.

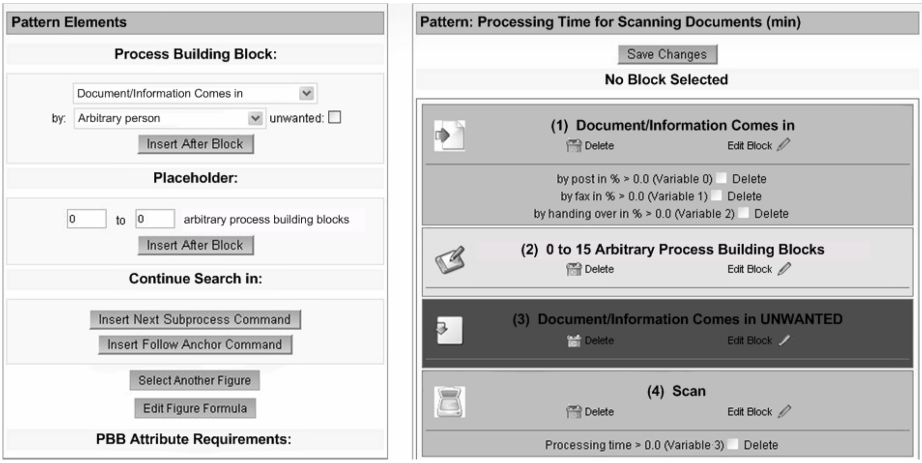


Fig. 6. Screenshot of the Construction of a PPBPattern

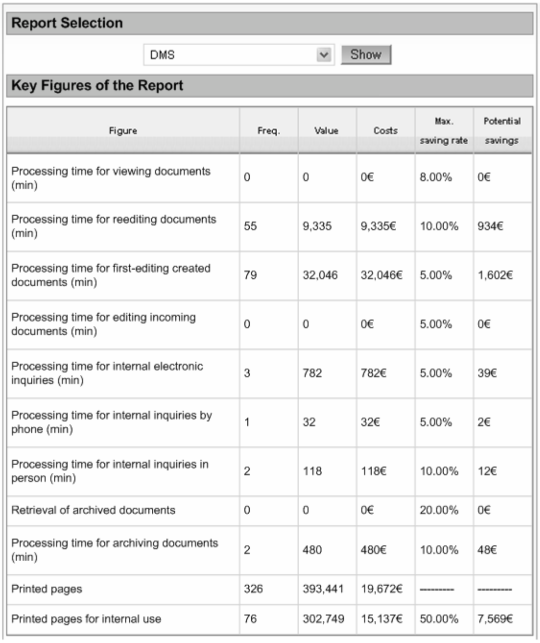
The PICTURE process landscaping module has previously been evaluated in two case studies [20, 21]. After that the reporting framework has practically been applied in a project in Altenberge, a small municipality in the Münsterland with about 10,000 inhabitants employing 40 officials in the core administration. In this case study 88 interviews with the officials were conducted. The project group was composed of a project manager, four sub-project managers and fourteen team members. Each interview was conducted by two team members together with one or two officials of the administration. In these sessions altogether 466 processes could be identified. Two-thirds of them were modelled as detailed PICTURE processes during the interviews using the process landscaping module. Based on the interviews an ICT reorganization potential analysis was performed. The following three steps have been performed to evaluate the investment in a DMS:

First, 30 DMS-related key figures and corresponding PBBPatterns were entered into the tool. They were configured with cost- and saving rates. Fig. 6 shows an example of a PBBPattern. It maps to incoming printed documents that are scanned within the next 15 PBBs and not forwarded before scanning. This example refers to the savings potential for a central DMS in a PA.

Second, after the definition of the key figures and PBBPatterns the analysis algorithm was started for the project. The automated search for *PBBPatterns* such as the example in Fig. 6, the calculation of the *key figure* values, and the aggregation of these results took about half an hour.

Third, the evaluation results in form of reports were examined and manually interpreted. While exploring a holistic IT-Strategy for Altenberge, time consumption for creating, editing, and archiving documents could not justify an investment for the small administration Altenberge (c.f. Fig. 7). More promising as starting point for future investments was the time consumed for gathering all required information intra-organizationally, since this is performed mostly manually so far.

The processes, in which the about 300,000 pages are printed for internal use only, were also analyzed manually. For that purpose the tool provides a list of all relevant



Report Selection

DMS Show

Key Figures of the Report

Figure	Freq.	Value	Costs	Max. saving rate	Potential savings
Processing time for viewing documents (min)	0	0	0€	8.00%	0€
Processing time for reediting documents (min)	55	9,335	9,335€	10.00%	934€
Processing time for first-editing created documents (min)	79	32,046	32,046€	5.00%	1,602€
Processing time for editing incoming documents (min)	0	0	0€	5.00%	0€
Processing time for internal electronic inquiries (min)	3	782	782€	5.00%	39€
Processing time for internal inquiries by phone (min)	1	32	32€	5.00%	2€
Processing time for internal inquiries in person (min)	2	118	118€	10.00%	12€
Retrieval of archived documents	0	0	0€	20.00%	0€
Processing time for archiving documents (min)	2	480	480€	10.00%	48€
Printed pages	326	393,441	19,672€	---------	---------
Printed pages for internal use	76	302,749	15,137€	50.00%	7,569€

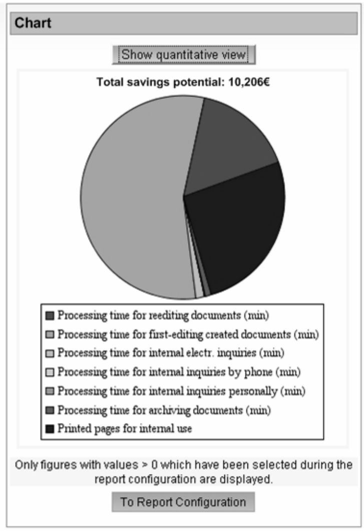


Fig. 7. Screenshot of a DMS Report

processes ordered by the number of printed pages. It is possible in the tool to change the savings rates "on the fly" while interpreting the results. This allows for answering questions like "If the printing costs rise to the amount of x, will that justify the investment in a DMS?" With these mechanisms the break even for the ICT investment was calculated.

5 Conclusions and Further Research

In this paper we have employed the domain-specific modelling method PICTURE. PICTURE uses semantically predefined process building blocks for the process modelling. Based on that we have presented an architecture for an automated evaluation of ICT investments. The entire approach was implemented and evaluated in a case study in the small municipality Altenberge.

The example of Altenberge shows that not in every case ICT investments that were considered before are sufficient. In smaller organizations the costs for a software solution might exceed the expected benefits. The example also indicates that the aggregation of weaknesses in the process landscape can lead to the identification of additional reorganization potentials not expected beforehand and therefore provide more transparency for ICT investments.

The proposed methodology cannot only be used to calculate on ICT investments. Furthermore, it is possible to evaluate process reorganisation, efficient application of employees or later on efficient handling of citizen services as a whole.

The aggregation of the efforts needed in the project in Altenberge show – in addition to the efforts calculated in former projects [20] – that the enforcement of a process modelling and analysis project with the PICTURE method is much more efficient than comparable projects with generic modelling methods.

In our future work we aim to extend our set of weakness patterns for public administrations and will evaluate those in future projects. Additionally we will try to incorporate further aspects of process enhancements like process quality or customer satisfaction into our approach.

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