An Approach to Support the Performance Management of Public Health Authorities using an IT based Modeling Method

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ABSTRACT

In this paper we describe a modeling method for supporting performance management by building upon the current challenges of public health authorities. Through focusing on the performance management requirements of national competent authorities (NCA) that fulfill several duties in regard to the marketing authorization of medicinal products, we derive a modeling language, an according modeling procedure and mechanisms and algorithms. Thereby, particular requirements in regard to the compliance to legal regulations, the competition of NCAs within the European Union, the allocation of resources under uncertainty, and the specific human resource requirements of NCAs have to be taken into account. The modeling language is formally described using a meta model based approach and implemented on a meta modeling platform. For the evaluation, the modeling method has been applied in a scientific study with the Austrian national competent authority AGES PharmMed.

1. INTRODUCTION

According to the latest OECD data, public and private spending on health care continues to have a large share of GDP in the western countries, ranging from sixteen percent in the United States to about nine percent on average in the countries of European Union [31]. Thereby, the growth of the expenditure for pharmaceuticals has recently exceeded both economic growth and growth in the health care sector as a whole [30]. In the European Union, the pharmaceutical market therefore received continuous political attention with the goal to liberalize the market and encourage innovation and competitiveness of the European pharmaceutical industry [40].

This view also applies to the public authorities that perform official duties in the health care sector as a public service. They work together as partners with other member states, other agencies, the European Medicines Agency (EMA) and the European Commission (EC) in a European medicines network [13]. One of their central duties is to act as national competent authorities (NCA) in regard to medicinal products [8]. This includes but is not limited to the approval of clinical trials, the marketing authorisation of medicinal products, the inspection of clinical trials and medicinal product manufacturers, and the provision of scientific advice mostly to the pharmaceutical companies and other sponsors of drug developments. They thus fulfill an important function in regard to the safety of medicinal products on the market and play a key role during the research and development stages of new substances and devices. To meet these tasks, the authorities have to maintain a high scientific standard and use their resources in the most effective way. Constant progress in scientific methods and the development of new therapies such as gene therapy, tissue engineering or nanomedicine, require the permanent adaptation of the evaluation and inspection procedures on the side of the authorities [26]. Furthermore, the unpredictability of potential applications that need to be processed within legally defined timeframes and unforeseen crises such as the European influenza pandemic in 2009, make it difficult to almost impossible to forecast the required resources. Although the authorities receive financial remuneration and fees for some of their services by the EC and the EMA or the pharmaceutical companies, several procedures are not fully reimbursed but still have to be completed on time [33]. This leads to major challenges in regard to managing and optimizing their performance that have to be met on a strategic, long-term basis as well as during day-to-day operations.

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To address these challenges and support performance management in this environment, we developed a modeling method for performance management and evaluated it in the course of a scientific study with Institute Science and Information of the Austrian competent authority AGES PharmMed. The goal of the approach is to take into account the specific requirements of competent authorities and support them in the definition of their strategy, the operationalization of the strategy, and the implementation of the strategy in their day-to-day processes. Thereby, particular attention was given to the online scheduling and re-scheduling of resources and the full compliance to national and EU wide regulations.

The remainder of the paper is organized as follows: In section 2 we will briefly outline the foundations of model based performance management and the specific requirements by competent authorities. Section 3 will describe the performance modeling method that has been developed specifically for the use by competent authorities. The application of the approach in a scientific study with AGES PharmMed together with a first evaluation constitutes section 4. Section 5 discusses work related to our approach and section 6 concludes the paper and gives an outlook on future developments.

2. PERFORMANCE MANAGEMENT FOR COMPETENT AUTHORITIES

Performance management in general comprises the systematic generation and control of an organization's performance with the ultimate goal to achieve sustainable organizational performance [25, 41]. Thereby it is assumed that an organization that performs well is one that attains its objectives in the way of effectively implementing an appropriate strategy [32]. Performance management typically comprises tasks such as [32, 14]:

- Defining the goals and measuring the attainment of goals
- Formation of strategy and its deployment to the business processes and operations management
- Defining the level of performance by setting appropriate performance targets
- Linking the achievement of performance targets to employee reward systems
- Defining the information flows that enable the organization to learn from its experiences

Whereas early approaches of performance management focused mainly on financical figures as the foundation for measuring performance, most of the currently used approaches take a holistic view that links strategy and operations by using a broader set of measures [39]. Thereby, financial figures are treated as one among several types of performance indicators that support decision-making processes [6, 14, 39]. For implementing performance management in an organization it can be chosen from a wide range of frameworks [41], each with its particular advantages and pitfalls. Several authors have therefore proposed to integrate different aspects of performance management frameworks to provide an interface between performance management concepts, the underlying IT infrastructure, and the involved stakeholders [36, 37, 41].

2.1 Model based Performance Management

To cope with the complexity involved in integrating different performance management frameworks and deploying such a holistic approach successfully in an organization, it can be reverted to IT based modeling approaches [35]. This applies to the formal representation of strategic relationships and measurements [23], the description of the according data models [5], as well as their integration and implementation on IT systems [22, 36, 37].

From a generic point of view, model based approaches in the scope of this paper are characterized by a modeling method which consists of a modeling technique and mechanisms and algorithms - see figure 1. The mechanisms and algorithms can either be generic in the sense that they are applicable to all modeling methods, specific in the sense that they can be applied to particular methods or hybrid in the way that they can be configured to work on several modeling methods. The modeling technique is composed of a modeling language with its syntax, semantics, and graphical notation and a modeling procedure that defines the application of the modeling language and the use of the mechanisms and algorithms [17]. The semantics of the language is defined by a mapping to a semantic schema. For our purposes, the schema will be natural language, which is common for conceptual visual models [28]. It is however also possible to use more formal approaches such as ontologies for the schema definition [29]. From the viewpoint of information systems, such modeling methods can be used to support the communication between developers and users, help analysts to understand a domain, provide input for the design process, and document the original requirements for future reference [19, 20]. In addition, they can be implemented in IT tools and used for the formal representation and IT based analysis. Thereby they can serve as direct input to the configuration of information systems such as enterprise resource planning systems, business intelligence applications or workflow engines.

In the context of performance management, the scope of the modeling method thus needs to be set in terms of the used modeling technique and the required mechanisms and algorithms. The modeling language and the modeling procedure can then be derived based on: the categories of information required to manage an organization; the methods used to generate this information; and the rules regulating the flow of information [6]. This concerns in particular information about: the goals and their measurement, the strategy and its embedding in the business processes, the current and intended levels of performance, the rewards for the employees, and the access to and use of the information itself.

2.2 Specific Requirements of National Competent Authorities

The management and measurement of performance in the public sector and health care organizations in particular, has been characterized by Mettler and Rohner as a "somehow daunting endeavor" [27, p.700]. For their argument they refer to Boland and Fowler who traced these difficulties back to the lack of a profit maximizing focus, little potential for income

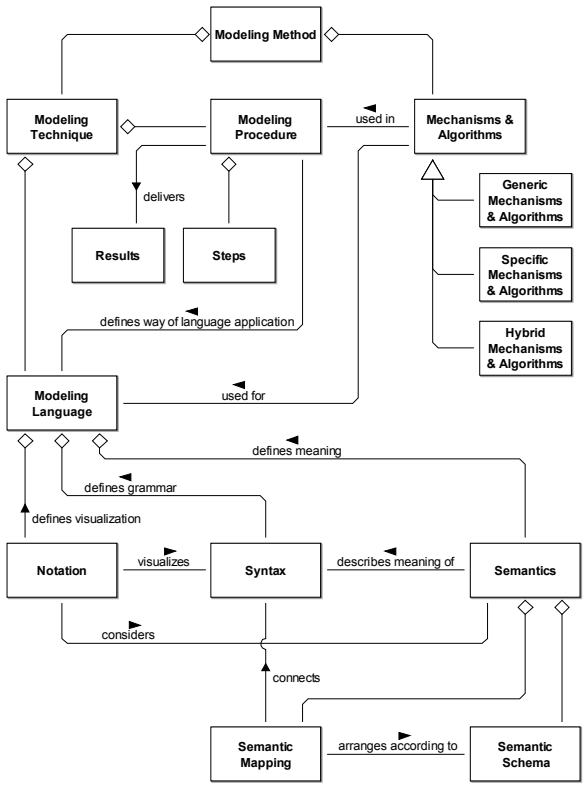

Figure 1: Components of Modeling Methods [17]

generation and no bottom line against which performance can be measured [4]. As national competent authorities are part of the public health care system, similar considerations can be applied to them. However, due to their specific field of competence and their embedding in the European context of pharmaceutical regulation, there are a number of additional factors that need to be considered. This concerns the influence of legal regulations and compliance requirements, the competition with other NCAs in the European Union, the largely unpredictable volume of evaluation procedures, and the requirement of highly skilled specialists.

The duties of national competent authorities are laid down in a number of national laws, European directives and according regulations by the EC and the EMA as the supranational authority. Apart from the obligation to comply to all of these legal regulations, which limit the set of possible actions that can be taken, they may also influence performance directly. This applies for example to the fees and reimbursements that need to be paid by pharmaceutical companies for filing applications with the European authorities [7]. In the same way, the maximum time spans for evaluations are specified by law and cannot be altered by the authorities, not even in the case of a crisis or shortage of resources. In addition, a number of industry standards and practices, which set the professional standards of operation - e.g. in regard to the due diligence of evaluations - need to be taken into account. The decisive factor of these regulations for performance management is their immutability in the short run. Although a single national competent authority is well represented in the national and international bodies governing the regulations, changes typically require the conviction of many stakeholders and can thus take very long. In addition, these factors also directly influence the choice and design of appropriate management support tools as it would be impossible to take any decision that does not fully comply with the multitude of applicable laws and regulations.

As for any public organization, the generation of income largely depends on financing by the state. The budget of NCAs is usually part of the public health budget and therefore subject to political decisions. However, as mentioned above, NCAs also receive fees for giving scientific advice, the evaluation of clinical trial applications and market authorization procedures. For evaluations on the centralized European level, NCAs need to apply for evaluation procedures that they want to carry out. The allocation of procedures thereby depends on the specific expertise and availability of an NCA in comparison to other NCAs in Europe. Depending on the role of the NCA during the evaluation, also the level of financial remuneration is determined. Thus, this leads to competition between the NCAs in Europe: The better an NCA can plan ahead its capacities, manage its applications, and develop a good expertise profile, the more revenues it will be able to receive.

However, even if an NCA excels in all these aspects, it still faces a considerable degree of uncertainty in regard to the future allocation of resources. This not only stems from the fact that it may not receive all applications it has competed for, but because there are a number of unpredicatble fluctuations in regard to the date when evaluations start, the possibility of referrals of evaluation procedures due to additional findings by other authorities or because the subject of the application requires more resources for its evaluation than anticipated. Furthermore, applications for the approval of clinical trials may be submitted at any time by the pharmaceutical companies and need to be evaluated within a defined, relatively short timeframe of mostly 35 days [11]. Besides these regular procedures, NCAs also have to fulfill duties in the case of crises or pandemics for which they receive no fees or reimbursements, but that still need to be carried out according to the highest professional standards. Due to the short-term nature of these fluctuations and the high costs associated with additional personnel, it is not possible to simply use over-provisioning methods. Although it is possible to hire additional specialists within short notice for some tasks, the availability of external specialists who are familiar with the overall handling of such procedures is very limited.

The procedures conducted by NCAs such as the evaluation of clinical trial approvement applications, central European authorization procedures for medicinal products or the provision of scientific advice for pharmaceutical companies require not only sound scientific knowledge of the subject matters but also of the legal and regulatory requirements. Therefore, NCAs employ top specialists in fields such as medicine, biochemistry, pharmaceutics or statistics. Besides their active role in the evaluation procedures, these specialists have to constantly update their knowledge about the most recent research and developments of pharmaceutical and medical therapies. This also involves the active participation in the

scientific community and on the standardization boards in the form of publications and trainings. Despite their high expertise, it is usually not possible for NCAs to remunerate their staff at the same wage level as the pharmaceutical industry. Therefore, NCAs compete for the most qualified human resources with private industry and are consistently facing the fluctuation of employees.

When putting these factors together, it becomes obvious that the management of performance in such a setting is a complex issue. This concerns in particular the multitude of dependencies between strategic, long-term goals and the day-to-day operations, especially in coping with the described uncertainties. To support these management tasks by using information technology is therefore highly desirable. However, a balance has to be found between the effort for designing, implementing, and maintaining such a support system and the expected benefits. This concerns in particular the formal representation of information for the purpose of conducting analyses. Although strictly formal methods may provide additional benefits in terms of machine processing, the effort required for defining information in such a detailed way may outweigh its benefits, especially for day-to-day operations. We will therefore describe in the following an IT based modeling method for performance management that can be used to analyze these dependencies and directly support human users in taking appropriate decisions. Although the formal definition of the modeling language will permit to conduct also machine-based analyses, the main goal of the method is to enhance the discussion and decision processes of the responsible executives by supporting human communication and understanding.

3. DESIGN OF AN IT BASED MODELING METHOD FOR PERFORMANCE MANAGEMENT

As has been briefly outlined above, the design of a modeling method requires the specification of a *modeling technique* and the according *mechanisms and algorithms*. In order to align the constructs of the *modeling language* to the steps of the *modeling procedure* and both of them to the mechanisms and algorithms, we pursued a concurrent engineering approach. Thereby, we conceptualized the modeling language in a formal language that can be later used for building the modeling method in machine language [15]. After the first conceptualization of the necessary model types was in place, we also began to work on the modeling procedure and the necessary mechanisms and algorithms. According to the requirements of the modeling procedure and the mechanisms and algorithms, we then started to continuously refine the constructs of the modeling language.

When designing new modeling languages it can be generally distinguished between two directions [16]: The modeling language can either be *created* from scratch or it can be *composed* of several already existing languages. The first direction involves the definition of language constructs that cover all aspects that the resulting modeling language will be used for. The second direction denotes the combination of existing modeling languages in order to map constructs of these languages to each other for a new purpose. In the following we will take a *hybrid* approach: Based on the concepts of two existing modeling languages that have been mapped to each other, additional constructs are specified.

3.1 Setup of the Model Types and Definition of the Meta Model

The two modeling languages that we have taken as a start for our approach are: (a) a specifically adapted business process modeling language that is based on the concept of semantic information models [11] and (b) a modeling language for IT based balanced scorecards [24]. The choice for these languages was based on a series of workshops with domain experts from the Austrian NCA AGES PharmMed to identify the relevant aspects that needed to be taken into account. Thereby, the process modeling language was selected because it has been used in a previous project at AGES PharmMed where its applicability to the requirements of AGES PharmMed in terms of knowledge representation and visualization, process performance analysis, and knowledge distribution could be successfully evaluated [11]. It thus could be re-used for dealing with the performance management processes. The second modeling language was chosen based on previous successful use by the University of Vienna in several strategic and performance management projects. From the first modeling language we re-used the model types *business process model*, *working environment model*, *document model*, and *view definition model*. These can be used to describe business processes, their linkage to organizational resources and documents. In addition, the view definition model allows to semantically annotate elements of the business process model to support advanced visualization and analysis mechanisms - for details of semantic information models we refer to [11]. From the second modeling language the model types *success factor model*, *cause effect model*, and *measures model* were taken. These allow to: represent relevant success factors for implementing a strategy and aggregate them to strategic goals; set up cause effect relationships between strategic goals; and assign performance indicators and measures to the strategic goals. The modeling language was complemented with a *procedure data model* and a *treemap model*. Their purpose is to represent the resource allocation in current and future evaluation procedures, which was a specific requirement for NCAs.

We then defined the syntax of these nine model types using a meta model approach [16, 17] - see figure 2. The formal description that results from this has the advantage of being intuitively understandable so that it can still be easily discussed with non-technical domain experts. In additon, it is formal enough to be directly implemented in a machine language as will be shown below. To integrate the different modeling languages, reference links denoted as *interref* were defined between them.

3.2 Definition of the Modeling Procedure

In alignment with the modeling language, the according modeling procedure was set up. It is characterized by a top-down approach that begins with the representation and analysis of strategic relationships and then links them directly to the operative processes [14]. The definition of the modeling procedure was largely influenced by the requirement of NCAs to gain a holistic view on the relevant strategic relationships, the compliance to national and international laws, regulations,

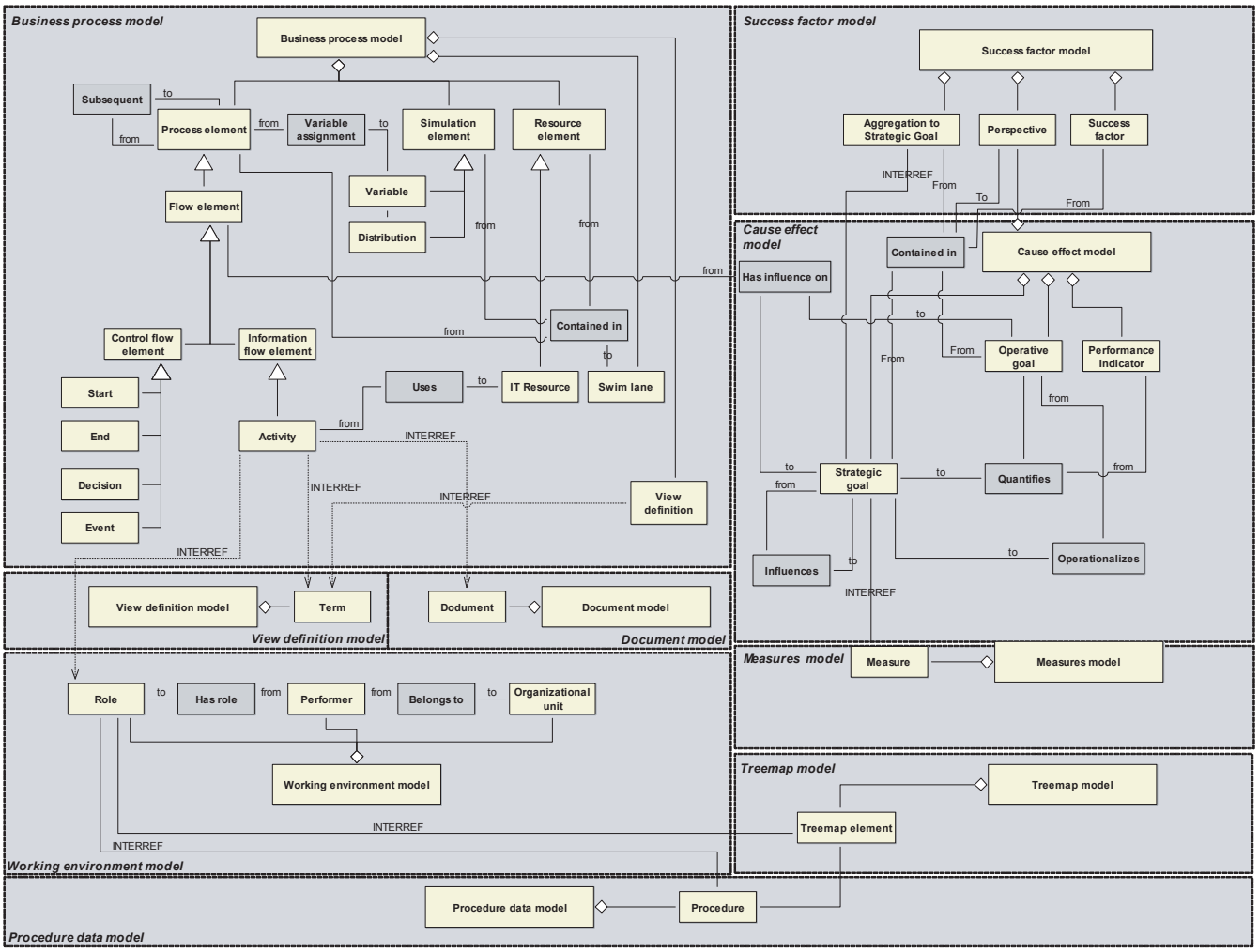

Figure 2: Excerpt of the Integrated Meta Model for Performance Management (Named relations are shown in dark grey)

and best practices, and the consequences on the operative allocation of their resources. Due to highly complex dependencies between these aspects and the large uncertainty of the future amount of evaluation procedures, the goal of the modeling procedure was to make these relationships explicit and provide a better basis of information for human decisions. It also marked a first step towards the specification of requirements for a more automated allocation of resources based on incoming data.

In detail, the modeling procedure consists of six steps - see table 1. For every step one or more model types are assigned that support the generation of results in the form of visual models. Thereby, the relevant factors for the management of performance are successively made explicit by letting human users create the models. Ideally, this process involves all executives who are responsible for the management of performance. Depending on the type and structure of the organization this may include top executives, line managers or process owners. The modeling procedure starts in *step 1* by determining *success factors*, which are essential for achieving an optimal performance of the organization. This concerns the factors for the compliance with legal requirements, the competition with other NCAs, the human resource aspects, and the resource allocation. These factors are then grouped together and aggregated to *strategic goals* based on shared characteristics. This allows for an easier handling and the consolidation of information. Furthermore, it leads to a shared understanding of the goals of the organization as it is also demanded in the widely-used balanced scorecard approach [14].

In *step 2* the strategic goals are re-created using the cause effect model type. In the cause effect model, the dependencies between strategic goals are made explicit by using the *influence* relation. Next, suitable performance indicators are identified that allow to measure the strategic goals. To conduct this identification it can be reverted to a large number of performance measurement approaches that have been discussed in the literature - we refer to [12] for examples. The performance indicators are then linked in the cause effect model to the strategic goals using the *quantifies* relation. If necessary, *operative goal* elements can be used to further detail the strategic goals by linking them via the *operationalizes*

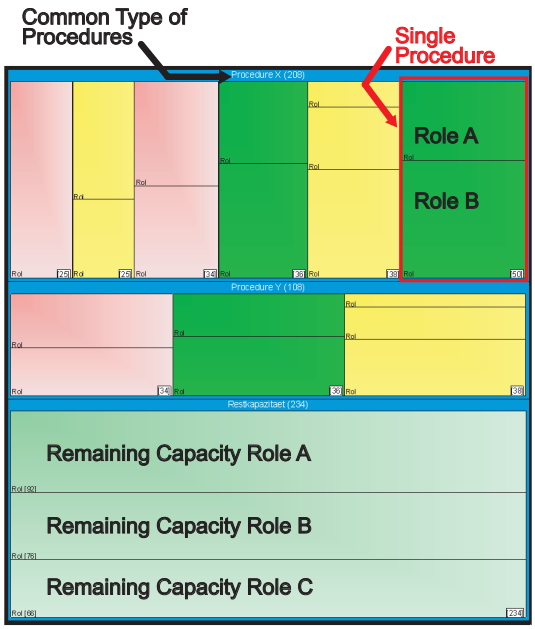

Figure 3: Illustration of the Treemap Modeltype

relation. This can be the case if a performance indicator only measures a part of a strategic goal or particular operational aspects of a strategic goal shall be highlighted. By representing this information about the goals and their relationships in a visual form, the users of the modeling language can easily discuss potential conflicts between the goals and the compliance to legal regulations.

In *step 3*, *measures* are assigned to the strategic goals. These stand for the possible actions that can be taken to improve a strategic goal in regard to its performance indicators [12]. In the context used here, measures are mainly used for collecting possible actions. The actual implementation of the actions takes place in *step 4*. Here, the *business processes* that are relevant for the performance management of NCAs are represented and linked to the strategic and operative goals. This concerns in particular the business processes for handling the evaluation procedures, which includes activties such as the application for new procedures, the allocation of resources for incoming procedures and clinical trial approvement applications or the handling of crises. The business processes are represented by their control flow in the business process model, by their information flow through activities that can be linked to the *document model*, and by the roles of the performers in the *working environment model*. In addition, activities can be semantically annotated by using *terms* from the view definition model to enable the derivation of semantic based views on the business processes [10]. This has proven to be useful for complex business process models in the context of NCAs [11].

In order to provide support for the operative handling of resource allocations, the data about current and anticipated future evaluation procedures is represented in the *procedure data model* in *step 5*. In this data model, each evaluation procedure is characterized by its unique internal ID and estimates of the expected resource consumption in the form of person hours per required role and about the expected cost recovery. Although these last two figures are subjective estimates and could so far not be further formalized, discussions with the management team at the Austrian NCA have shown that these estimates can be quite well given by the involved managers and can help them in their decisions about the operative resource allocation. This data is then used in *step 6* to create an information visualization of the committed and available resources in the form of a treemap [38] - see figure 3. It shows the evaluation procedures according to their type and based on their resource consumption per role - which determines the size of the treemap elements - and the expected cost recovery - which determines the color of the treemap elements. The remaining capacity per role is shown at the bottom, the total size of the visualization directly corresponds to the total capacity of all roles.

After the steps of the modeling procedure have been completed, the user is able to explore the relationships expressed in and between the models and thus gain an overview of the current implementation of the performance management. It further allows to create what-if scenarios by adapting all model parameters and analyzing the effects of these changes. Furthermore, the models can be made available to third parties in order to make the determining factors of performance management transparent.

3.3 Mechanisms and Algorithms

As already mentioned, several algorithms have been added to the modeling method. These include the visualization algorithm for the generation of the treemap models based on the procedure data, various analysis algorithms to query the mutual influence of strategic and operative goals on the business processes, and the automatic transfer of strategic goal definitions between the success factor model and the cause effect model.

3.4 Technical Implementation

The meta model was implemented on the ADOxx[1] meta modeling platform - see figure 4. To accomplish this, the meta model had to be transformed to the ADOxx specific implementation language ALL. The visual notation was specified in the graphical representation language GRAPHREP [9]. The mechanisms and algorithms were coded in AdoScript, which is a scripting language for the ADOxx platform. ADOxx provides multi-user support via a client-server architecture and provides several generic import and export functionalities for formats such as XML, HTML, and Microsoft Office file formats.

4. APPLICATION AND EVALUATION

The described modeling method has been applied in practice in the course of a scientific study of the University of Vienna in cooperation with the Institute Science and Information of the Austrian NCA AGES PharmMed. For reasons of confidentiality only an outline of the study will be given in the following. AGES PharmMed is a division of the Austrian Agency for Health and Food Safety (AGES). AGES is responsible for several tasks in regard to nutrition and health for the

[1]ADOxx is a commercial product and trademark of BOC AG.

Step	Description	Used Modeltype
1	Derivation of Success Factors	Success Factor Model
2	Derivation of Strategic Goals and Performance Indicators	Cause Effect Model
3	Assignment of Measures	Measures Model
4	Representation of Business Processes and Linkage to Strategic and Operative Goals	Business Process Model, Working Environment Model, Document Model, View Definition Model
5	Set-up of procedure data and linkage to Roles	Procedure Data Model
6	Visualization of Committed and Available Resources	Treemap Model

Table 1: Steps of the Modeling Procedure

Austrian government. AGES has been established by federal law as a private limited company with the sole owner being the Austrian federation. It therefore has to comply with all legal regulations that are applicable to private limited companies such as regulations about the articles of association and proper accounting principles. This concerns in particular the accounting of AGES PharmMed, which has to issue separate financial statements. In 2009 AGES PharmMed generated a turnover of about 21.2 mill. euro in fees that it can charge for the evaluation procedures. From this the largest part was spent on personnel costs, which amounted to about 19.5 mill. euro. Together with other revenues and additional costs, it generated a deficit of about 3.4 mill. euro [1]. Due to a settlement with the ministry of health this deficit is entirely absorbed. It is however one of the strategic guidelines of AGES PharmMed to reduce this deficit and establish the financial autarchy of AGES PharmMed in the future.

The main goal of the scientific study was therefore to apply the modeling method for performance management in one of the institutes of AGES PharmMed in order to develop opportunities for the optimization of its performance management. As the Institute Science and Information of AGES PharmMed is directly responsible for the application and resource allocation in regard to evaluation procedures including evaluations of clinical trial approvement applications, it was the first choice for the study. Based on the outline of the general strategy of AGES PharmMed and an already existing strategy of the institute, the success factors and strategic goals were elaborated. This was done in a series of workshops with the executives of the institute. Thereby, it was focused on the central strategic perspectives of the institute's strategy: *financial autarchy*, *scientific competence*, and *reasonable workload of staff*. Whereas the first perspective is clearly derived from the overall AGES PharmMed strategy, the other two are of particular importance for the Institute Science and Information. As already mentioned above, the maintaining of a high scientific competence is essential for the evaluation procedures. At the same time the salaries paid by a public health authority do not amount to the levels paid by the pharmaceutical industry. Therefore, it has been essential to establish good working conditions including the optimization of the workload across all staff members.

After the derivation of the strategic goals the cause effect relationships were modeled and performance indicators were assigned to all goals. The final cause effect model contained thirteen strategic goals, six operative goals and forty-six performance indicators. The next step was the elaboration of appropriate measures that could be used to reach the strategic goals. In total four areas for measures could be identified: *strategy*, *processes*, *knowledge management*, and *procedure handling*. The focus was then put on the measures for procedure handling as they constituted the most relevant aspect for the performance management. In order to analyze the current status of the application and resource allocation processes for the evaluation procedures, interviews with the operative managers for handling these tasks were conducted. Based on this information the according business processes were modelled including the working environment of the institute. To analyze the mutual influences between strategic and operative goals and activities in the business processes, the necessary links were established between these models. This gave already a good insight into the complex decision process and the influence of the various strategic goals and according performance indicators. It could be directly seen, in which business processes improvements for certain performance indicators could be made and which other strategic goals and indicators could be affected.

The final step was the provision of the data on the evaluation procedures. This could be accomplished by querying the existing data bases and making the data available in the modeling tool. Based on the subjective estimates for the hours per role to be allocated to each procedure and the estimated costs, according treemap models could be generated. Additionally, the treemap models were used to evaluate possible changes in the resource allocations. Although the existing treemap algorithm was able to create the visualizations, it turned out that due to the high number of procedures, the visualization of a resource allocation of a whole year would need further adaptation. However, for the medium and short-term planning it proved satisfactory.

Based on the insight that could be gained through the analysis of the created models, a first version of the future process for the allocation of resources across all other processes could be set up. Furthermore, it was agreed to constantly evaluate this process and add more details to it during its actual execution. Thereby, it is envisaged to gain a better understanding of how to deal with resource allocation requirements in the future and which data - either by using performance indicators or external factors - may be used to optimize the allocation.

When evaluating the designed modeling method in regard to the specific requirements of NCAs, the following can be stated: Due to the legal regulations and compliance requirements, the choice of measures to influence the handling of procedures was not very large and could be reduced to eight concrete measures. Even though these measures were valid from a theoretical point of view, the implementation

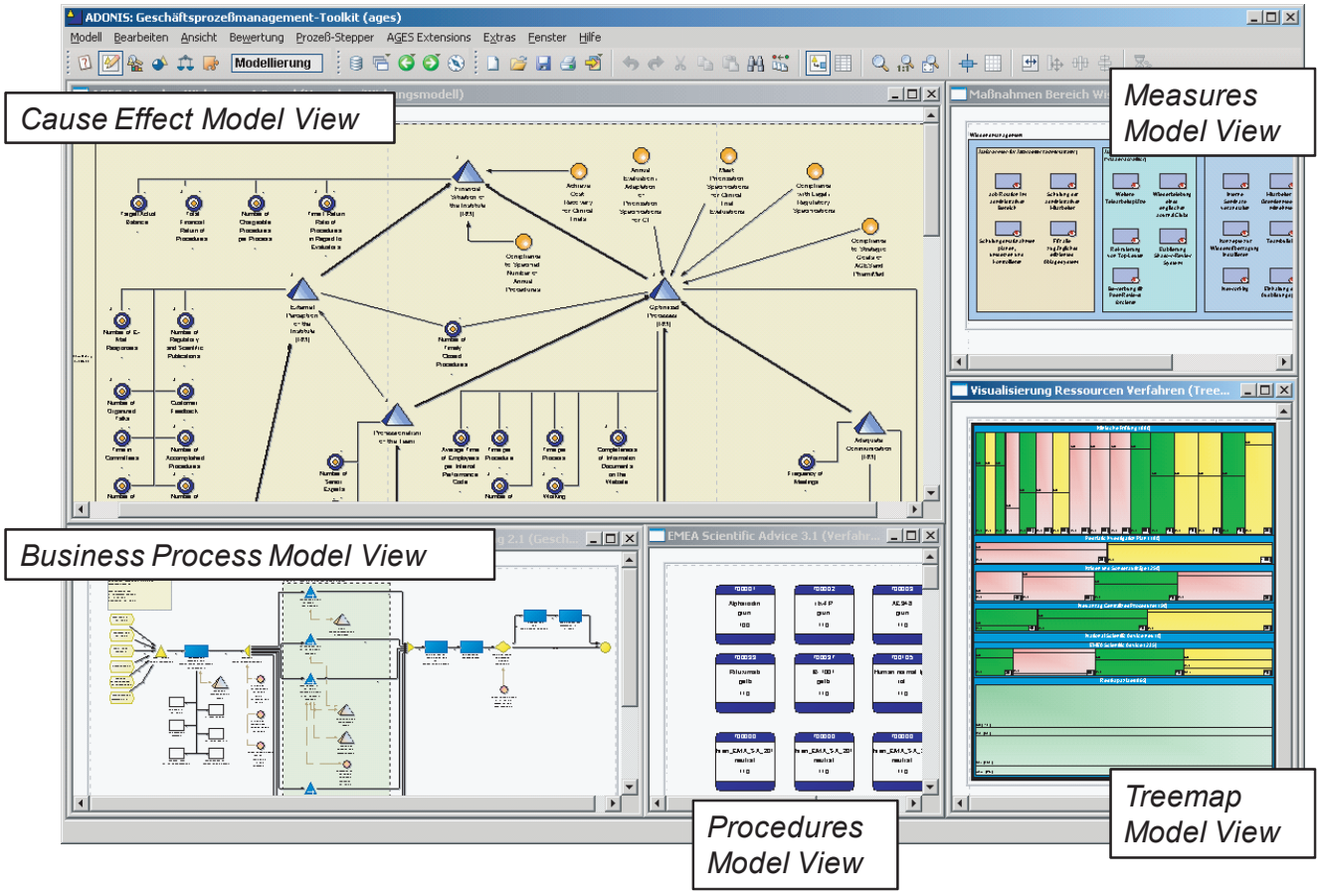

Figure 4: Implementation on the ADOxx Platform

in practice could only be considered for some of them due to dependencies with other strategic goals. As an example, one measure concerned the increase of fees for procedures that were not regulated. However, this would be detrimental in regard to the competition with other NCAs in Europe where AGES PharmMed could recently position itself as a well skilled authority. The analysis of such dependencies was directly supported by the modeling method. Although some of the involved executives would have reached the same conclusions, the explication in the form of models allowed a common understanding of these relationships and could serve as a basis for future adaptations. In addition, the models are meant to be made available to involved employees on the intranet to achieve a higher level of transparency and a technical solution has been established for this purpose. Thereby, it is envisaged to facilitate a better understanding of the overall decision process and help to raise the awareness of the involved complexity when taking human resource decisions. Hard facts such as an improvement of the financial situation of the institute cannot be directly related to the modeling method as the share of human knowledge processing is very large in this approach. However, it may be worthwhile in the future to conduct a survey with all persons involved to assess their subjective impression of the use of the modeling method. The feedback received so far has however indicated the appropriateness and usability of the method.

5. RELATED WORK

When comparing our approach to existing work three main areas can be identified: IT-based modeling methods, job-shop scheduling approaches, and information visualization approaches for strategic management. In the area of IT based modeling methods for performance management, several academic and industry solutions have been developed [2, 36, 37, 24]. The most closely related are the approaches for a modeling method for integrated performance management [36] and the business engineering navigator [2]. Although the meta model of the integrated performance management approach is similar to ours, it neither provides a linkage to the process based view for deploying performance management nor does it offer a direct support for allocating resources. The business engineering navigator on the other side is more directed towards business-IT alignment. Although several aspects for linking strategy and performance are available in this approach, its focus on integrating IT infrastructures would have clearly exceeded the requirements of NCAs at the current stage. And likewise it does not offer support for an on-demand resource allocation.

For supporting the allocation of resources several approaches have been developed in the past. In production management and manufacturing, similar resource allocation problems have been discussed in job-shop scheduling. Job-shop scheduling characterizes production orders that have different routes

and the orders may visit a given route several times. These approaches aim for feasible, robust, and optimal schedules, thus delivering optimal performance in regard to the processing of orders. General deterministic optimization models that are used in this field where all parameters are known based on a finite number of jobs can not be related to the problem at hand. This is due to the large uncertainty of incoming evaluation procedures and the multi-dimensional nature of the dependencies of actions. Nevertheless, more specific approaches for dealing with uncertainty and on-demand scheduling can be related [21]. As pointed out in [34] however, formal frameworks for online scheduling and rescheduling have so far not yet been established. These would be required for NCAs to deal with suddenly incoming procedures and changes in procedures. So far, also approaches dealing with uncertainty in scheduling would at least require to have a description of the uncertainty parameters either in bounded form, through a probability description, or by using fuzzy sets [21]. Unfortunately, in the case at hand these estimates cannot be given at the current stage. It may however be possible to apply some of these approaches in the future when sufficiently precise log data from the executed performance management processes is available.

Apart from mathematical approaches, the use of visualizations has also been reported to support decision makers in strategic problem solving and the scheduling of resources. In [18] a theoretical framework has been described to link visual modeling and visualization techniques for strategic analysis. In this way it is similar to our approach although it focuses mainly on the visualization aspects and does not describe the formal relationships. In the area of manufacturing it has been found that in some cases humans using graphic interactive scheduling systems were superior to dispatching rules in multiple objective situations [3]. This strongly supports our approach of using the treemap visualizations for supporting the allocation of resources.

6. CONCLUSION AND OUTLOOK

It has been shown that the performance management for national competent authorities is a complex issue that involves several dimensions. The described modeling method has been found to well support the human decision makers and provide a first step towards a formalization of the alignment between an NCA's strategy and its operative processes. The use of treemap visualizations proved to be a good way to support the allocation of resources under multiple constraints and the high uncertainty that NCAs face. By applying the same approach also to other NCAs in Europe it can directly enable the comparison and benchmarking between NCAs, thus giving additional insight into possible options for the optimization of performance in this domain.

Although the approach builds upon the requirements of public health authorities, it has been designed in a way that allows for a direct application to other domains. For example, the described model type for specifying procedure data could be directly re-used for representing the data of customer requests in a service domain or orders in a production plant. In the same way, the corresponding treemap model could be adapted to show the status of these requests or the types of orders. In addition, the approach could be re-used for existing business process modeling projects to take into account also strategic perspectives in the form of the success factor model and the cause effect model.

For the future it is planned to further detail the approach by making it part of a daily work routine. Thereby, it is envisaged to enhance the available data on performance indicators and the allocation of resources, which could then be used for additional optimization techniques.

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