Interactive Visualizations in the Process of Policy Modeling

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Abstract: The policy making process in public authorities is nowadays usually an offline process. ICT is just very conservatively used, which also limits the inclusion of citizens' opinions. In difference the ICT sector consists of a rapid development in the area of eParticitpation and also in data-storing approaches and visualizations. But today it is hard to assign such new technical approaches to the policy modeling process, because of their non-ICT orientation. In this paper we introduce a new detailed ICT-based policy modeling process and an assignment of some modern ICT technology features. To support decision-makers, the main contribution of this paper is an assignment of useful visualization-types to the technological features and furthermore to the ICT-based policy-making process. Therewith we describe an approach how interactive visualizations can lead to a more effective policy making.

1 Introduction

The role of policy modeling is a growing issue that gets an increased focus not only by politicians and researchers, even more from the public. Especially the increasing problems of most countries, e.g. because of the financial crisis in 2008, changed the focus of a number of citizens. The citizens expect an opportunity to get at least to be heard by the government or in best case, to get the chance to be involved in the policy making. The researches in eParticipation and eGovernment provided a couple of new approaches how the citizens' opinions could be more and better considered.

In difference to these society developments, the researches in policy modeling address just basic ideas on the surface. Especially the policy modeling process that is used for policy making in public authorities brought just moderate changes. Nowadays no detailed ICT-based policy modeling process is published in the literature that describes a detailed formulated policy making process. For sure, there are some established researches e.g. by Macintosh [Ma04a, Ma04b] that flank this issue. But these researches

are only on a basic level, there is lack of in detailed described process models for ICT-based policy making.

Another challenge is the inclusion of modern strategies of massive public data-sources and techniques to visualize certain aspects for in-depth analysis. In the past years technical systems become more powerful and provide intuitive and interactive user-interfaces to allow a precise problem and solution analysis. Therefore big-data sources and modern interactive visualization allows users to watch data in complete new ways and to gather on this way an encompassing picture about a topic. In the domain of policy making, these possibilities are just less researched. Usually simple charts are used to visualize the statistics data. Modern data-sources, i.e. from social media platforms or dbpedia as semantic-data source, are usually unconsidered and thereby the visualization abilities are very limited.

In this paper we present a new ICT-based policy modeling process that is characterized in a very detailed form. The fundament of this process consist of established but just abstractly defined ICT-based policy modeling process, and traditional but well elaborated literature for non-ICT based policy modeling process descriptions. Also experts from public authorities were involved in the process definition to ensure the function of the process definition. On this process different ICT technology features were assigned, for which we identified modern public data-sources. After all this work, we are able to determine visualization-types that ensures a beneficial data-visualization for each technology feature and furthermore for each task of the defined policy making process. As a main outcome we define a set of visualizations for different technology features, which representing a task and included some data sources that are required for an efficient task solving. Basing on this set of visualizations, new and innovative visualizations systems can be developed that providing interaction and analysis features, which are closer on the behaviors of policy makers. In fact policy makers get the ability to work with highly interactive visualizations to explore and analyze data.

2 Policy Modeling Processes: an Overview

The process of Policy Modeling (PM) is a complex challenge, which includes various tasks with a predefined order to ensure the creation of an effective policy. To face this challenge the structure of the accruing tasks were investigated by several existing process definitions. The processes enable the definition of process-tasks and supporting tools for an efficient task-solving. In particular the supporting tools are nowadays brought by the Information and Communication Technologies (ICT), with the rising role of internet, social web and further ICT-based technologies. The definition of PM-processes was often defined in existing works by setting goals for their categorization.

The most established process-definitions are the conventional ones, which are mostly used in public authorities. We mean with conventional that the process definition does not involve ICT-based tools. Beside these conventional processes, few adaptations were applied to use ICT-tools in the PM-process. We sub-summarize in this paper the PM-processes that involve ICT-based tools for supporting tasks as ICT-based policy

modeling processes. A third group of PM-processes is technology-driven and constrains the PM-process to the limitations of technologies.

2.1 Conventional Policy Modeling Processes

The conventional PM processes are the most established definitions and primary used and implemented at public authorities. They have been researched since decades, but unfortunately they lightly consider the ICT-tools and their opportunities. Novel approaches for eParticipation and eGovernment cannot be reconciled with the conventional PM-processes. The most advantage of such conventional PM-process definitions is their accurate documentation. No other category of PM-process definition provides such a well described definition of each process step.

Most of the conventional defined PM-process, i.e. in [Jo84, BD83, An84, HH06], are not equal, but they describe the most necessary steps in a similar way [HRP09, HH06]. Therefore they are using a three to seven stage model and cover with the diverse stage-numbers the same issues. This fact allows the grouping of these approaches into a generalized five-stage model [HRP09]:

(1) *Agenda Setting*: The function of this stage is to recognize a problem and to identify the related reasons.
(2) *Policy Making*: Based on the identified problem, in this stage proposals for solutions are defined.
(3) *Policy Decision*: Mostly Politicians in the role of decision-makers act in this stage to decide which proposal and with which condition a policy should be implemented.
(4) *Policy Implementation*: The goal of this stage is the ratification of a new policy for validation.
(5) *Policy Evaluation*: In this stage the implemented policy is analyzed and observed. The goal of this stage is to identify if the faced policy-problem is solved.

The description for these five stages of the PM process is just an outline, which is more explained in the above mentioned literature. In this paper we primary focus on the detailed description of the model proposed by Howlett et al. [HRP09], which contains an aggregation of most of the existing and established researches in that domain and describes the PM-process stage in a clear shape.

2.2 ICT- based Policy Modeling Processes

A more recent approach to define the PM-process is the inclusion of ICT-tools in the entire process. In particular the involvement of citizens and their opinions can be supported in a more sufficient way. These process models adapt the conventional PM-process to include ICT-tools.

There are two established and equal PM-process definitions that investigate ICT in the process model: The well-known definition of Macintosh [Ma04a, Ma04b] (Figure 1) and published model proposed by the OECD [OE03a, OE03b] to reinforce eDemocracy. Both processes define a five-stage PM-process:

(1) *Agenda Setting*: The Agenda Setting defines the need for a policy or a change to an existing policy. It further clarifies the problem that triggered the policy need or change.
(2) *Analysis*: The Analysis clarifies the challenges and opportunities in relation to the agenda. This step's goals are examining the evidence, gathering knowledge, and a draft policy document.
(3) *Policy Creation*: The Policy Creation aims to create a good workable policy document, taking into consideration a variety of mechanisms such as risk analysis or pilot studies.
(4) *Policy Implementation*: The Policy Implementation involves the development of legislation, regulation etc.
(5) *Policy Monitoring*: Policy Monitoring might involve evaluation and review of the policy in action.

Next to the above described process definitions, there are very similar definitions with a deviation in the number of stages. They address the same issues, similar to the parallel existing process definition for the conventional PM-processes. The process definition of Mashinini [Ma08] consists of four phases. His model combines the first two stages of Agenda Setting and Analysis in one stage. Another PM-process definition was proposed by the World Bank [Wo10]. It describes a more structured PM-process with an assessing and coordination responsibility within the governments.

All of these kinds of process definitions do not describe the process in a detailed form. Neither the concrete tasks are named or described, nor are the possibly useful ICT-tools defined for supporting the tasks. Nevertheless the mentioned processes are for many eDemocracy project-ideas a well foundation, even if they are just defined on a very abstract level. The breach of a detailed description makes it difficult to use such a PM-process definition in planned concrete implementations. Concrete implementations needs to be developed for specific tasks to ensure that it help users. In consequence a detailed defined ICT-based PM process is also essential to determine appropriate visualizations for each PM-stage.

2.3 Technology-Driven Policy Modeling Processes

The third group of PM-process definitions is defined for the use of specific technologies in the Policy Making. Some technologies allow the definition of specific processes, which addresses the challenges for this single type of technology. Therefore the PM-process is abstracted and adapted on the requirements of the technology. The goal of these technology-driven PM process is not to define a global process for public authorities, even more these definitions are focusing on the behaviors of a technology and thereby to ensure an optimal exploit of the technology's benefit.

A less number of approaches address general technical issues. On examples is the three-phase process of Misuraca et al. [MBC10]. It provides a general idea to include technologies in the decision making process. The goal is not establish the inclusion of a concrete technique, even more it acts as a motivation factor to create more ideas and techniques that possibly can be considered by decision makers [MBC10].

Most of these PM process definitions are addressing a certain topic. Through the combination of multiple technologies, a new service is obtained that aims to improve a part of the policy making process. The resulting process definition does not always correlate with conventional or ICT-based PM-process, but this is also not the primer proposed goal. The goal of such PM-processes is to provide a beneficial process to improve a concrete aspect. An example for such a PM-process definition is the Policy Making Lifecycle of the European project ePolicy [Mi12, KNR12].

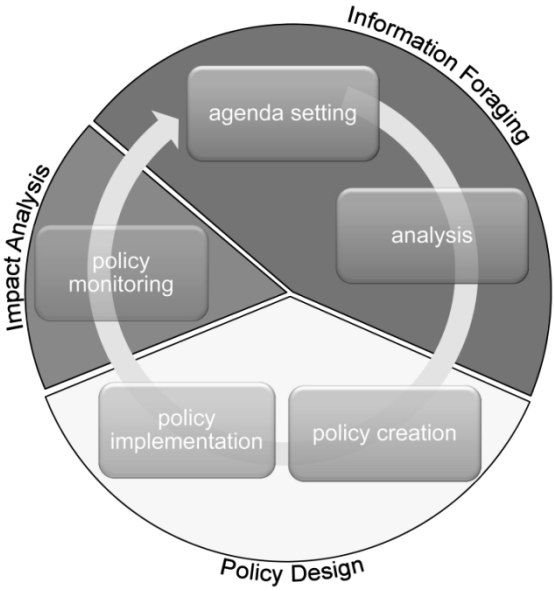

Figure 1: Comparison of a 5-step ICT involving Policy Modeling-process (based on Macintosh [Ma04a]) with an ICT-specific Policy Modeling-process (based on Kohlhammer et al. [KNR12]) that focuses on the main visualization tasks.

According to previous type, there are also process definitions that are defined for a specific technology type, i.e. for information visualization [KNR12] or simulation techniques [Pa02]. The idea is to provide a process definition for this type of technologies, based on an abstracted and adapted general PM process definition that considers the technology's specific behaviors. An example of such a technology-driven process is the visualization-process of Kohlhammer et al. [KNR12]. For this exemplary visualization purpose, they reduced the entire PM process on the relevant parts for the visualization on (Figure 1): (1) Information Foraging, (2) Policy Design, and (3) Impact Analysis.

3 An ICT-based Policy Modeling Process

In the European project Future Policy Modeling (FUPOL), we defined a novel policy modeling process that uses ICT-tools for supporting the entire policy creation process

[SNB13]. This model uses Macintosh's ICT-based process model [Ma04a, Ma04b] as fundament for a more granular specification of ICT-capabilities. Therefore the processes are broken down into sub-processes and tasks. This ensures a detailed ICT-based PM-process. Supporting technologies can be assigned in a more specific way in the process, which leads to the establishment of a new and more efficient policy making process. [SNB13] To specify the sub-processes and tasks in detail, the work of Howlett et al. [HRP09] with its elaborated process descriptions was investigated, although they investigated in particular conventional PM-processes. The process could be adapted to include ICT in an appropriate way, through investigation of the needs of pilot cities involved in the project [Pa12, TG12], and the further ICT-based PM-processes [Ma04a, OE03a, OE03b]. This entire process description and the explanation of the identified FUPOL technology features are completely documented in [SNB13]. The results of this work are summarized in the following figure. It shows the global process definition and its sub-processes and tasks and the assignment of the FUPOL technology features to the existing PM process tasks.

To consider ICT, we could not align technologies directly on the process, because of the available heterogeneous kinds of data and very different analysis purposes. Therefore we focused on what technologies could be used for each task. The technologies were selected and aligned to the process in discussion with the pilot cities that are involved in the FUPOL project. This ensures that the process as well as the technology alignment addresses the goals and the work of the municipalities. In consequence, we get a list of technologies that are appropriate and should be used to solve the existing task.

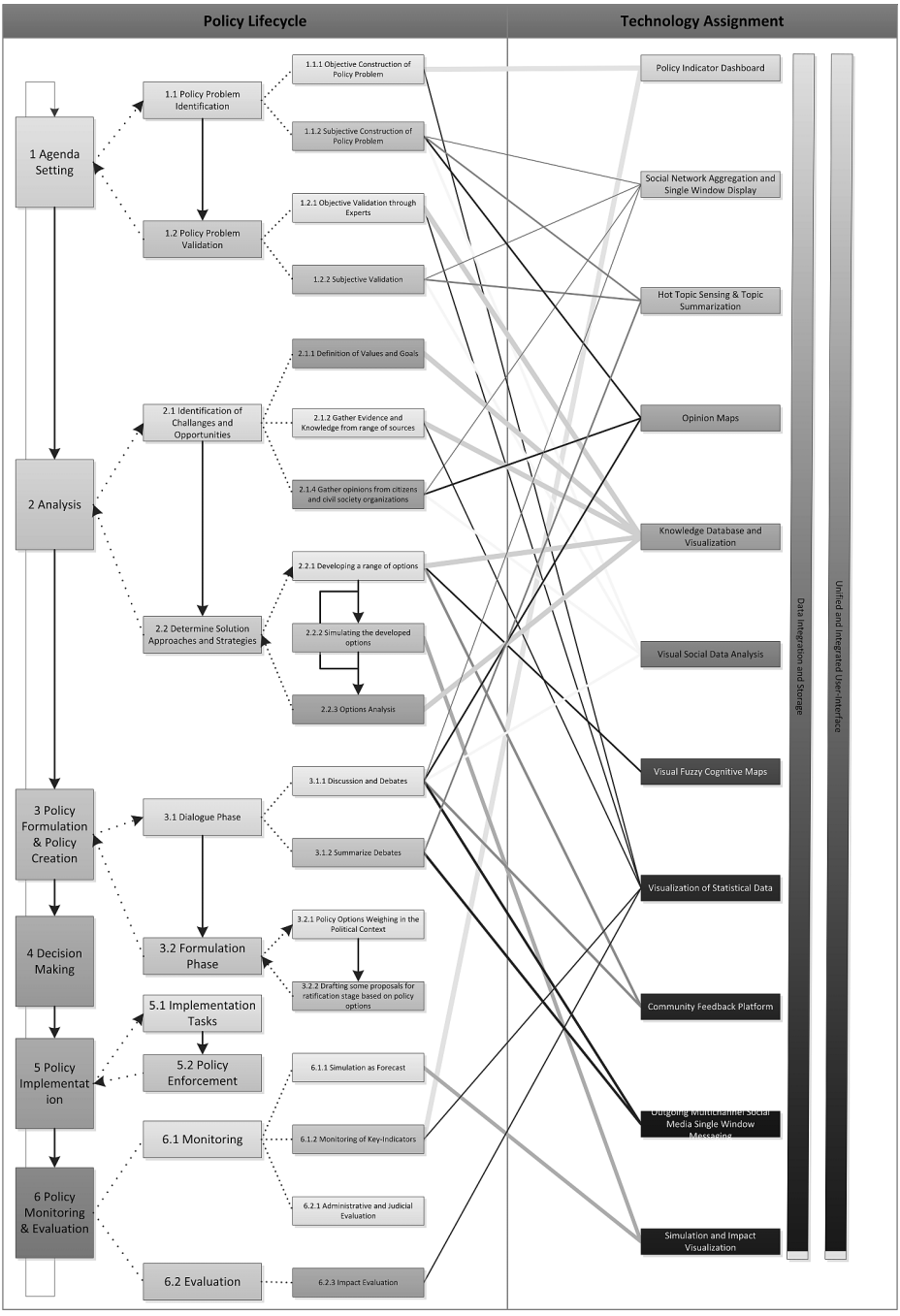

Figure 2: The FUPOL ICT-based Policy Modeling process with the Technical Feature alignment (based on the described process in [SNB13]).

4 The Role of Visualizations in the Policy Modeling Process

To explain the role of visualizations, we have to define the context of visualization first. We define as visualization context the main influencing factors that impact the visual appearance and interaction behavior of visualizations. To reduce these factors in an abstracted and comprehensible way, we classify three main influencing categories (Figure 3):

- *Data*: Data is essential to visualize information on the screen. In dependency of the data, different visualization types, e.g. hierarchical, temporal or graph-based, are appropriate. The data mainly limits the range of applicable visualization. Only if the data provide the required attributes for a specific visualization type the underlying information can be visualized. For instance, if there is no temporal data, it is impossible to use timelines and visual spreads over time.
- *Task*: The second main influencing factor is the task to be solved. We define tasks in visualization context as an iterative process of perceiving visual information and interacting with visual entities for achieving a wished target, goal or awareness. The solving of a task is more efficient, if the visualization is dedicated designed to the achievement of the goal.
- *User*: The user is the third main influencing factor. All aspects of this human-computer-interaction situation aiming on the provision of a more efficient and effective interaction. In perspective to visualizations, the users' behaviors are a major influence factor that needs be considered. The perception of visualization can vary significant between two different users. In consequence, the user with her behavior, expertise, pre-knowledge etc. needs to be considered as a main influence factor for the visualization.

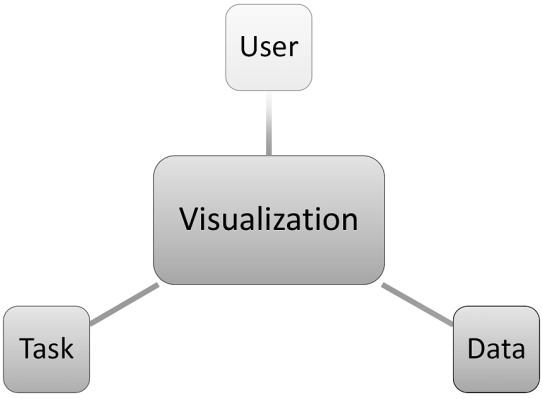

Figure 3: The depending objectives of the general visualization context, which consists of the three main objectives: user, task and data.

In the previous chapter we introduced the PM-process which is used in the FUPOL project. Based on this process we are able to directly address concrete tasks. But the defined process itself allows no direct assignment of appropriate visualization-types to solve the given tasks. However, through the introduced FUPOL technology features we

can make a recommendation to (existing) public data-sources. Regarding the mentioned visualization-context, the data and task-aspect can be clearly defined.

In the following assignment the aspect of user is reduced to the analysis experts. In this case this assumption can made, due to the knowledge about the main actors with visualization technologies. This means, we expect an intermediate level of knowledge with ICT-tools. That allows the conduction of users' familiarity with graphical and interactive visualizations, in particular to solve analytical tasks. Overall we are able to define now the entire visualization context in the PM-process. Based on this context, we can now assign concrete visualization-types that are suitable for each PM technology feature of the ICT-based Policy Modeling process. For the visualization-type recommendation we determined what kind of visualizations can be used in dependence of the technology feature (and its implicitly defined goal) and the available data source and therefore the existing data (statistical, semantic, textual, etc.).

Policy Modeling Technology Feature	Recommended Public Data-Sources	Recommended Visualization-Types
Policy Indicator Dashboard	• Statistical Databases	• Spreadsheet Visualization ○ Spreadsheet Visualization with traffic lights for indicators ○ Scatterplot Matrices • Simple Statistical Visualizations ○ Line/Area Charts ○ Bar Charts
Social Network Aggregation and Single Window Display	• Social Media Databases	• Semantics Visualization ○ Node-Link Visualization → i.e. showing topics relations ○ Tree-based visualizations → i.e. to explore by data-source and by topic • Statistical Visualizations ○ Charts → i.e. to allow identification of hot topics • Geographical visualization ○ Map visualization → i.e. to show the location for an issue
Hot Topic Sensing & Topic Summarization	• Social Media Databases • Political Communication Platforms (e.g. Blogs, Forums, Comment section of Newspaper articles)	• Statistical Visualizations for Trend/Opinion Visualizations ○ Stacked Charts ○ Weighted Graph Visualization → e.g. to identify opinion leader • Social Network Analysis Visualizations ○ Node-Link Visualizations ○ Weighted Graph Visualizations ○ User Relationship Diagrams
Opinion Maps	• Social Media Databases • Political Communication Platforms (e.g.	• Geographical Visualizations ○ Simple maps ○ Geographical heat-maps ○ Statistics visualization within maps • Statistical Visualizations

	Blogs, Forums, Comment section of Newspaper articles)	○ Charts → i.e. for trend-/reasonability mining
Knowledge Database and Visualization	• Semantics Data (Linked-Open Data)	• Semantics Visualization: ○ Tree-based Visualization ○ Node-Link Visualizations ○ Time-based Visualization ○ Geo-based Visualizations
Visual Social Data Analysis	• Social Media Databases	• Social Network Analysis Visualization ○ Node-Link Visualizations ○ Weighted Graph Visualizations ○ User Relationship Diagrams • Geographical visualizations ○ Map visualizations → i.e. to show influence location or the geographical correlation for his postings • User Activity Visualizations (focus on postings)
Visual Fuzzy Cognitive Maps	n/a	• Graph-based visualizations to show the Fuzzy Cognitive Maps
Visualizations of Statistical Data	• Statistical Databases	• Social Network Analysis Visualization ○ Statistical visualization to support analysis (compare, identify etc.) • Semantics visualizations ○ All kinds of semantics visualizations → i.e. to visualize the meta-information like SDMX-ML • Correlation Visualization of statistical Data
Community Feedback Platform	• Social Media Databases • Political Communication Platforms (e.g. Blogs, Forums, Comment section of Newspaper articles)	• Statistical Visualizations ○ Node-Link visualizations → i.e. to visualize dependencies and initiators of initiatives ○ Tree-based visualizations → i.e. to navigate between different topics ○ Timeline-based visualizations → i.e. to show history of initiatives and feedbacks • Social Network Analysis Visualization ○ Weighted-graphs → i.e. to show opinion leaders • Geographical visualizations ○ Map visualizations → i.e. to show addressed regions and problem areas
Outgoing Multichannel Social Media Single Window Messaging	n/a	• Text-based visualizations and browser-based visualization to see published results • Semantics visualizations ○ Graph-based visualizations → i.e. to observe feedbacks separated by the social media platform

Simulation and Impact Visualization	• Statistical Databases • Simulation Results Data-Sources	• Statistical Visualizations ○ Diagrams and charts → i.e. to observe the quantitative result of the simulation • Geographical visualizations ○ Map visualizations → i.e. to visualize impacts and consequences on a specific region

Table 1: Assignment of recommended public data-sources and visualization-types to the technology features of the FUPOL policy modeling process.

The introduced visualizations-types correspond just to classes of visualizations and not to concrete visualization-algorithms. This means that for every process-task different visualization algorithms fit. Furthermore the visualizations can be more individualized through adaptation methods, which define the user-aspect in a more precise way.

5 Conclusion

A major challenge in using visualization in the policy making process is the less concrete definition of existing ICT-based policy modeling processes. So visualizations experts are not able to design interfaces that will more helpful for decision-makers, because they do not know about the process. On the other hand decision-makers are limited in their analysis because of the miss of more efficient analysis tool, i.e. analytical visualizations.

Because of this fact, in this paper we presented a new ICT-based policy modeling process that is characterized in a very detailed form. On this process different ICT technology features were assigned, for which we identified modern public data-sources. After all this work, we determined visualization-types that ensures a beneficial data-visualization for each technology feature and furthermore to each task of the defined policy making process.

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