Web-based Participatory System Dynamics Modelling – Concept and Prototype Development

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Abstract

In this paper we present our concept and prototype of a web platform which supports participatory modelling. This platform facilitates web-based collaborative and cumulative modelling when face-to-face participatory modelling sessions cannot be organized as often as desired. Successive iteration steps of the model development can thus be displayed interactively in a standard web browser together with comments and explanations made by the modeller. The platform strengthens the support of formal model construction and documentation on the one hand and reduces the effort of model re-publishing on the other hand. This platform shall be used to support participatory modelling and decision-making processes in different fields.

Keywords: participatory modelling, web platform

1. Introduction

Decision support is one of the most exciting and important application fields of system dynamics. One of the main advantages of system dynamics in this context is that it provides a clear and transparent model structure which can, beside other things, promote the cooperation between the system dynamics modellers and decision-makers in the sense of participatory or group modelling (Andersen 1997).

In this paper we present our concept and prototype for supporting participatory modelling using a web platform. A system dynamics model viewer, as a part of this, streamlines the model publishing and thus enables a web-based collaborative and cumulative (Hagel 2005) modelling when face-to-face participatory modelling sessions cannot be organized as often as desired. Not only the result of the model development but also its successive iteration steps can be displayed interactively together with comments and explanations made by the modeller. The web system also provides possibilities for all participants of the collaborative process to contribute to online discussions. Model development is thus closely connected to and also triggered by shared model understanding and intensive discussion.

In the following section we first discuss some aspects of participatory system dynamics modelling. The prototype of our web viewer of system dynamics models is presented in section 3. Section 4 concludes our contribution.

2. Participatory modelling

2.1 Participatory modelling as an essential component of a participatory decision process

Today's decision-makers are urged more often to assess the impact of their measures and their major intentions on the basis of different aspects (Bonjour 2009). This necessitates using applied scientific models, for example system dynamics models, as instruments for identifying and evaluating different kinds of impacts of alternative decisions.

As described by Bonjour, most decision support systems have to integrate the following decision-making features:

- multi-criteria multi-perspective design problem,
- knowledge-intensive distributed product modelling and also
- conflict-oriented problem solving (Bonjour 2009)

In a more general point of view the process of decision-making can be considered as a cognitive process leading to the selection of specific actions among several alternatives. In scientific literature, three decision levels have been distinguished according to their temporal impacts (from short to long term): operational, tactical and strategic. However, every decision has to be associated with human activity, which represents the operational context of this issue.

One of the main aims for establishing a model is to target operationalization of the arguments used and thus to achieving inter-subjectivity. For this reason formal logical models are developed that structurally match the verbal argumentation chains. In this sense system dynamic models can be designed and used to support the decision-makers as a comprehensible collaborative decision support system. By designing a system dynamics model for complex system aspects the structuring of sensitive and complex argumentation chains in a simulation model can be reached in an understandable way (Forrester 1994). Furthermore the integration in a decision support system can be achieved quickly.

With every of the six major "system dynamics steps from problem symptoms to improvement" which have been defined by Forrester, from the hypotheses and stock and flow diagrams, via simulations and alternative policies, through discussions and implementations, "active recycling occurs back to prior steps" (Forrester 1994). Especially in step 2 when formulating a simulation model "writing equations reveals gaps and inconsistencies that must be remedied in the prior description" (Forrester 1994).

One of the key aspects of system dynamics modelling is to integrate all participants in the building of a model and not only in discussing the final result. System dynamics has specific advantages in structuring complex debates in a very understandable way (Andersen 1997). In other words, this way decision-makers are more often integrated into the whole process of model development. Collaboration can be described as an efficient way to share useful knowledge between different actors in the aim to improve the collaborative decision-making process. Collaboration is often necessary to solve different issues that are direct consequences of the strong interdependencies between the actors' activities and decisions. The need of collaboration does not aim at solving technical aspects only but also at building or adapting the project organization in the area of implementation of decisions (Bonjour 2009).

2.2 Web-based participatory modelling

In a collaborative or group modelling process it is an ideal case if the decision-makers and system dynamics modeller can meet and discuss frequently to have "fairly sophisticated pieces of small group process" (Andersen 1997a). In many situations, however, due to long distance or tight schedules group meetings cannot be organized in a frequent way. Instead, digital communication methods especially Web 2.0 approaches (Hagel 2005; O'Reilly 2005) are more often used to achieve group work processes. A web based system dynamics tool has the potential to quickly motivate all participants to further develop their system dynamics model.

The prerequisite for an intensive discussion, however, is that the participants do at least understand the system dynamics model as a starting point of their discussion. To achieve this, an intensive manual preparation for publishing the model has been necessary so far. That reduces the willingness of the modellers to update and re-publish the model, thus the willingness of the decision-makers to contribute to the discussion in turn. Since facilitating frequent cumulative updates present a critical success factor for Web 2.0 based collaboration the effort of model publishing needs to be reduced by means of software support. At the same time it is also important to facilitate contributions to the model discussion, as shown in fig. 1.

The result of the complete modelling process can be made more understandable if the model can be de-composited in successive steps which lead from scratch to the final stage. The web based viewer and certainly the confidence in using system dynamics modelling can be essential for the success of the whole modelling project (Richmond 1997). Furthermore this specific method of system dynamics modelling strengthens the support of formal model construction, and identification of action steps to maximize the overall impact of the intervention on the modelling team (Huz 1997). Related to this context, Cavaleri and Sterman present that different managers reported that the necessary systems thinking helped shifting many people's thinking from a mainly reactive mode to a more strategic mode, which gave them an edge over competitors who relied on a traditional view of managing (Cavaleri 1997).

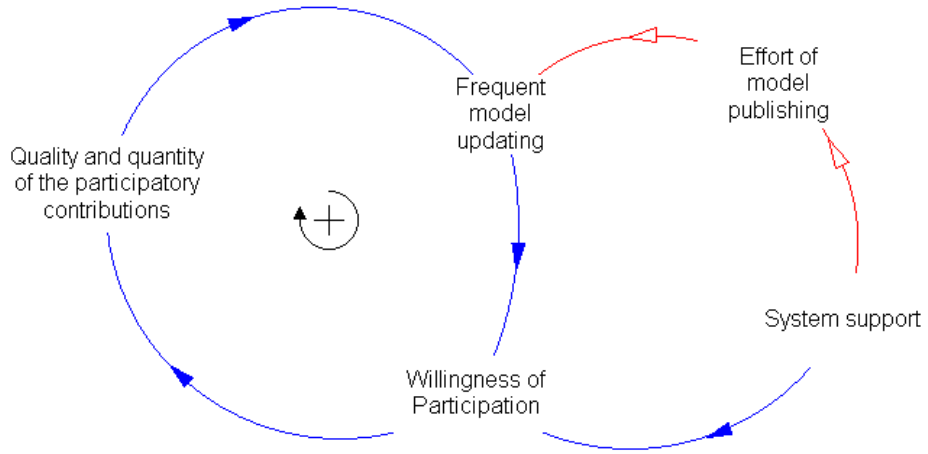

Figure 1: A causal loop diagram for participatory modelling

3. Prototype of a web viewer of system dynamics models

As mentioned previously the success of a model-based collaborative decision-making process does not only depend on the sharing of a common view of the results of the model simulation. It is also essential to achieve a mutual understanding of the model itself. Since the modelling process today is generally an iterative one (Forrester 1994) a model viewer should be capable of representing the different iterative steps interactively. It is aimed to provide this system dynamics model viewer as a part of a working environment for participatory model building (Andersen 1997) in the next years. A simplified use cases diagram of the working environment is shown in fig. 2. When a decision-maker views the model with the model viewer both textual documentations made using the modelling & simulation environment (MSE) and explanations about the each iteration step made on the web-based participatory modelling platform are displayed step-by-step in synchronisation with the model which is displayed graphically.

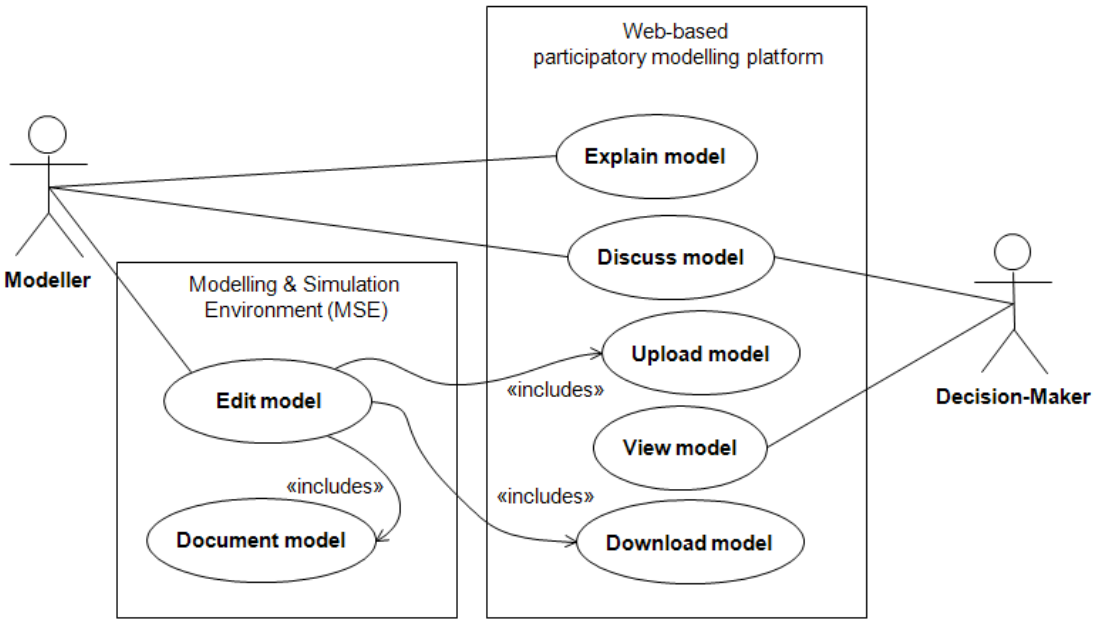

Figure 2: Use cases diagram for a web-based participatory modelling platform

We have chosen a web-based and XML-centric architecture to maximize the reach of the model viewer. As shown in fig. 3 a system dynamics model in Vensim's MDL format (Ventana Systems 2009) is first transformed into XML then into an image. The two logical modules, “Mdl2Xml” and “Xml2Img”, are embedded in an existing web content management system resp. collaborative authoring system which was first introduced in 2004 and has been being developed since then continuously (Hu 2004; Hu 2006; Hu

2010) to take the advantage of existing content management functions like role and group based access control, layout and design control, forum management functions and more.

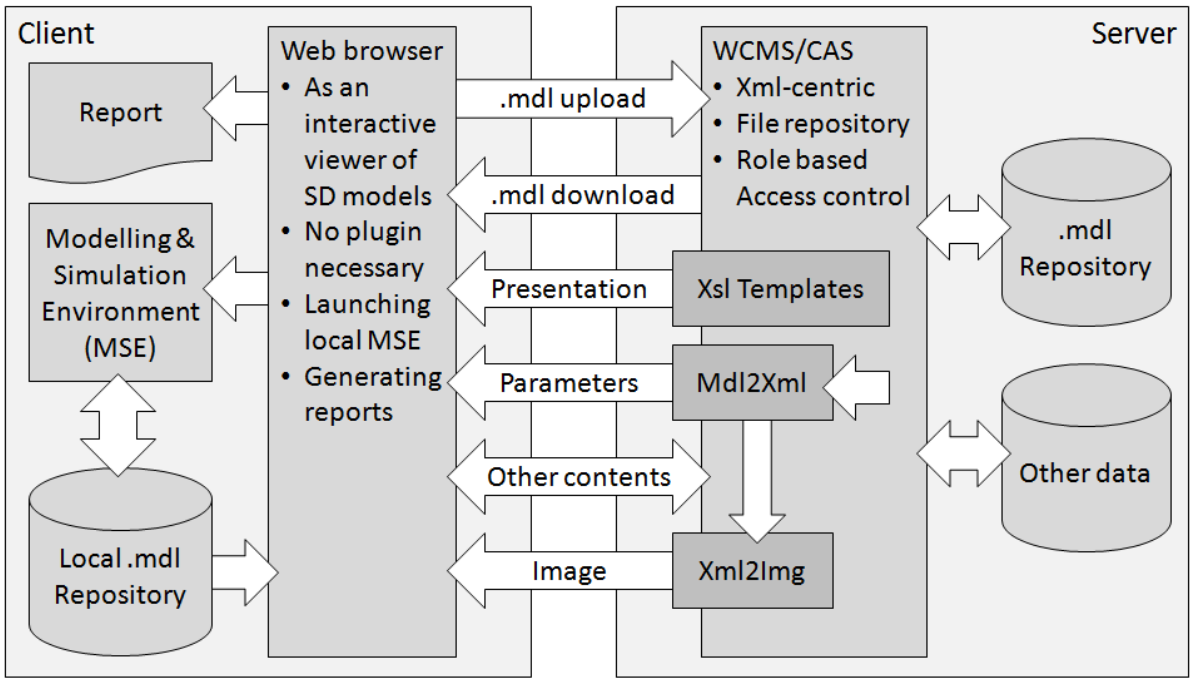

Figure 3: A web-based and XML-centric architecture for the system dynamics model viewer

Using the functions provided by the model viewer system dynamics models in Vensim's native MDL format can be managed by the server directly. To publish a model for discussion the modeller uploads the model simply to the server. The model can be viewed by each person having access to the website using a standard web browser. The most essential feature is certainly that each variable of the model can be assigned to a certain step of the iterative model development. The assignment is carried out within the Vensim's simulation environment using the comment field of each model element.

Once uploaded to the server the iterative development of a system dynamics model can be interpreted by the system automatically and displayed step-by-step by mouse clicks (fig. 4). Another major advantage is the fact that no local software or plug-in is necessary. Moreover, since the model viewer is embedded in a web content management system even complex descriptions about the iteration steps can be integrated and synchronized with the viewer on the same web page. Furthermore a report tool lists all iteration steps together with their graphical and textual descriptions for export into a document. Additionally there exists the possibility to download the whole model as a Vensim file for further model refinement. Discussion forums and other web based tools can be linked to the web interface to streamline model development and discussion. Generally speaking, this web viewer of system dynamics models was developed thoroughly as a part of the web-based system dynamics modelling environment within the last years and will be now used for different types of system dynamics based projects with international partners.

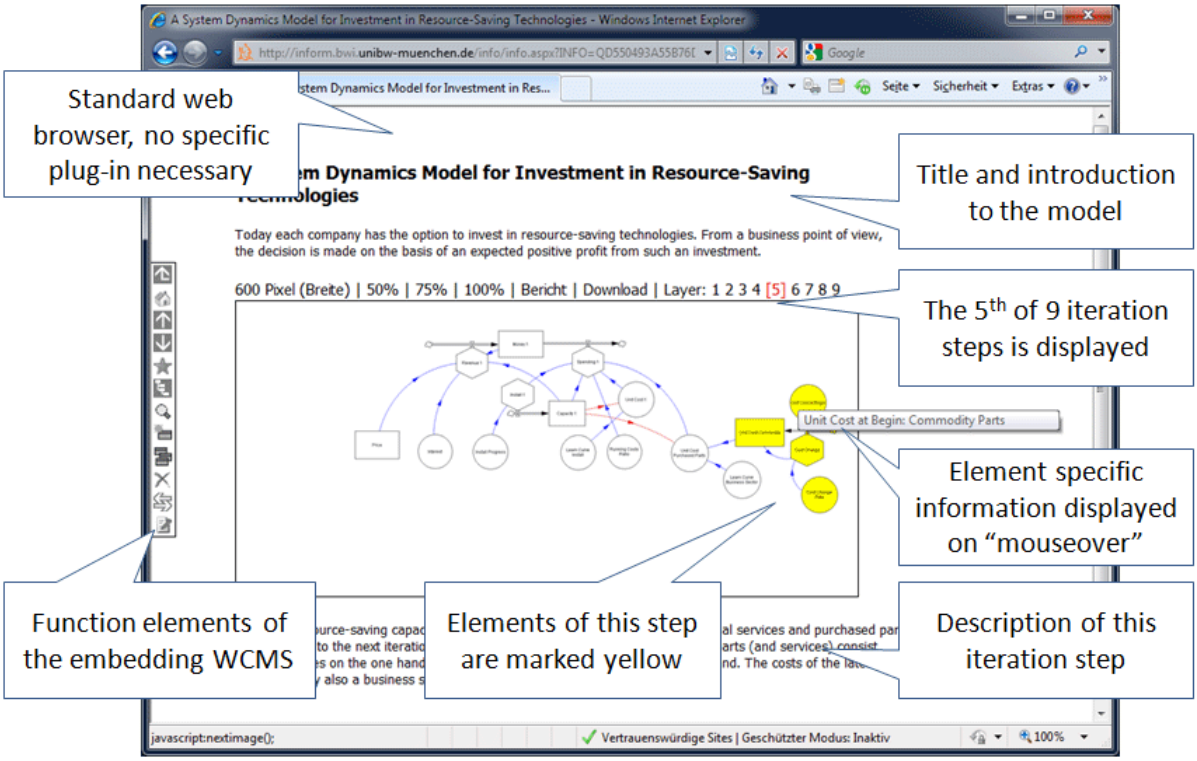

Figure 4: User interface for the system dynamics model viewer

The web viewer is a key component within our concept of web-based system dynamics modelling environment. It facilitates a more intensive discussion and more frequent updates through reducing the effort for updating and re-publishing a system dynamics model remarkably.

4. Conclusion

From the current point of view the platform that we presented in this paper can intensify web-based participatory modelling processes. It strengthens the support of formal model construction and documentation on the one hand and reduces the effort of model re-publishing on the other hand. The modelling processes are made more transparent to all participants by the web viewer of system dynamics models since each of the iteration steps of the model development can be displayed on the web interactively.

Recently we are using the web platform intensively to enable web-based participatory modelling both in an educational context and for our research projects. Further research should help to understand the real impact of the web platform to participatory modelling and decision-making processes in different fields.

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