Support for Model Based Water Management With the HarmoniQuA Toolbox

Ayalew Kassahun[a], Huub Scholten [a], George Zompanakis [b] and Costas Gavardinas [b]

[a]Information Technology Group, Department of Social Sciences, Wageningen University, The Netherlands (ayalew.kassahun@wur.nl)

[b] Department of Water Resources, Hydraulic & Maritime Engineering, School of Civil Engineering, National Technical University of Athens, Greece

Abstract: The drive to improve the quality and reliability of model based water management has resulted in a number of quality assurance guidelines. Up to now all of these guidelines were available only in the form of handbooks. Within the HarmoniQuA project a software-based modelling Knowledge Base and support tools have been developed, that greatly enhance the way quality assurance guidelines are applied in modelling. The Knowledge Base is built using ontological knowledge engineering techniques, which enable us to structure the knowledge and make it easily accessible. A web-based interface is used for the purpose of knowledge acquisition. The Knowledge Base is then accessed via tools that constitute the HarmoniQuA Toolbox. The Guideline Tool is the front end to the Knowledge Base, filtering the relevant knowledge depending on the user profile and needs. A modelling process involves a complex set of activities executed by several users. To manage this complex process and enhance the reproducibility of modelling tasks the Monitoring Tool has been developed. This tool guides users through the execution of their modelling tasks and stores their activities in a model journal. A reporting functionality of the Monitoring Tool generates a report on the modelling project with the required level of detail. This paper describes how the HarmoniQuA Toolbox will support the work of all persons involved in model based water management through the full modelling cycle.

***Keywords**:* quality assurance; model based water management; knowledge base; HarmoniQuA toolbox; model journal

1. INTRODUCTION

The drive to improve the quality and reliability of model based water management studies has resulted in a number of quality assurance guidelines. Some of the most popular quality assurance guidelines include the good modelling practice developed in the Netherlands [van Waveren et al. 2000], the Murrey-Darling groundwater flow modelling guideline in Australia [Middlemis H. 2000] and the Bay-Delta modelling protocol for water and environmental modelling in Californian (BDMF 2000). However these quality assurance protocols and procedures lack software tools that support them.

A new computer-based quality assurance (QA) procedure is being developed within the HarmoniQuA project. Two kinds of software tools are implemented (or arein their final stage of implementation.) The first kind is the knowledge base system and knowledge base editor to be used by experts in the field of water management to gather and organize quality assurance procedures.

The second, and the most important, kind in the context of this project is a support tool called the HarmoniQuA Modelling Support Tool (MoST) to be used by users such as water managers, modellers, auditors, stakeholders and interested public who want to apply these QA procedures in their modelling effort or who want to see what is being done and track the progress of a modelling study.

We created guideline ontology that prescribes modelling process in the field of water management, specifically for catchment and river basin modelling studies. A knowledge base (hereinafter referred to as KB) and a corresponding editor that enables experts to enter and edit knowledge elements in the KB was then build. The KB and the KB-editor run on a central computer

on a web server enabling experts to cooperate smoothly in the development of these procedures.

The HarmoniQuA MoST is a collective name for a number of tools or functionalities. The Guideline Tool is a user-friendly access to the KB, allowing users to set up a customised view of the KB. Traditionally guideline protocols are provided as handbooks containing all information. With the help of the guideline tool users can specify which part of the guidelines they are interested in and get only relevant information to their study.

The second tool we developed is called the Monitoring Tool. This tool records decisions made and methods and data used during the modelling process. This tool is used not only to record user actions but also guide the user what the next action should be following the standard procedure.

The third tool is a reporting facility that filters the myriad of logged information by the monitoring tool into a readable and compact report to assist users to get an overview of project progress.

The last part of MoST is the advisor tool, which is designed to use experience of previous model based water management studies to give advice on modelling problems at hand.

2. OVERVIEW OF THE PRODUCTS

Figure 1 shows the overview the HarmoniQuA system and the relationship between the different components. The KB is the repository of expert knowledge in the field of water management. It is edited and kept up-to-date by experts using the KB-editor.

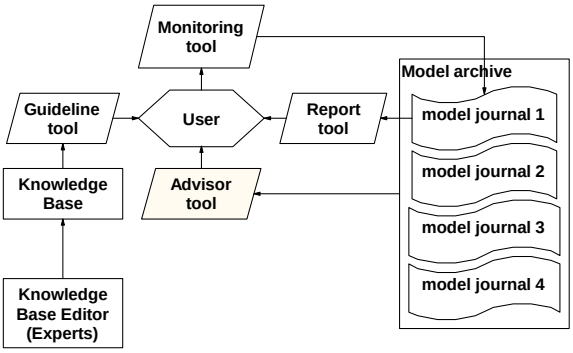

Figure 1. Overview of the HarmoniQuA system.

The Guideline Tool interacts with the KB, centrally stored on a network server, to upload the guidelines to the users personal computer.

The monitoring tool gathers user inputs and stores these in a model journal. The model journal is kept local on the users computer and can later be uploaded to a network server store called model archive where model journals are centrally stored.

In the reverse process, the reporting tool reads the model journal and generates a report.

The advisor tool is part of the design of the HarmoniQuA system but its full functionality may not be realized within the lifetime of the HarmoniQuA Project. This tool is meant to crawl through the different model journals and give advice to the users, mainly modellers. The advice is based on the accumulated experience of different previous modelling studies stored in the model archive. For instance the advisor tool may advice that the specific method to execute a certain activity may have been used in a similar kind of study as the modeller is working on by several other modellers.

3. KNOWLEDGE BASE

3.1. Knowledge base structure

The term *knowledge base* in this context is used to refer to a machine-readable and -interpretable collection of information that uses ontology to structure the information. We developed an ontology that describes a modelling process in water management as shown partly in Figure 2. The dashed lines indicate relationships between knowledge elements. The solid lines indicate a special kind of relationship called inheritance.

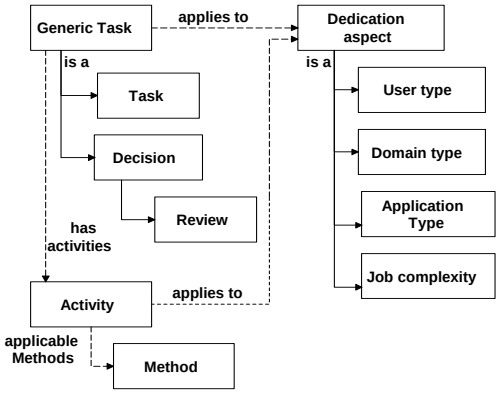

Figure 2. Part of the ontological structure for the KB, which is used to produce the modelling guideline.

The ontology comprises of two parts. The first is the *Task ontology*; it decomposes the tasks and related information into fine-grained concepts such as Activity and Method. The second ontology describes *dedication aspects*. Dedication aspects are qualifiers of concepts from the task ontology.

Dedication aspects tag a knowledge elements of the *Task ontology* as to who (water managers, modellers, auditors, stakeholders and interested public) the knowledge element is relevant to, which domain (ground water, flood forecasting, etc) it is applicable for, which application types (planning, design or operational management) it apples to and what the complexity of the modelling study is [Scholten *et al*., 2004]. Please refer to accompanying paper [Scholten *et al*., 2004] for detailed description of the decomposition.

The knowledge base has been designed according to the following criteria: correctness, consistency, maintainability, accessibility and flexibility [Huub & Osinga 2002]. *Correctness* concerns about the truth of individual knowledge elements. *Consistency* refers to the validity of the relationship between knowledge elements. The rest of the criteria are self-explanatory.

3.2. Knowledge base system

A knowledge base system with a web-based editor is built to satisfy the requirements stated above. It should be noted though that careful review processes that accompany knowledge acquisition was vital for a correct and consistent KB. The fact that the KB is based on ontological techniques make it easy to improve the structure of the KB, thus making it flexible in terms of adopting new insights. For instance, in the past the structure of the KB has changed after a review process while the tools required no major changes.

The knowledge base system is based on the Protégé-2000 ontology editor and knowledge base system [Noy et al. 2000]. Protégé-2000 is widely for medical and clinical information systems that support clinical procedures. We develop an extension to Protégé-2000 and a web interface to support the modelling guideline ontology. Knowledge base experts and specialists in model based water management interact through this web interface with the Protégé system.

3.3. Knowledge base editor

The knowledge base editor is web tool that allows experts to view and edit the contents of the knowledge base. We developed a knowledge base editor that reflects the ontology developed for the knowledge base. When the ontology changes the editor adjusts to the new ontology.

Because the editor is aware of the dedication aspects, the editor allows experts to enter information only in their own field of expertise. The authorisation mechanism of the editor minimises conflicting updates and errors.

The editor is supposed to be used not only for the lifetime of the HarmoniQuA project but also beyond, since modelling guidelines have to reflect new insights and new developments. In this perspective the knowledge base editor provides all interested individuals the possibility of providing their comments and suggestions.

4. HARMONIQUA MODELLING SUPPORT TOOL (MoST)

The HarmoniQuA Modelling Support Tool (MoST) is a desktop application. Depending on the need of the user the tool can be used as a Guideline Tool, Monitoring Tool, Reporting Tool or Advisor Tool. At present the Guideline, Monitoring and Reporting functionalities of the tool are implemented. The Advisory Tool is only part of the design.

4.1. Introduction to the tools

The HarmoniQuA MoST is built with ease of use in mind. The user interface is composed of three resizable windows. The left-hand side window shows an overview in the form of a tree structure or flowchart. The other windows show the details for the selected item on the left-hand side window, thus resembling most common desktop applications. This resemblance minimizes the need for training to new users. At present the tools have been built for Windows™ operating system and in the near future we will port the tools to Java™ so that the tools will be available on a wide variety of operating systems.

4.2. Guideline Tool

The guideline tool is the front end of the KB. This tool keeps a copy of the guidelines and is capable of updating the guidelines by requesting the knowledge base server for the recent version of the guidelines.

To use the guideline functionality users need to specify their personal profile. The user profile is a combination of all dedication aspects that user specifies as applicable to his work.

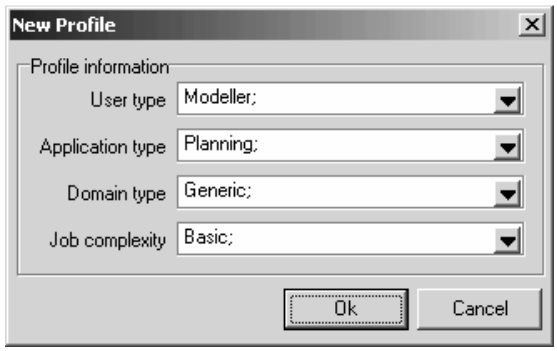

Figure 3. Profile selector of the Guideline Tool

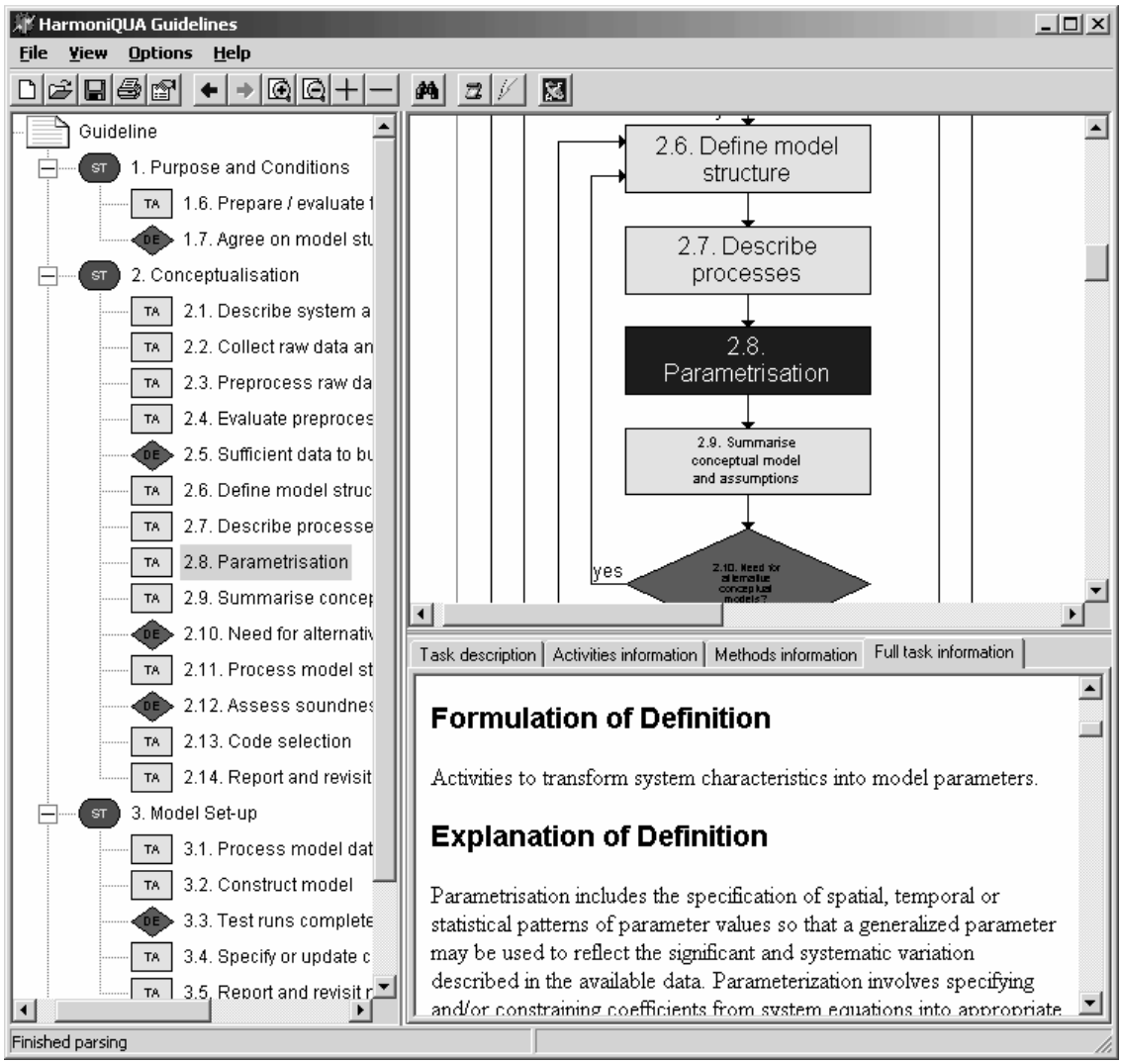

Figure 4. The HarmoniQuA Guideline Tool

Figure 4 shows the guideline tool. The left-hand side window is called the *tree view*. The tree view shows the HarmoniQuA flowchart as a tree structure. The top right window is called the *flowchart view* and shows the flowchart complete with feedback loops as a flow diagram. The lower-right window shows the detailed information of the task and is called the *task view*.

4.3. Monitoring Tool

The monitoring functionality of MoST is used when users mainly water managers and modellers want to track the tasks and activities performed during a model study. This tool records tasks and activities that are executed or skipped, decisions that are made and methods and data that are used so that the whole modelling can be tracked and checked.

Like the guideline functionality this tool is composed of three resizable windows (see Figure 5.) The left-hand side window is called *navigation view* and shows the sequence of model tasks that are already completed or skipped. The tick mark against the task indicates that the task has been completed; the *x* marks indicates that the task was skipped. The question mark indicates that the task is being worked on at the moment.

The top-right window shows detailed information on the task and is called the *task view*. This information is the same information that is shown in the *task view* of the guideline tool.

The lower-right window is called *activity view*. This view shows the list of activities for the task selected in the *navigation view*. In the same way as in the *navigation view* the tick marks in the *activity view* indicate completed activities, the *x* marks indicate skipped activities and the question marks indicate the activities not yet completed.

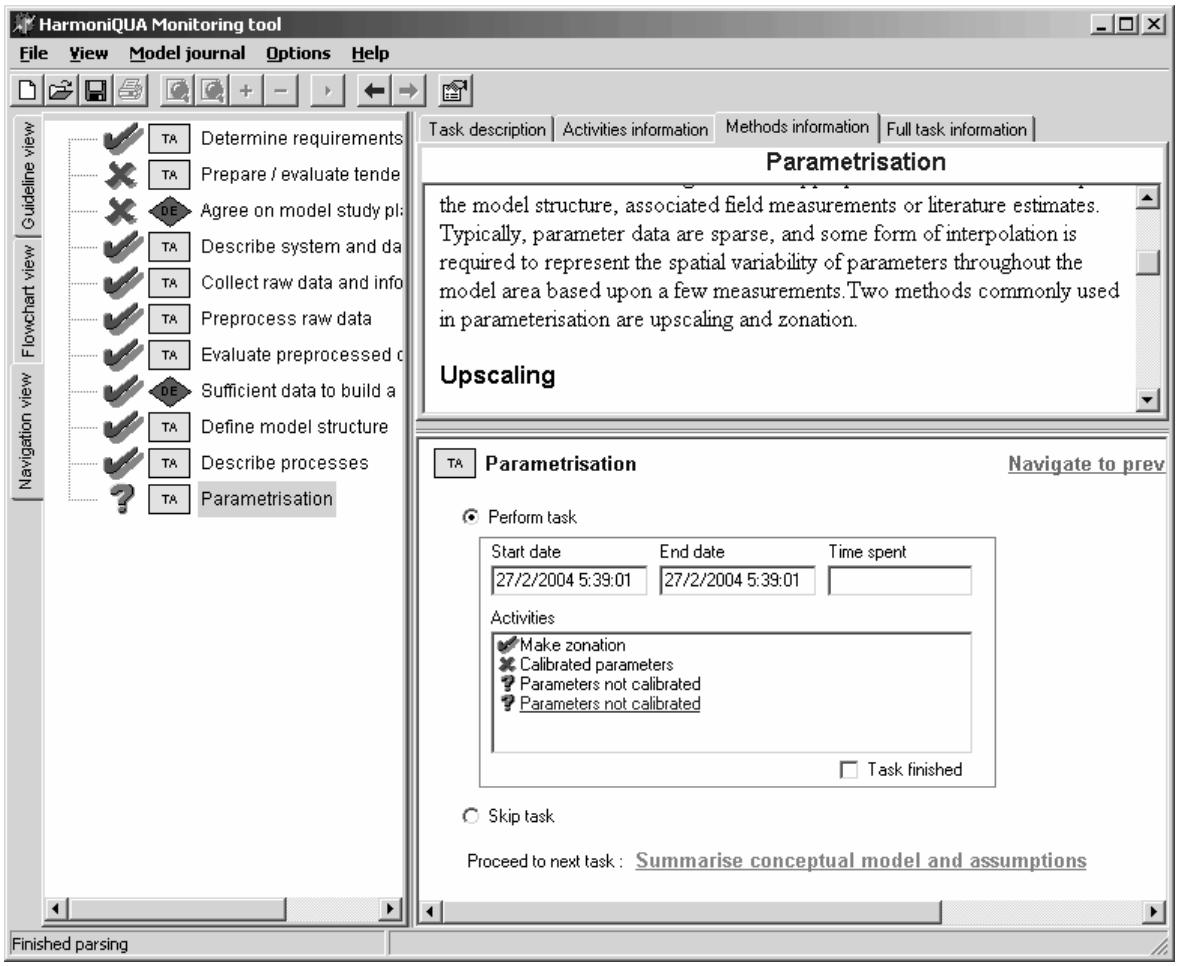

Figure 5. The monitoring functionality of MoST.

Clicking on an activity takes us to the *journal view*. The journal window is where the users actually record model journal information (Figure 7). This window also provides the possibility of attaching log files or relevant project documents.

4.4. Reporting

The purpose of the reporting functionality is to provide a report in a readable format to water managers, modellers, auditors, stakeholders and interested public. The benefit of the audit trail recorded by the monitoring tool will be severely restricted if there is no tool that can filter the myriad of recorded decisions made, methods and data used and other information such as the time a specific task is finished to the level of detail users need for a specific goal. Moreover, not all information may be publicly available. For instance some part of the audit trail may not be allowed to be released in the public domain. A reporting facility is designed like the other tools to be sensitive for the actual dedications aspects. Thus it will be aware of the context of the information elements in the model journal and will be capable of generating the right information for a given audience.

At present the reporting tool is a work in progress and doesn't fully provide the designed functionality. Figure 6 shows a sample report.

5. CONCLUSIONS

The HarmoniQuA modelling support tool gives guidance to water managers, modellers, auditors, stakeholders and interested public software-based guidance on good practice. It also provides them a tool to record what they are doing, leaving an audit trail of the modelling study. A reporting facility allows users to generate reports on projects that are completed or in progress, which is particularly useful for water managers and auditors.

The tool and the KB incorporate the concept of dedication aspects since different types of users are involved and have different views and interests, modelling studies differ in the domain of application, job complexity and application purposes.

Our tool and KB attempt to support the complex process of model based water management. A substantial part of the HarmoniQuA resources are spent to two rounds of testing the tool and the KB.

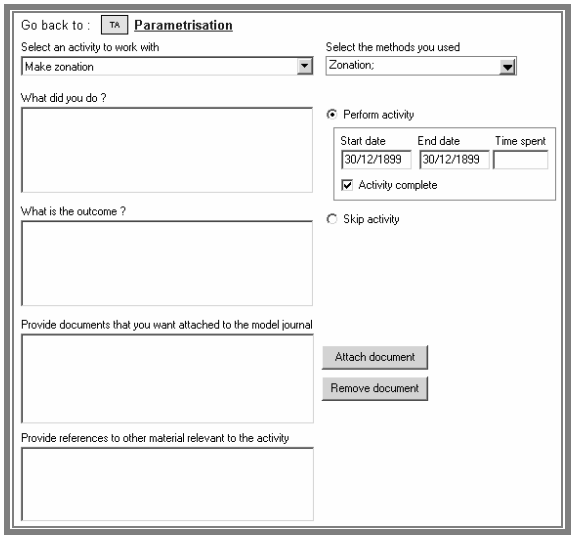

Figure 7. The journal window of the Monitoring Tool

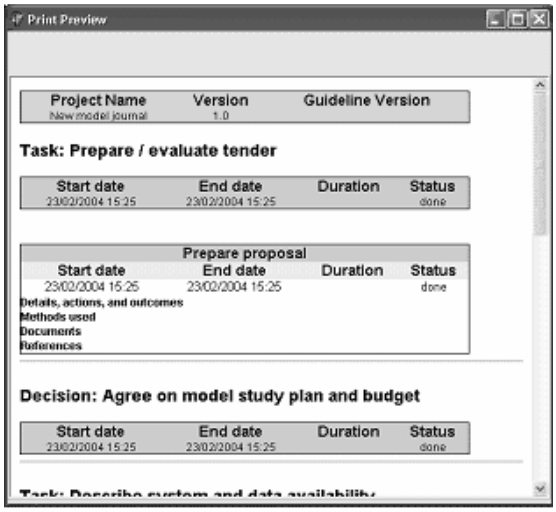

Figure 6. Sample report

The first round of testing, mostly done by modellers and some water managers, showed that users found the tool and the KB useful. The present guideline functionality was very satisfactory according to the test. The monitoring functionality received also very positive reactions but also lots of feature requests, which indicates that modelling support tools are valuable in modelling studies.

Our choice for an ontology-based implementation of the knowledge based has also paid dividends. The guideline procedures have undergone its first review process that resulted in some modification to the structure of the knowledge base. That resulted in only minimal modification to the knowledge base and the tools.

Finally while the knowledge base is at present rather stable, the development of the tool is still work in progress. The monitoring tool needs multi-domain support and extra fine-tuning. The reporting tool needs to support fine-grained report generation. The advisor tool is not further developed than some rough brainstorm ideas and will only be developed if time and resources allow.

6. ACKNOWLEDGEMENT

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