HarmonIT: Towards OMI, an Open Modelling Interface and Environment to harmonise European developments in water related simulation software

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Abstract The paper will describe a large new EC funded project developing mechanisms for linking models of different aspects of the water environment.
To allocate scare water resources between competing demands in a fair and sustainable way, Europe has adopted a policy of integrated water management. However, this approach places great demands on water managers. Consequently, they are turning to decision support systems to help them find viable solutions. To date, these have helped managers forecast the likely outcomes of policy decisions within relatively confined areas of the environment.
Integrated water management requires that managers should attempt to foresee and allow for the likely results of their decisions across the whole of the natural and socio-economic environments. To do so requires the linking of a wide variety of models so that process interactions can be foreseen. Current attempts to solve this problem have usually been within the context of a particular supplier's software. This effectively limits the user's ability to access the wealth of available models. HarmonIT is about removing this limitation.
The paper will describe the project, its aim of producing a European Open Modelling Interface and Environment (OMI), the consortium of research institutes, universities, consultants and river authorities behind it and the approach being adopted.

Keywords model linkage, software architecture, integrated water resource management, OMI, Open Modelling Interface and Environment

1. Background

Integrated catchment management has arisen, because managing environmental processes independently does not always produce sensible decisions when the wider view is taken. However, the problem for those charged with integrated management is the complexity of the process they are attempting to manage. Managers are therefore turning to decision support systems. In this context, a decision support system comprises one or more models, their associated data and a user interface. The models are used to predict the likely outcomes of pursuing different policies for given scenarios and thus help the manager chose the most appropriate option. So far, the models used in these systems have tended to address single issues, accounting for only a limited number of the process interactions taking place within a catchment. However, under integrated catchment management, the manager needs to understand all the possible impacts of pursuing any given policy. For instance, the managed retreat of the coastline may reduce the cost of coastal defence but could also incur costs in

terms of lost habitats, loss of agricultural land, employment and so on. Thus, it is the need to be able to understand process interactions that is driving the HarmonIT project.

A model of the whole environment is not feasible and therefore it is necessary to link models, together. For example, an investigation of a new dam might require an assessment of its impact on fisheries, tourism and the local economy. Linking models, however, is fraught with problems, the more important of which are summarised in the panel. Models have different strengths and weaknesses and during the various phases of a modelling exercise, it may be appropriate to replace one model by another. For example, a model suitable for plot scale work is unlikely to be appropriate for regional scale modelling.

Emerging from this background are two requirements: one is for a framework on which models can be mounted and interchanged. The other is for a device to link models together. Although, individual organisations have addressed the linking problem, there is, as yet, no generic solution. Currently, model linking is therefore either confined to the products of a single supplier or requires a major software development exercise.

Model linking issues

- Scale & resolution (spatial, temporal)
- Representation of the time dimension (steady state/dynamic)
- Representation of the spatial dimension (lumped/distributed)
- Model concept (deterministic/stochastic)
- The regime for which the model is designed (e.g. arid/Mediterranean/arctic)
- The aspect of the variable modelled (e.g. high flows or low flows)
- The need to represent feed back loops
- A lack of common data definitions (e.g. the term 'nitrate' is interpreted differently by riverine, estuarine, marine and atmospheric modellers)
- Absence of an agreed generic data model to describe the world
- The lack of a framework on which models to be linked can be mounted
- Platforms on which the models to be linked run (e.g. Unix or Windows NT)
- The physical location of models to be linked (same machine, different machines, different locations)
- The medium by which linking is achieved (export and import of files, shared memory between programs, etc.)

The absence of an open modelling environment therefore makes it difficult to capitalise on the huge past European investment in model development. The high cost of developing a generic solution to the problems indicated is only justified when it can serve a large user base. For the solution to be adopted, a climate is required in which the advantages of co-operating outweigh the disadvantages of having to conform to a standard. The introduction of the Water Framework Directive across Europe has created the need and the potentially large user base. Recent technological advances in computing and software design techniques and the availability of digital spatial data have removed many of the technical problems. A number of national initiatives, for example, in the Netherlands [van der Wal *et al*. 2000, Blind *et al*. 2001, WL|Delft Hydraulics & RWS-RIKZ 2001], Denmark [Havnø *et al*. 2001] and Australia [Reed *et al*. 1999], have shown that frameworks can be developed into which alternative models can be plugged. But so far, most frameworks have not progressed beyond the conceptual design stage and only a few have been implemented. However, sufficient progress has been made to convince the major European commercial players in the water resources software market, that a generic solution to linkage of legacy systems is now feasible. By their presence in this project, the major commercial players have clearly

demonstrated that they believe that the advantages of co-operating now outweigh those of competing. Nevertheless, the task remains a scientific and intellectual challenge of a high order.

On the initiative of the Institute for Inland Water Management and Waste Water Treatment (RIZA, NL), a European consortium, led by the Centre for Ecology and Hydrology (CEH, UK), submitted a proposal to the EU 5th Framework programme under the key action 'Water' within 'the Environmental, Energy and Sustainable Development' programme. The proposal, called, 'HarmonIT: IT frameworks' was accepted and started in January 2002. The full list of the consortium members is given in Table 1.1

This paper, written on behalf of the consortium, introduces the R&D project, sets it in context, and describes the objectives, deliverables, scheduled activities, as well as some preliminary results from the first months of work.

Table 1.1 Participants of the HarmonIT consortium

Participant short name	Participant name
CEH	The Centre for Ecology and Hydrology
RIZA	Institute for Inland Water Management and Waste Water Treatment
DHI	DHI- Water & Environment
WL|Delft	WL | Delft Hydraulics
HRW	HR Wallingford
Dortmund	University of Dortmund
IRSA	Water Research Institute of the Italian National Research Council
NTUA	National Technical University of Athens
WRc	WRc Plc - The Water Research Centre (UK)
DHI HIF	DHI Hydroinform a.s.
PL	Povodí Moravy s.p.
HDP	Hydroprojekt a.s.
Alterra	Alterra, Green World Research
Cemagref	Cemagref

2. The HarmonIT-project

2.1 Objective

The aim of the project is to develop, implement and prove an European Open Modelling Interface and Environment (OMI) that will simplify the linking of models. If such linkages can be achieved, the understanding of catchment process interactions at the basin and sub-basin scale can be extended, hence allowing catchment managers to explore more fully the likely outcomes of different possible policies.

Given the amount of knowledge (and human resource capacity) encapsulated in existing tools, an important objective of the project, is to ensure that this vast investment is made as accessible as possible to those charged with the management of Europe's water resources. Hence, the primary design objectives of the Open Modelling Interface and Environment are to remove the current obstacles to the use of models, to facilitate the use of appropriate models and to facilitate the migration of existing models to the new standard so that they are more widely accessible. This implies that the project is not about the development of new tools that render existing facilities obsolete. Rather, it is considered a software refactoring project, where existing solutions are combined, modernised and reused.

2.2 Approach

To achieve the objectives, the activities have been grouped in ten work packages over four years (see Figure 2.1), which are organised in a waterfall development approach. The arrows on the left indicate the provision for feedback from the inevitable learning process that will take place.

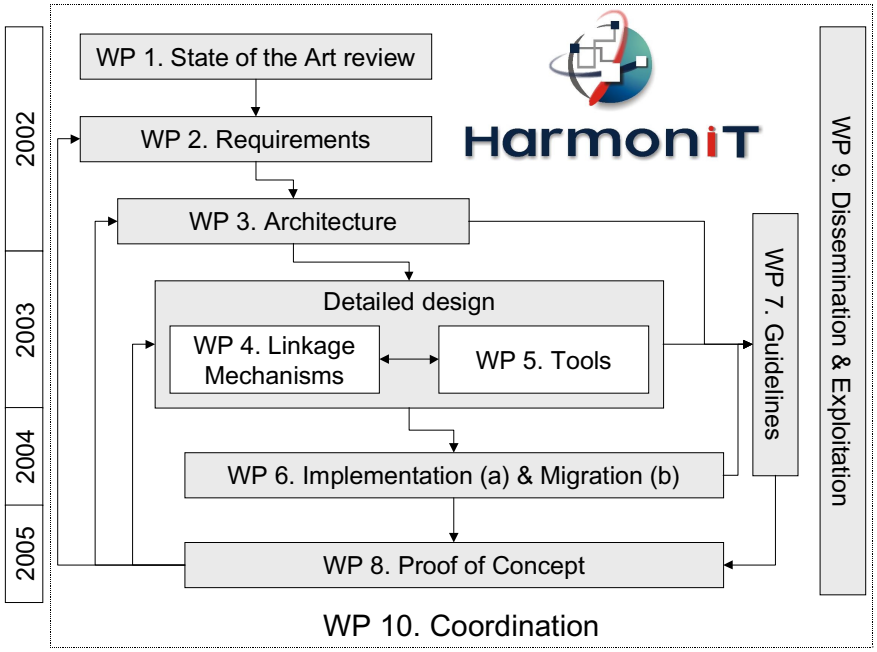

Figure 2.1 HarmonIT working package relations and time schedule

2.2.1 State of the art

The first work package is a review of the state of the art with respect to building frameworks for model integration (WP1). Its main purpose is to document the different model architectures in use, how they are linked at present and how they are used in integrated water management. An implicit part of this task is to understand the limitations of the current procedures and facilities. If HarmonIT is successful, then question arises of how to maintain the OMI into the future. Part of the task is therefore to review how other similar interfaces, such as 'Open GIS' are maintained and funded.

2.2.2 User requirements

Although the overall objective of the project is clear, a much more detailed statement of user needs is required before work can begin on a solution. The second work package will therefore seek to identify the requirements not just of the

User Requirements - Contents

- The background to the OMI
- The aims and objectives of the OMI
- The water management domains that the OMI is intended to serve and link
- The types of model that the OMI

participants but of the wider community. HarmonIT will actively seek out views and will conclude with a workshop, open to all, where interested parties can express their views. At the end of this work package, decisions will be made as to how much of the ideal requirement can be delivered within HarmonIT.

should be able to link
- The types of linkage required and the information to be passed
- The functionality required to create and monitor links and operate the resulting linked models
- The hardware and software environment in which the OMI should function

The final report will specify the functional capability of the Open Modelling Interface and Environment with respect to the linkage mechanism and an initial set of tools to support and monitor its use. It will also include a preliminary list of the models to be migrated. A continuous task throughout the work package will be achieving positive acceptance of the proposed functionality by the potential user community. The specification will provide the main input to the work packages developing the OMI architecture.

2.2.3 Architecture

The Architecture work package represents the first stage in the design process. Its main objective will be to develop the principles and concepts that will guide the rest of the project. These are expected to include:

- A generic conceptual model (to explain the concept to users at all levels)
- A high level system architecture describing the main components and their mutual relationships and basic interfaces
- A high level specification of the domain boundaries and associated data structures and semantics
- A specification of basic mechanisms and protocols for communication and flow

It is proposed to place all those parts of the Architectural Design Document concerning interfaces and protocols in the public domain via the HarmonIT web site (www.HarmonIT.org).

2.2.4 Detailed design of linkage mechanisms and tools

In terms of software, there are perceived to be three major deliverables for HarmonIT. These are a linkage mechanism, a set of tools for creating and monitoring links and a small set of models converted to work in the new environment. The development will take place in two stages, detailed design and implementation.

The first design task, the detailed design of the linkage mechanism, will extend the architectural design into a clear, well-documented and detailed specification document, covering the data models, data definitions, linkage mechanisms, and interface definitions for all components of the Open Modelling Interface and Environment.

A second task will deal with the detailed functionality and design of tools for creating and monitoring links and for managing the linked models.

2.2.5 Implementation

The aim of the implementation work package is a) to transform the detailed design specifications prepared in previous work packages into operational code and b) to migrate a

selection of available existing simulation models used in water management to the new standard.

The code development of the Open Modelling Interface and Environment is anticipated to be an incremental, iterative process. It will focus on implementation of the individual tools and components in parallel with the migration activity, so a fully functioning code implementation, but limited to certain applications, can be tested at an early stage and then subsequently be expanded as the project progress. This is seen as an important approach for a successful implementation, as simple prototypes are tested and experience is gained while the complexity increases.

The migration process covers the transformation and modification of a selection of available models to fit the framework developed in WP 6a. These models will be used in the testing carried out both in this work package and the Proof of Concept Work Package.

2.2.6 Guidelines

As the framework and its specification is developed, guidelines for its use will be prepared and placed in the public domain.

2.2.7 Proof of concept

Within the consortium, the parties have one of two roles as either ‘developers’ or ‘testers’. The latter are not involved in any of the previous working packages and their task is to migrate some of their model programmes to the OMI-environment. The objective is to prove both to the consortium and the user community that the ideas developed within the HarmonIT project are workable and of benefit.

The ambition of the consortium is that the Open Modelling Interface and Environment, which will become a European, hopefully global, standard for model linkages. In order to increase widespread acceptance, a User Group will be established, which will include members of IMUG. Additionally, other parties are invited to contribute to discussions (e.g. by attending workshops, conference presentations), to comment on draft documents published on the web-site (www.HarmonIT.org) and to test the OMI by migrating their own models.

2.2.8 Implementation and exploitation

Implementation and exploitation are

- To disseminate information about the standard under development to potential users through publications on its web-site (www.harmonit.org), conferences (e.g. HydroInformatics) and workshops (WP9).
- To establish a plan which will ensure that the Open Modelling Interface will continue as a living standard after the end of the project (WP9).

It is considered important to keep the development cycle as short as possible – bearing in mind that a standardisation process takes time. Hence, the project aims at having a complete Beta version of the main deliverables (i.e. the specification of the software architecture and component interfaces, resulting from WP 3, 4 and 5) ready 24 months after the project start.

2.3 Who is the target group to benefit?

One of the first items to be addressed in the project will be the identification of the people who in some way must benefit the project if it is to be judged a success. Table 2.1 provides

an initial assessment. When the list is complete, it is these people that Harmon will consult to obtain a balanced set of requirements.

Table 2.1 OMI user profiles foreseen in the HarmonIT project

User type	Description: potentially will…
System Administrator	• install and support the OMI environment within the organisation. • be responsible for maintenance
Model-coder (IT)	• use the OMI to build new or redesign existing model components
Tool-coder (IT)	• use the OMI to build OMI-compliant tools • use the OMI to redesign / migrate OMI-compliant tools
Product assembler	• assemble OMI-compliant components (model codes, tools and GUI-components) into integrated software products for non-specialist users
End user Application builder	• build dedicated user interfaces for non specialist users
Data Manager	• manage underlying general data for modelling purposes
Model-builder	• use the OMI-based software products to build an integrated model of a physical system
Model Integrator	• link models and tools to form integrated systems
Specialist end user	• use the integrated system for scenario studies
Non specialist end user	• use the integrated system for scenario studies / scenario inter-comparison

Summary

The paper has described a new project called HarmonIT, whose aim is to develop an Open Modelling Interface and Environment to facilitate the holistic approach to water management called for in the Water Framework Directive. A consortium of the major European model producing companies, research institutes and universities backs the project. Fifty percent of the funding will come from the European Commission and the rest from the partners themselves. The consortium believes the necessary political, commercial and technical conditions now exist for the project to be feasible. An important element of the approach will be maximising the extent to which the wealth of existing models can be brought into the new environment and made more accessible to the European user community. The ultimate aim is the creation of a European standard. Potential users outside the consortium are invited to contribute to this development.

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