Lean interfaces for integrated catchment management models: rapid development using ICMS

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Abstract: A move towards the development of lean, issue-focused interfaces is being explored to provide a rapid delivery mechanism to transfer catchment science to managers and custodians. This approach is a move away from development of large decision support systems which attempt to anticipate a myriad of management questions. It relies on having a modelling system which supports the rapid building and integration of catchment models, and is independent of the interface. ICMS (Interactive Component Modelling System) is a PC-based software tool which has been developed with this in mind. The kernel of the ICMS system, ICMSBuilder, provides the modeller's view of the world, on top of which can be built any number of interfaces which provide the targetted audience's view of the world. This paper presents an ICMS prototype to demonstrate the power and flexibility of such an approach. It describes an ICMS project - a suite of linked models which explore the relationships between hydrology, water allocation and extraction rules, and on-farm decision making; and an ICMS View - an interface for that project tailored to address specific management scenarios. Interestingly, the ability to interact with parts of the models through the View gave managers the confidence to delve into the underlying models and data, something often denied to them by traditional decision support systems.

Keywords: resource management, decision support, interface design, water allocation

1. INTRODUCTION

Delivery of science to environmental managers and stakeholders in a meaningful and understandable way is a crucial element in building expertise in sustainable and robust catchment management. It is also a crucial link in building confidence and trust between science providers and science users.

This paper looks at the use of decision support systems (DSSs) to capture and deploy scientific understanding. Over the past ten years or so in Australia, DSSs have formed a core component of many environmental R&D projects. Indeed, many R&D granting agencies require development and delivery of products as integral to a research project. In this technological age, products mean not just static reports with limited shelf life but software products which can be used in a dynamic fashion to explore alternative management and catchment condition scenarios.

In accepting that DSSs have a significant role to play in capturing and deploying science, it is useful to define a DSS and then investigate these two functions. In this paper, the classic definition of DSS as "*interactive* computer-based systems that *help* decision makers utilize *data* and *models* to solve *unstructured* problems' [Sprague and Carlson, 1982] is used. In today's terms, this means that the DSS must, at the very least, include data and model management systems, and the ability to construct queries that can interrogate the data and execute the models.

DSS can play a powerful role in the capture of science—they provide a framework in which members of a multi-disciplinary research team can contribute both to the description of 'the problem' and the design and implementation of 'the solution'. A DSS with well-designed integration and linkage protocols can thus provide the mesh that binds different disciplinary approaches (and solutions) together.

DSSs can play a significant role in the deployment of science. However, their usage, especially by decision-makers, appears to be limited. While there are surely cultural and political factors contributing to this, the authors assert that usage is significantly inhibited by delivery issues, in particular that many DSSs are:

- overly complex
- time-consuming in their design, construction, transfer and training phases
- not well targeted (ie the audience is not well understood (or even known)).

In a nutshell, they are designed to suit their capture role and their captors' view of deployment.

Taking for granted that most DSSs are genuine attempts to transfer good science, we can hypothesize that these problems are strongly influenced by:

- inefficient and time-consuming deployment tools
- inability to recast the solution appropriately for different audiences.

This paper explores the use of a 'leaner' approach to DSS development and deployment and whether this approach can make a positive contribution to the transfer of science to a wider, usually non-technical, audience. It does this by building a suite of models which address a real environmental issue, water allocation in a stressed Australian catchment, and then building a lean interface to that suite to facilitate transfer of the system.

The following sections describe the water management issue, the software platform used to build an application to describe and explore the issue, and the application itself. Most importantly the usefulness of the approach to application development and the reaction of different audiences to the application is analysed.

2. BACKGROUND

2.1. Management Issue

The Namoi river catchment in northern NSW covers an area of approximately 42000 km^2, with the Namoi river flowing for approximately 350 km before meeting the Barwon river at Walgett (see Figure 1). The Namoi river is a regulated river with three main storages: Keepit Dam on the Namoi river just above the junction with the Peel River, Chaffey Dam on the Peel River and Split Rock Dam on the Manilla river. This catchment covers a diverse range of land uses, including heterogeneous cropping and grazing activities in the upper catchment, native forests, and large irrigated cotton growing areas in the lower catchment. Water allocation is a significant management issue in the basin. In particular, the resource is now overallocated in many areas. Policy options to deal with this overallocation are likely to have significant economic and social effects, as well as environmental impacts.

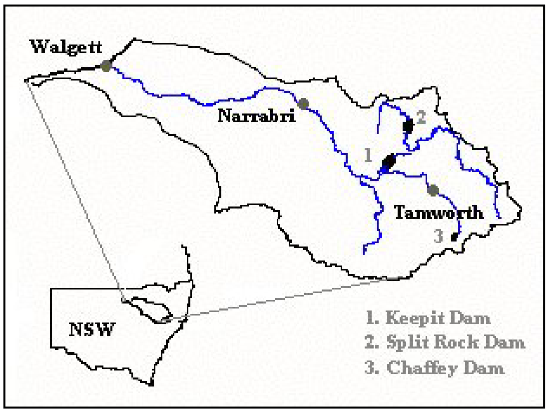


Figure 1. Namoi River Basin showing the major river system and storages

Irrigators have access to surface and ground water throughout the catchment and access to off-allocation water when it exceeds users' demand and identified environmental needs. This access involves a trade-off between upstream and downstream users as increases in upstream usage impact on availability of water to downstream users.

Letcher [2001] describes an integrated modelling tool developed to assess long term outcomes of management options for off-allocation water. A simplified version of these models has been developed in ICMS [Letcher and Croke, in preparation].

2.2. Software Platform

The Interactive Component Modelling System (ICMS) [Reed et al., 2000] is a PC-based product developed to support the rapid building, integration, and deployment of models. The model building component, ICMSBuilder, provides a simple C-like internal language for writing models, a drag-and-drop palette for linking objects (and their models) to describe the flow of processes and/or materials through the system (usually a catchment), and visualisation tools for editing and presenting data and model results. An application is developed as an ICMS Project, which is completely self-contained in a .icm file.

ICMS is a powerful tool for model writers and technically-minded users who want to experiment with data and models. It has another purpose though — to provide non-technical users such as managers and decision-makers, with sufficient information to make informed decisions. Unfortunately it is difficult to achieve these two purposes with a single user interface, since it must be a get-at-everything interface for modellers and a more focussed interface for general users.

One solution (used by ICMS) is to provide multiple interfaces to the same system. Technical users have all the power of the system. Non-technical users, while having access to the technical interface, use a customised interface (a View) that has been designed for them, with just the right level of input control and output presentation. In fact, these two interfaces are merely the extremes of potential interfaces. Any combination between these extremes is also possible, such as providing a technical user with any number of customised tools.

The role of ICMS is to provide maximum technical use when necessary, and to allow customisation of an interface when the details of processing need to be hidden or automatic results need to be produced. This is achieved through custom DLLs, or Views. A DLL (Dynamic Link Library) is a standard Windows file designed to provide information and functions dynamically to a program. The View has access to all of ICMS's functions and data—it can easily extract the correct information to present to the user, or write and run its own models, or even provide a linkage to external programs and data sources like spreadsheets, GIS, or weather stations. In fact, ICMSBuilder comes with its own set of customised Views (eg the numeric View). ICMS Views are written in Borland Delphi^{TM} to be compatible with the underlying ICMS engine. Figure 2 shows the relationship between Views and the ICMS engine (the Open Modelling Engine) [Reed et al., 2000]. Custom views from DLLs link into ICMS through the Open Modelling Engine (OME) Interface.

The usefulness of such an approach, ie separation of interface from models and data, is that it allows the same set of models (captured in a Project) to be made available to many classes of user, simply by providing different Views into the Project. This is one way of tailoring interaction with complex models to suit a particular audience.

With the flexibility inherent in a View, it is merely a matter of deciding what to include in the View. This is a similar problem to that faced by most program developers - what should it look like? - yet much of the work can be done by ICMS. ICMS provides all the data management functions, so the view does not need to worry about how to store its data, and any of ICMS's predefined views can be used. Development of a View can be achieved using standard GUI design principles, and accepted application design principles can be employed as though the view were a standalone application (ie the full software development life-cycle).

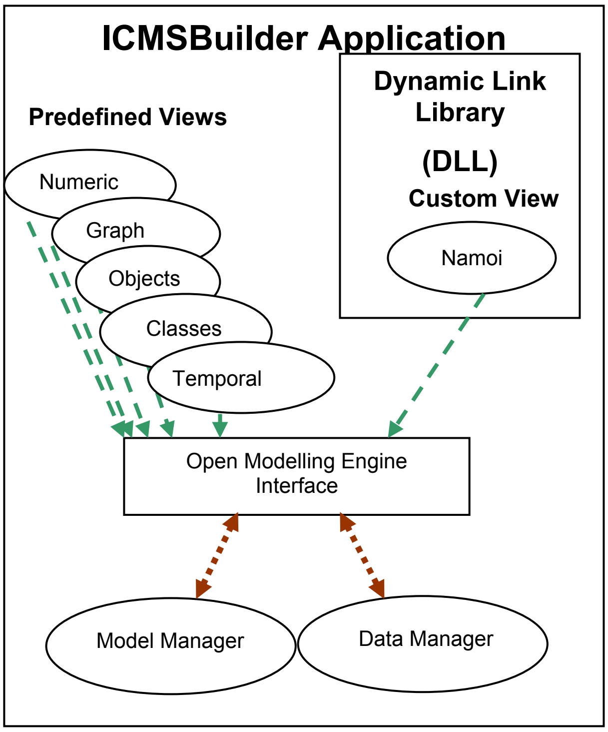


Figure 2. The interfacing of custom views into ICMS

ICMS has been used to build the Namoi ICMS Project, a suite of models linking economic, policy and hydrological models, and the Namoi Water Allocation View, an interface to the Namoi Project designed for and with stakeholders in the Namoi catchment.

3. THE APPLICATION

3.1. The Namoi ICMS Project

The Namoi ICMS is an ICMS project which links farm economics with water allocation and flow models. It can be used to perform a series of 'what-if' analyses on a range of surface and ground water allocation, and extraction limit scenarios in subcatchments of the Namoi River.

The basin has been divided into regions which are linked to a network of stream gauging stations.

The project is built within ICMSBuilder using its System View canvas to define classes (in this case a nodal and a dam class) and then create objects of these classes. Objects are linked by associating output data from one object to input data of another. The Namoi river system is described by a network of nodes which represent 16 stream extraction points and one dam object (Figure 3).

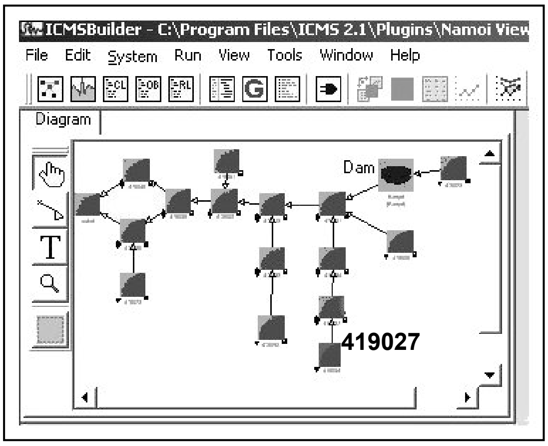


Figure 3. System View of the Namoi region's network of nodes ■ and dam ●.

The Namoi ICMS contains 2 models to predict catchment runoff (IHACRES) and stream flow (Routing); and 3 models to simulate regional economic decision making (Economic), based on a range of water allocation rules (Extraction and Policy). These models are fully described in Letcher and Croke [in preparation]. Each model is associated with a class and an object of each class is created on the system view canvas for each node, ie each node contains a suite of models. Figure 4 shows the system view for the 419027 nodal object. The models are run in an order determined by ICMS based on dependencies in the data and on the links that have been established in the system views.

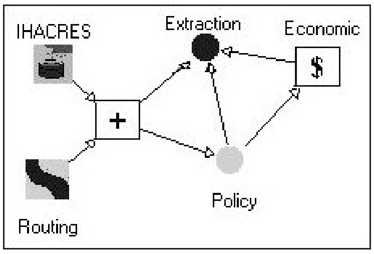


Figure 4. System View of the model objects of node 419027

In this section we have briefly described the modellers' view of the system available via ICMSBuilder. We next describe a View, built 'on top of' this system, which has been tailored to address a specific set of management questions.

3.2. The Namoi ICMS Water Allocation View

The Namoi ICMS Water Allocation View [CSIRO, 2001] is a set of screens which have been designed to allow users to change parameters used by the Policy and Extraction models within each node as well as climate data used for simulation. Parameters in other models are changed (by ICMS) as a result of changing these parameters. Different combinations of parameter values are captured as pre-run scenarios. Users can also create their own scenarios, and run and store the results.

While the underlying system view took many months to develop in ICMS (preceded by many months of conceptualisation of the problem and solution), the View was designed and coded within a few weeks. The View writer required no knowledge whatsoever of the models or Namoi system structure, other than the names of data variables and objects to access. However, they did require knowledge of internal ICMS functions and how to access them. This prototype View does not take advantage of many ICMS features, such as storing run results in the run library. (It stores its own results, simply as a test of that method.)

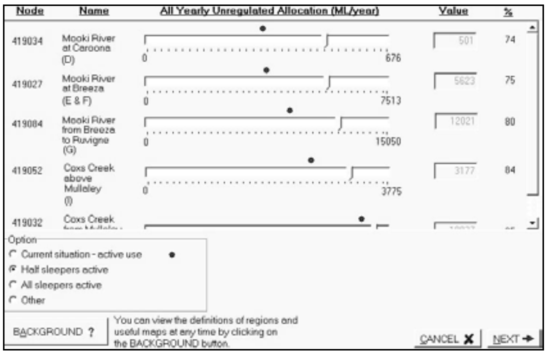
The parameters that can be changed are those that describe, for each node, the:

- allocation of unregulated surface water
- allocation of groundwater
- extraction (ie commence to pump) limits
- climate.

Sets of values (options) are provided for the first 3 components; and 20 sets of climate data. Users can work with pre-run scenarios or create their own. For each scenario run, ICMS calculates crop mix, profit, median non-zero flow, number of zero flow days, and time series of extracted and instream flow through the catchment.

The interface is a set of simple forms and screens, accessed by tabs, which guide the user through the steps in viewing and designing a scenario, and viewing scenario run results. Figure 5 shows the unregulated water allocation form which allows the user to set yearly allocation limits for unregulated water at each node. Three options are provided (current, sleeper licences half and fully activated). Constraints on upper limits are built in to assist users design their own allocation rules.

Many other Views into the Project can be written to deploy the Project to different audiences, eg more technical audiences such as hydrologists or agronomists.



Node	Name	All Yearly Unregulated Allocation (ML/year)	Value	%
419034	Mooki River at Caroona (D)	0 676	501	74
419027	Mooki River at Breeza (E & F)	0 7513	5623	75
419084	Mooki River from Breeza to Ruvigne (G)	0 15050	12021	80
419052	Coxs Creek above Mullaley (I)	0 3775	3177	84
419032	Coxs Creek			

Option
○ Current situation - active use ●
● Half sleepers active
○ All sleepers active
○ Other

You can view the definitions of regions and useful maps at any time by clicking on the BACKGROUND button.

Figure 5. Form for viewing and editing unregulated allocation limits (ML/year).

4. AUDIENCE REACTION

The View was workshopped with a group of regional state agency staff and catchment committee members in September 2001. Many of these members were familiar with the concepts, assumptions and capability of the Namoi ICMS project, insofar as they had attended presentations on the modeling work. The purpose of this workshop was to seek reaction to both the facility provided by the View, namely the ability to explore the impacts of a range of water allocation scenarios, and the View approach itself.

The content of the View was very much driven by an understanding of the needs of the user group—to gain a clear picture of the economic and environmental impacts of different water allocation and farm management decisions. The model developer identified a series of 'indicators' which would be relevant to a non-technical audience (providing the output specifications) and the scenarios they might like to run (providing the input specifications). The style of the interface was driven by the need for rapid development while being relatively intuitive and easily modified and/or expanded.

4.1. Model Developer

The model developer, ie the person who had developed and implemented the underlying suite of models and system view in ICMS, was keen to have a tool which would make the system accessible to a non-technical audience. She played a major role in the design specifications and proved to be close to the mark in identifying the parameters that the users wanted to play with, and the sorts of results they wanted to see. The complete separation of the underlying modelling system from the View meant that the integrity of the system was not compromised in any way by the interface development and she could continue to develop, calibrate and validate the models. The enthusiasm of the model developer has served to strengthen the assertion that this approach has a major role to play in science delivery.

4.2. View Developer

The View developer was experienced in interface design and Delphi coding, but had no previous exposure to the ICMS architecture or concepts. Written design specifications, identifying the relevant object/variable names to be retrieved and stored, were sufficient to progress the design.

The assertion that a View could be developed without the developer having to understand the underlying science was supported. The only interaction the View developer had with the Namoi Project was its .icm file. The View writer did require access to ICMS source code.

All difficulties experienced by the View writer were the result of insufficient written documentation about the ICMS engine. This was overcome by direct access to ICMS developers. The exercise has identified the level of documentation required.

4.3. Stakeholders

Stakeholders' needs and expectations mature with time and exposure to new science. The ability to interact with a complex representation of their catchment and its processes through a simple 'window' was very appealing. In effect, they had two Views open to them at all times—the technical ICMSBuilder View providing access to all parts (objects, models, linkages, data) of the Project; and the 'lean' water allocation View. Many expressed the opinion that it was empowering to be provided access to the modelling system, in spite of its technical nature, and fun to identify what extra elements they would like to see in the View to make it a real what-if tool for them. Lots of good ideas emerged about other 'indicators' that would be relevant to them in interpreting the impacts of different water allocation scenarios.

4.4. Workshop Presenters

The existence of the two Views, ie the technical ICMSBuilder View and the lean water allocation View, enabled the workshop to explore extensions/modifications to the lean View. It avoided the need to ever respond "Oh, I'm sorry. I can't show you that because the DSS does allow you to do that/see that/know that …". It also provided the ability to talk through with stakeholders whether a change they identified was simply an interface issue, or associated with the system representation, models or data.

4.5. Other Audiences

The View has been used to present the application to policy makers and R&D granting agency staff. It enabled presentation of the integrated solution (suite of linked flow-policy-economic models) through a practical perspective, without being limited to that perspective. Reaction to this approach, ie access to the underlying 'solution' (especially data and model code), and a separate construct that demonstrates how the solution can be used to address particular management issues, has been surprising—and always positive. They felt that their ability to understand and interpret the models and data had not been pre-judged by the developers, in fact they were being given the opportunity to delve into the underlying system, something usually denied to them by traditional DSSs.

5. CONCLUSIONS

We believe this approach to development and deployment of environmental modelling systems places the emphasis in the right place – namely on the development of the modelling system. The ability to rapidly develop multiple interfaces to suit particular audiences removes much of the overhead of DSS development, especially developing the system framework, and trying to capture all the possible questions that users may wish to ask of the system.

Audience reaction to the lean approach to interface design and delivery has convinced us that users are happy to do without the bells and whistles style of interface in exchange for two things: (a) access to the underlying system (representation, models and data) so that they can make the decision about their ability to appreciate its complexity; and (b) rapid production of interfaces and turn-around after discussion.

ICMS proved to be a powerful tool for implementation of this approach. It provided the framework for independence and separation of system from interface, reduced the functionality required in the interface, and provided sufficient tools to build the interface in a rapid and robust fashion. The adoption of such an approach has the potential to significantly reduce deployment costs and recoup manyfold the effort that has gone into designing the modelling solution. It means that one solution can be offered to many audiences, simply with a different interface.

Such model development frameworks offer huge benefits to researchers, developers and users, and have a major role to play in the delivery of catchment science.

6. ACKNOWLEDGEMENTS

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ICMS is supported by the CRC for Catchment Hydrology, under a licence agreement with CSIRO and Land and Water Australia. It is available via its web site, http:///www.cbr.clw.csiro.au/icms.

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