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Knowledge management system on flow and water quality modeling

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Abstract Due to the complexity of the numerical simulation of flow and/or water quality, there is an increasing demand for integration of recent knowledge management, artificial intelligence technology with the conventional hydraulic algorithmic models in order to assist novice application users in selection and manipulation of various mathematical tools. In this paper, a prototype knowledge management system on flow and water quality is addressed to simulate human expertise during the problem solving by incorporating artificial intelligence and coupling various descriptive knowledge, procedural knowledge and reasoning knowledge involved in the coastal hydraulic and transport processes. The system is developed through employing Visual Rule Studio, a hybrid expert system shell, as an ActiveX Designer under Microsoft Visual Basic 6.0 environment since it combines the advantages of both production rules and object-oriented programming technology. The architecture, the development and the implementation of the prototype system are delineated in details. Based on the succinct features and conditions of a variety of flow and water quality models, three kinds of class definitions, Section and Problem as well as Question are defined and the corresponding knowledge rule sets are also established. Both forward chaining and backward chaining are used collectively during the inference process. A typical example is also presented to demonstrate the application of the prototype knowledge management system.

Keywords: Knowledge management system; flow and water quality modeling; artificial intelligence; object-oriented programming; production rule; visual interface

1. Introduction

The current techniques for numerical simulation of flow and/or water quality are highly specialized tasks requiring detailed knowledge. Up to now, a variety of flow and water quality models are available and the techniques become quite mature. The numerical technique can be based on finite element method, finite difference method, boundary element method and Eulerian-Lagrangian method. The time-stepping algorithm can be implicit, explicit or characteristic-based. The shape function can be of first order, second order or higher order. The modeling can be simplified into different spatial dimensions, i.e., 1-dimensional model, 2-dimensional depth-averaged model, 2-dimensional layered model, 3-dimensional model, etc (Blumberg et al., 1999; Chau et al., 1996; Chau and Jin, 1998; Li and Ma, 2001; Tucciarelli and Termini, 2000). The analysis of coastal hydraulics and water quality generally involves heuristics and empirical experience and it is effected through some simplifications and modeling techniques on the basis of the experience of specialists (Yu and Righetto, 2001). However, the accuracy of the prediction is to a great extent dependent on the accuracy of the open boundary conditions, model parameters used, and the numerical scheme adopted (Martin et al., 1999). It is a difficult task for novice application users to select an appropriate numerical model due to varying factors, such as the water depth, water velocity, grid spacing, etc. As a result, it is desirable to establish the bridge between model developers and application users.

Due to the complexity of the numerical simulation of flow and/or water quality, there is an increasing demand to integrate artificial intelligence (AI) with these mathematical models in order to assist selection and manipulation. However, up to date, research studies on the incorporation of AI technology into numerical modeling are, as a matter of fact, very scarce.

During the past decade, AI techniques have been applied to the numerical simulation of flow and/or water quality (Chau and Yang, 1992; Chau and Zhang, 1995). These expert systems made use of the commercial expert system shell VP-Expert (Friederich and Gargano, 1989), which was run on personal computer under the then popular DOS development environment. These systems facilitated easy representation of heuristic reasoning and were helpful for users to select an appropriate numerical model and associated parameters, yet, with the popular user of the interactive Windows platform, they are currently no longer the most effective in system operation and design. Thus it is worthwhile to develop an integrated system for coastal water processes, which incorporates the recent AI technologies into traditional numerical models.

Over the past few years, there has been a widespread interest in the field of knowledge management (KM) (Hendriks, 2001; Huber, 2001; Liebowitz, 2001; Tiwana and Ramesh, 2001). KM techniques have rendered it possible to simulate human expertise in narrowly defined domain during the problem-solving by integrating descriptive knowledge (e.g., data, information), procedural knowledge (e.g., algorithms) and reasoning knowledge (e.g., rules). The advance in AI techniques allow the development of these intelligent management systems by employing some shells under the established development platforms such as Visual Basic, C++, etc.

The objective of the present study is to integrate descriptive knowledge, procedural knowledge and reasoning knowledge for a KM system on flow and water quality modeling together with AI technology. This paper focuses on the description of the architecture, the development, the implementation and its application. One of the main emphases is on the knowledge representation and the visualization during the problem solving.

2. Architecture of KM system

For the modeling issue, the most difficult part is how to select an appropriate model as well as the associated model parameters. The advance of computer techniques has speeded up the research of numerical simulation for complex models on flow and water quality. With the more delicate and complex models, there is a strong demand on the understanding of modeling details. Compared to the pure algorithmic simulation, the obvious features of KM system are to represent knowledge in a fashion that is appropriate for the modeling of application decision knowledge, to isolate the policies and decisions from application logic and to supply the intelligent support during problem solving by visual window interfaces. The packaging of a set of problem-solving production rules allows for the management and reuse of knowledge within, and amongst software development projects. The advantage of this packaging is to isolate the application rules into identifiable and separate components of the system, rather than allowing the knowledge contained in an application to be dispersed throughout the programming of the application. Figure 1 shows the workflow paradigm of the KM system on flow and water quality, as well as the logical relationship between the two Rule Sets. The representation of object-oriented programming and production rules is at the core of the process.

3. Problem description

Generally, users are familiar with details of the projects but not with numerical modeling. It is very difficult for novice application users to select an appropriate model directly. Comparatively, simple interactive questionnaires, incorporating most of questions related to users' knowledge, are easily understood and responded by users. Thus, the main objectives of problem description are to design appropriate questionnaires accordingly. Good questionnaires can infer the intrinsic conditions of model selection on the basis of responses from the users. The initial work at this stage is thus to analyze the factors that have significant effect on simulating computation.

Project types usually impose some limitations on the application of certain models, i.e., models that are applicable become clearer if the project types are known. Let us consider reservoir routing as a simple example. Reservoir acts as storage facilities and the water level in such a storage facility may thus be considered horizontal. This simplifies the analysis significantly since dynamic effects are neglected and only the continuity equation needs to be considered. A finite-difference approximation can be utilized to describe the change of storages, i.e., the classic continuity equation of de Saint-Venant (Chaudhry, 1993). Furthermore, available data and tasks on the numerical simulation of flow and/or water quality have also significant effect on the selection of numerical model on flow and water quality. When detailed data are lacking, only some simplified models can be chosen. When some special tasks are undertaken, such as unsteady simulation of phytoplankton growth in a coastal water system and simulation of flooding and drying of tidal waves, some complex models are necessary.

The domain knowledge entailed in the development of this prototype system has been encoded mainly on the basis of literature review and interviews with experienced numerical modelers. According to these experience and knowledge about numerical models, visual window tabular interfaces are designed here. Each tab helps the user to locate different groups of questionnaire.

The purpose tab is provided for the selection from two optional buttons, i.e., real-time or planning (Figure 2). Usually, the simulation of flow and water quality can be applicable to planning, evaluating, and operating stages. In this context, planning refers to planning and evaluating whilst real-time represents operating.

The project tab is used to choose a project amongst 11 options: river flood forecast, flood plain, tidal dynamics, estuarine hydrodynamics, temperature/density distribution, salt water intrusion, wave propagation, wind storm propagation, outfall, water pollution and eutrophication (Figure 3). As it was mentioned above, different projects have their constraints on the choice of appropriate numerical models.

On the tasks tab, multiple selection of check boxes are allowed here. Common tasks are listed in the check boxes as shown in Figure 4, i.e., water current, water level, vertical advection, horizontal dispersion, dissolved oxygen (DO), biochemical oxygen demand (BOD), phytoplankton, nutrient concentration, sediment interaction, zooplankton, other physical variables (density, temperature, salinity, air pressure, etc.) and other water quality variables.

4. Automatically generation of conditions for model selection

After the user has completed the questionnaires, the conditions for selecting models can be generated automatically. Figure 5 shows the frame chart of the methodology. The first level is the problem description, which includes the primary factors having significant effects on model selection. Purpose, project and task are the three options in the first level. The second level denotes the answer sets comprising the answer for each problem description, which may be in single or compound format. The third level represents the hidden condition sets of the intrinsic constraints on numerical modeling that can be acquired through Rule Sets I. The fourth level is the condition sets after some repeated conditions have been filtered out. After the condition sets in the fourth level have been acquired, Rule Sets II can be fired.

5. Knowledge base

5.1 Development tool -- Visual Rule Studio

In order to facilitate development of the KM system, expert system shell containing specific representation methods and inference mechanisms is employed. The knowledge base and explanation facility of the system have been developed using a commercially available expert system shell called Visual Rule Studio which is a hybrid application development tool that integrates object-oriented techniques and expert system technology with traditional, procedural programming. (RuleMachine Corporation 1998) Visual Rule Studio installs as an integral part of Microsoft Visual Basic 5.0 as an ActiveX Designer.

Using powerful shells such as Visual Rule Studio, it is no longer acceptable to require that an entire application be developed wholly within a proprietary development tool in order to realize the benefits of rules programming and KM applications. They are no longer the limitations of traditional expert system development environments. By isolating application rules as component objects, separate from objects and application logic, Visual Rule Studio allows analysts and developers to leverage the proven productivity of today's component-oriented development tools. With Visual Rule Studio, rule development becomes a natural part of the component architecture development process.

The rule language of Visual Rule Studio, called Production Rule Language (PRL) is used as the development tool for the production rules. PRL is a high level grammar for problem representation and abstraction designed specifically for the specification and processing of rules. The grammar uses an object-oriented notation that is the same as that of all popular language environments, such as, C++, Java, and of course, Visual Basic. This familiar notation not only facilitates ease of learning, but also provides for the easy mapping of client objects to the objects of Visual Rule Studio. The object structure of a Visual Rule Studio is outlined in Figure 6. The basic structure of an object consists of name, properties, and attributes. The attributes consist of name, type, facets, method, rules and demons. Visual Rule Studio supports three types of inference strategies: Backward-Chaining, Forward-Chaining and Hybrid-Chaining. Using commercial PRL, the development of application systems is usually more efficient.

5.2 Representation of domain knowledge

The domain knowledge embraces condition generation and model selection. The key task for a knowledge engineer is how to encode them into a KM system. Since a variety of flow and water quality models are available, it is crucial to summarize the features and conditions of these models. Table 1 is the summary of the succinct features of numerical model. Table 2 lists the summary of conditions for part of the model parameters. As shown in Table 1, there are 15 feature indexes and each model is defined by a combination of one or more indexes. The most effective model can be chosen with respect to accuracy and computational efficiency according to the types and tasks of project. Since it is a complex task to select a model, the main aim of KM system on flow and water quality is to establish the knowledge rules based on the analysis of these conditions.

5.2.1 Object-oriented programming

The class definitions have significant effect on effective and correct conclusions. **Section**, **Problem** and **Question** are the three definition of class corresponding to Rule Sets I and Rule Sets II. The following shows the structure of class **Section**, which is typical for the other classes.

```
CLASS Section
WITH Dimensions COMPOUND One_D, Two_D vertical, Three_D horizontal, Three_D
      layed, Three_D fully, Unknown Value
WITH 0NumericalMethod COMPOUND Finite element, Finite difference,
      Boundary element, Eulerican_Lagrangian method, Unknown Value
WITH Scheme COMPOUND Explicit, Implicit, Semi_implicit
WITH Co_ordinateSystem COMPOUND Rectangular, Curvilinear, Polar, Unknown Value
WITH Grid COMPOUND Uniform, Not Uniform, Unknown
WITH Stability COMPOUND Unconditional stable, Conditional stable, Unknown
WITH TurbulenceModel COMPOUND Mixing length, k_e model, Dispersion coefficient,
      Unknown Value
WITH ErrorOfScheme COMPOUND First_order, Second_order, High_order, Unknown
      Value
WITH Equation COMPOUND Momentum, Continuity, State, Density, Pressure, Unknown
      Value
```

```
WITH EquationTerm COMPOUND Advection, Coriolis force, Horizontal diffusion, Decay,
        Sediment Interaction, Unknown Value
WITH Forcing COMPOUND Tide, River discharge, Wind, Density difference, Unknown
        Value
WITH VerticalCo_ordinate COMPOUND Normal, Sigma, Refined near surface, Refined
        near bottom, Refined near specific area, Unknown Value
WITH BoundaryCondition COMPOUND Zero value, First order zero, Second order zero,
        in_out_bc, Unknown Value
WITH InitialCondition COMPOUND Zero, Non zero, Unknown Value
WITH Time_steppingAlgorithm COMPOUND Single step, Alternating velocity and
        elevation split step, Alternating direction split step, Unknown Value
```

Section is a definition of class with its attributes related to the features of models. The class **Section** and its 15 attributes conform to the features of models detailed in Table 1. According to the values of attributes, we can define the features of models. **Problem** is a definition of class with its attributes related to the initial conditions of models. Part of these attributes can be retrieved from the condition sets in Table 2. **Question** is a definition of class with its attributes related to the questionnaires. These attributes are consistent with visual screen options in Figure 2 to Figure 4.

5.2.2 Production rules

Knowledge rules include two groups i.e., Rule Sets I, Rule Sets II. Rule Sets I generates automatically the conditions of model selection according to the replies. Rule Sets II recommends the most effective model for a project with special tasks. The conclusions from Rule Sets I will become the premises of Rule Sets II.

When all the requisite questionnaires have been entered, the conditions on selection of models can be generated automatically based on the production rules. The following gives typical examples of these rules under this category.

```
!================================
! Projects-Flood Plain Rules
!================================
RULE 1 for Conditions from Flood Plain
IF Question.Project IS Flood Plain
THEN Problem.ComputationTime IS Not strict

RULE 2 for Conditions from Flood Plain
IF Question.Project IS Flood Plain
THEN Problem.Accuracy IS Less Significant

RULE 3 for Conditions from Flood Plain
IF Question.Project IS Flood Plain
THEN Problem.Current IS Omitted

RULE 4 for Conditions from Flood Plain
IF Question.Project IS Flood Plain
THEN Problem.BoundaryCondition IS Open

RULE 5 for Conditions from Flood Plain
IF Question.Project IS Flood Plain
THEN Problem.WaterDepth IS Omitted
```

```
RULE 6 for Conditions from FloodPlain
IF Question.Project IS Flood Plain
THEN Problem.Geometry IS Less complex
```

The choice of model is based on the features of models. When these questionnaires have been completed, the features of models can be inferred through the production rules. The following gives typical examples of these rules under this category.

```
!=================================
!  Dimension Rules
!=================================
RULE 1D
IF Problem.ComputationTime IS Limited AND Problem.Current IS Omitted
THEN Section.Dimensions IS One_D

RULE 2D
IF Problem.ComputationTime IS Not strict AND Problem.Current IS Depth_averaged form
THEN Section.Dimensions IS Two_D

RULE 1 for 3D
IF Problem.ComputationTime IS Unlimited
   AND Problem.Current IS Large vertical current
   AND Problem.StratificationOfWater IS Significant
   AND Problem.Geometry IS Very complex
THEN Section.Dimensions IS Three_D

RULE 2 for 3D
IF Problem.ComputationTime IS Unlimited
   AND Problem.Current IS Vertical variation of current
   AND Problem.StratificationOfWater IS Significant
   AND Problem.Geometry IS Very complex
THEN Section.Dimensions IS Three_D
```

5.2.3 Inference engine

The Visual Rule Studio possesses a robust inference engine and all anticipative conclusions can be generated automatically, provided that the logical structures of the application problem have been carefully designed. The Visual Rule Studio inference engines control the strategies that determine how, from where, and in what order a knowledge base draws its conclusions. These inference strategies model the reasoning processes an expert uses when solving a problem.

The inference engine of Visual Rule Studio commences with **Dimensions**, which is a goal under the class **Section**. If the value of **Dimensions** is unknown, the search returns to those rules with consequent related to attribute **Dimensions**. The search explores the antecedent of the rules, for instance **ComputationTime**, which is a goal in the class **Problem**. If the value of **ComputationTime** is unknown, it then returns to those rules with conclusion related to attribute **ComputationTime**. In order to search its value, by rule chaining, the search explores the premise of the rules and evaluates **Purpose**, which is a goal under the class **Question**. Those rules related to **Purpose** will then be fired. When **Purpose** has been completed, other goals-**Project** and **Tasks** will be searched in order. The processes mentioned above will be automatically continued using PRL.

Question is answer sets from questionnaires through the interactive interfaces in Figure 2 to Figure 4. **Problem** is condition sets obtained based on Rule Sets I. **Problem** is the conclusions drawn from the premise **Question**, also the premise about intermediate conclusions of **Section**. The logical relationship is **Question** → **Problem** → **Section**. As such, when the problem description have been entered, the process of model selection can be accomplished automatically, based on the Rule Sets I and Rule Sets II.

6. Application example - Eutrophication problem of Tolo Harbour in Hong Kong

Tolo Harbour of Hong Kong is a nearly land-locked sea inlet with a narrow outlet connecting with Mirs Bay--one of the major south-facing bays in the South China Sea. The water depth varies from about 2 m in the inner part to over 20m in the outer part of Tolo Channel and about 12m on average. The averaged diurnal tidal difference is about 0.97m, mean high tide is 1.75m and mean low tide is 0.78m. For most of the year, little freshwater is discharged into the harbor, and it could be considered as an embayment. During the summer, however, the differences in surface and bottom water temperature and salinity, caused by solar radiation and rainfall, result in an obviously lighter surface layer and definite mesolimnion in the water column- a two-layered system. Density stratification weakens the vertical mixing and may remove the connection between benthic grazers and near-surface biobass by inhibiting vertical transport. In winter, higher dissolved oxygen levels in the bottom waters are generally recorded due to increased turbulent mixing within the water body, resulting from the strong northeast monsoon. However, during the summer, less bottom waters suffer from serious oxygen depletion, even approaching anoxic status, although the dissolved oxygen content in most of the surface was commonly found to be at satisfactory levels, even at super-saturation. Thus, it is necessary to simulate unsteady water quality transport in a density stratified natural water body. Details of the eutrophication modeling can be referred to Chau and Jin (1998).

According to the background of eutrophication problem for Tolo Harbour in Hong Kong, the questionnaires can be filled in through the user interfaces with the summary listed in Table 3. After the input data have been entered, a summary of the input requirements is shown in the left frame of questionnaires as shown in Figure 7. When the command button **INFER** is clicked, the process of model selection can be automatically attained on the basis of Rule Sets I and Rule Sets II. The right frame shows the inference result about the features of suggested model for this example, which are verified with the decision made by the expert modeler.

7. Conclusions

In this paper, the architecture, the development and the implementation of a prototype KM system on flow and water quality modeling are delineated in details. The use of the hybrid expert system shell Visual Rule Studio, which runs together with Microsoft Visual Basic 6.0, is found to be very effective in producing the system under the popular Windows environment. The advantages of both production rules and object-oriented programming paradigm are accomplished. Through the successful development of this prototype system, it has been demonstrated that the KM system can be integrated into the numerical flow and water quality modeling by incorporating AI technology so as to provide assistance on the selection of model and its pertinent parameters. The integration renders a more intelligent and user-friendly system in the problem domain, which can narrow significantly the gap between the numerical modelers and the application users.

Acknowledgments

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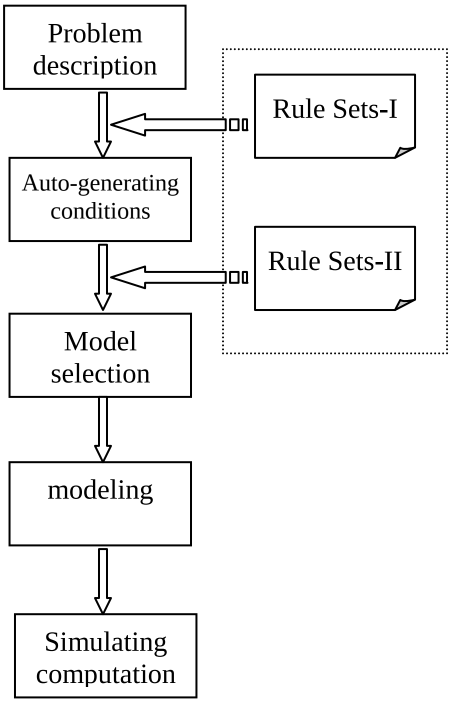
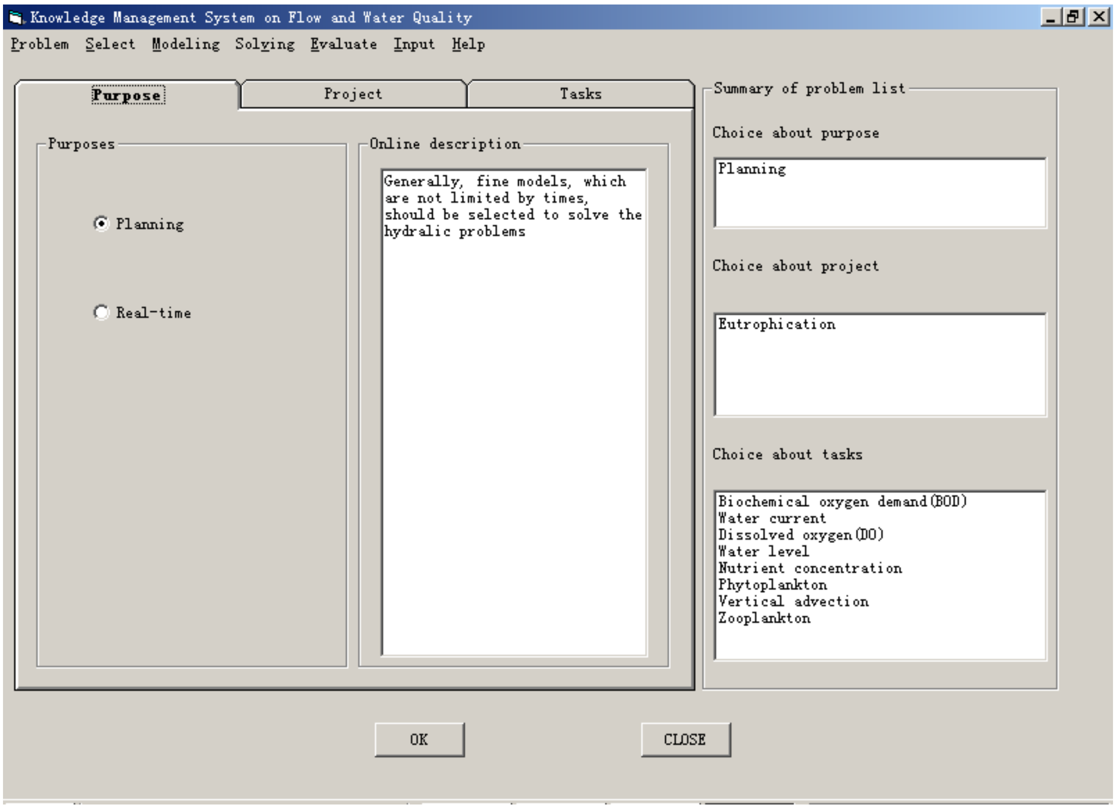


Figure 1 Workflow paradigm of the knowledge management system on flow and water quality modeling



Purposes

● Planning

○ Real-time

Online description

Generally, fine models, which are not limited by times, should be selected to solve the hydralic problems

Summary of problem list

Choice about purpose

Planning

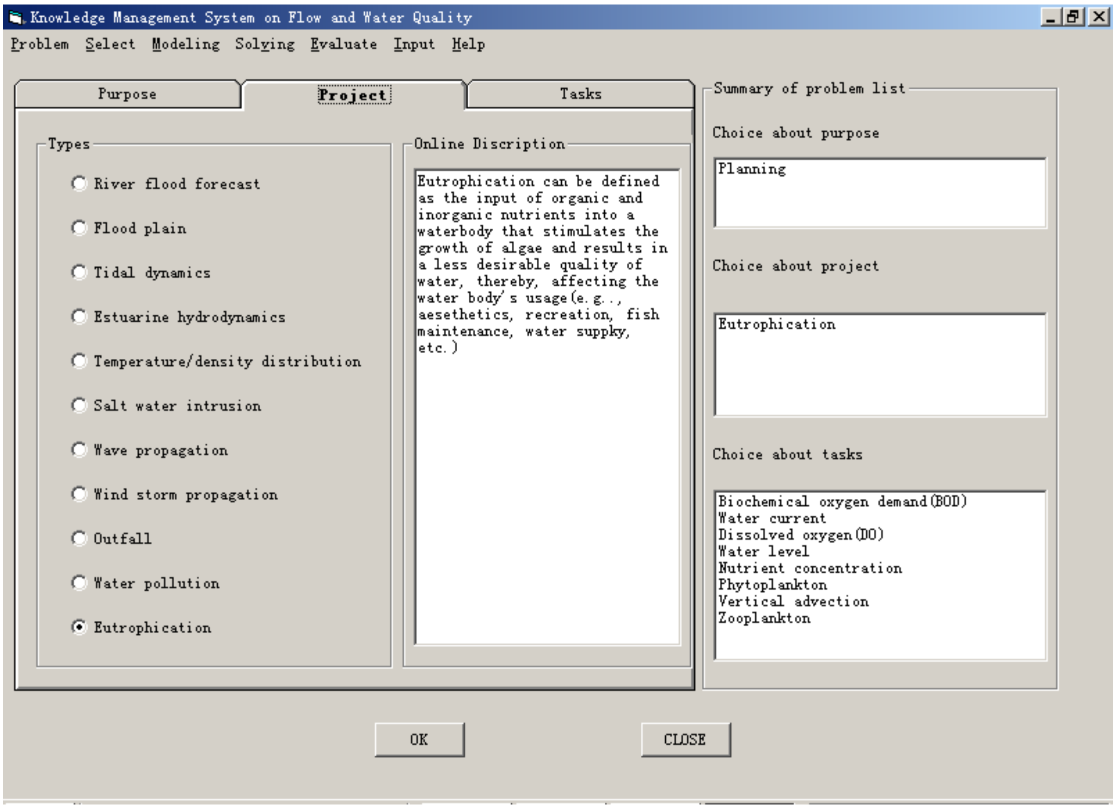
Choice about project

Eutrophication

Choice about tasks

Biochemical oxygen demand(BOD)
Water current
Dissolved oxygen(DO)
Water level
Nutrient concentration
Phytoplankton
Vertical advection
Zooplankton

Figure 2 The user interface of purpose tab



Types

○ River flood forecast
○ Flood plain
○ Tidal dynamics
○ Estuarine hydrodynamics
○ Temperature/density distribution
○ Salt water intrusion
○ Wave propagation
○ Wind storm propagation
○ Outfall
○ Water pollution
● Eutrophication

Online Discription

Eutrophication can be defined as the input of organic and inorganic nutrients into a waterbody that stimulates the growth of algae and results in a less desirable quality of water, thereby, affecting the water body's usage(e.g.., aesethetics, recreation, fish maintenance, water suppky, etc.)

Summary of problem list

Choice about purpose

Planning

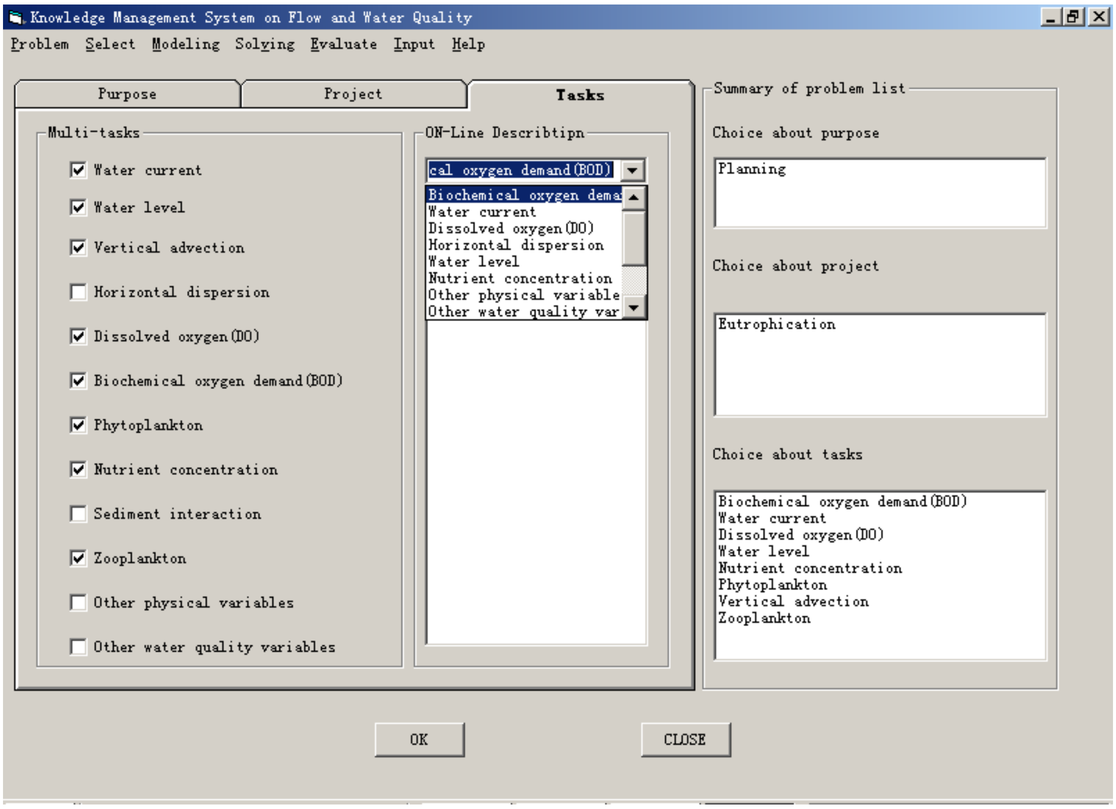
Choice about project

Eutrophication

Choice about tasks

Biochemical oxygen demand(BOD)
Water current
Dissolved oxygen(DO)
Water level
Nutrient concentration
Phytoplankton
Vertical advection
Zooplankton

Figure 3 The user interface of project tab



Multi-tasks

- ☑ Water current
- ☑ Water level
- ☑ Vertical advection
- ☐ Horizontal dispersion
- ☑ Dissolved oxygen(DO)
- ☑ Biochemical oxygen demand(BOD)
- ☑ Phytoplankton
- ☑ Nutrient concentration
- ☐ Sediment interaction
- ☑ Zooplankton
- ☐ Other physical variables
- ☐ Other water quality variables

ON-Line Describtipn

cal oxygen demand(BOD)

Biochemical oxygen dema
Water current
Dissolved oxygen(DO)
Horizontal dispersion
Water level
Nutrient concentration
Other physical variable
Other water quality var

Summary of problem list

Choice about purpose

Planning

Choice about project

Eutrophication

Choice about tasks

Biochemical oxygen demand(BOD)
Water current
Dissolved oxygen(DO)
Water level
Nutrient concentration
Phytoplankton
Vertical advection
Zooplankton

Figure 4 The user interface of tasks tab

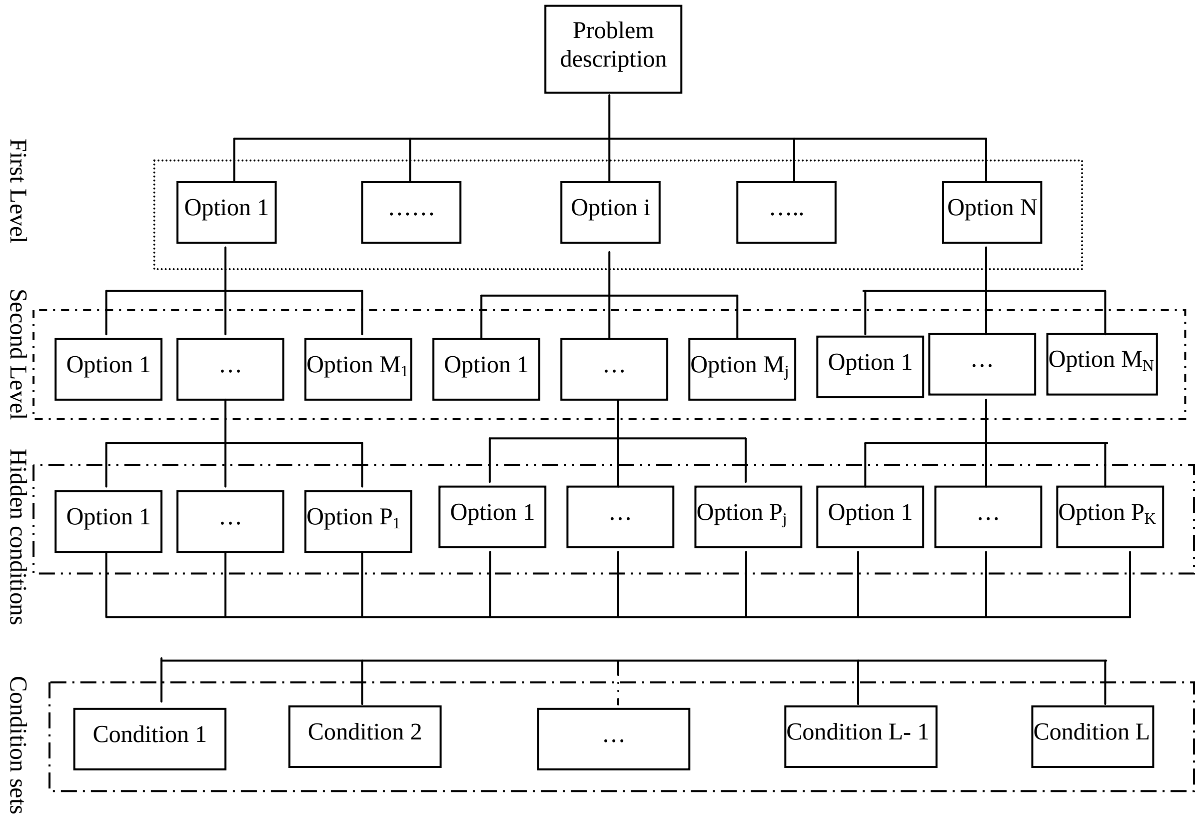


Figure 5 Frame chart of automatically generating conditions of model selection

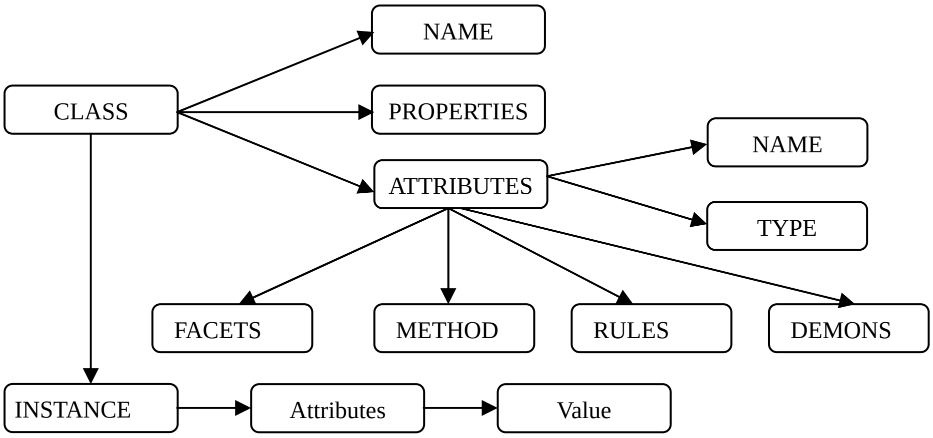
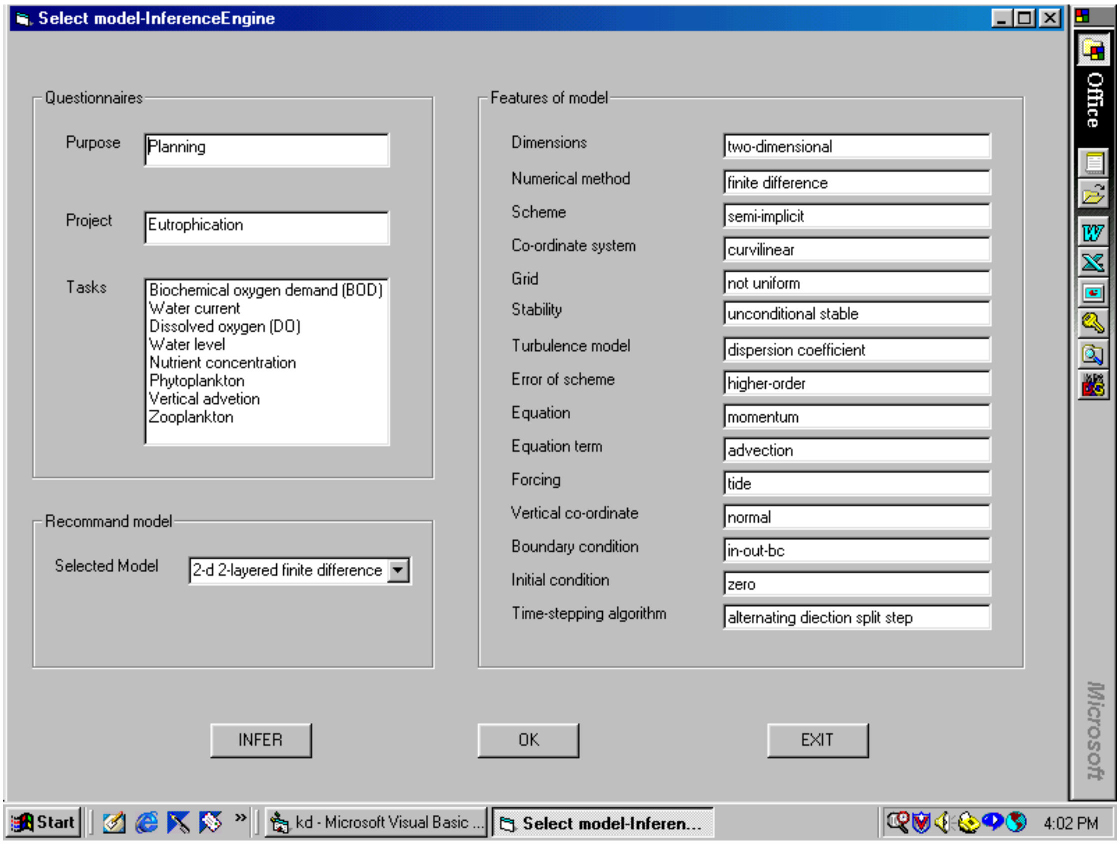


Figure 6 The object structure of a Visual Rule Studio



Questionnaires

Purpose	Planning
Project	Eutrophication
Tasks	Biochemical oxygen demand (BOD) Water current Dissolved oxygen (DO) Water level Nutrient concentration Phytoplankton Vertical advetion Zooplankton

Recommand model

Selected Model	2-d 2-layered finite difference

Features of model

Dimensions	two-dimensional
Numerical method	finite difference
Scheme	semi-implicit
Co-ordinate system	curvilinear
Grid	not uniform
Stability	unconditional stable
Turbulence model	dispersion coefficient
Error of scheme	higher-order
Equation	momentum
Equation term	advection
Forcing	tide
Vertical co-ordinate	normal
Boundary condition	in-out-bc
Initial condition	zero
Time-stepping algorithm	alternating diection split step

Figure 7. Display screen of model selection for the application example

Table 1 Various features of model

	Selection 1	**Selection 2**	**Selection 3**	**Selection 4**	**Selection 5**
Dimensions	1-d	2-d vertical	2-d horizontal	3-d layered	3-d fully
Numerical method	finite element	finite difference	boundary element	Eulerian-Lagrangian method	
Scheme	explicit	implicit	semi-implicit		
co-ordinate system	rectangular	curvilinear	polar		
Grid	uniform	not uniform			
Stability	unconditional stable	conditional stable			
Turbulence model	mixing length	k-ε model	dispersion coefficient		
Error of scheme	first-order	second-order	higher-order		
Equation	momentum	continuity	state	density	pressure
Equation term	advection	Coriolis force	horizontal diffusion	decay	sediment interaction
Forcing	tide	river discharge	wind	density difference	
Vertical co-ordinate	normal	sigma	refined near surface	refined near bottom	refined near specific area
Boundary condition	zero value	first order zero	second order zero	in-out-bc	
Initial condition	zero	non zero			
Time-stepping algorithm	single step	alternating velocity and elevation split step	alternating direction split step		

Table 2 Conditions for different model parameters

Parameter	**Conditions**
3-d	Large vertical current or vertical variation of current. Stratification of water is significant. Complex geometry Difference of salinity & temperature are important. Problem we are interested in is related to vertical current or vertical structure of current. Tidal elevation not too large relative to water depth.
2-d	Avoid excessive computation time in 3-d modeling. Variation of flow or water quality parameters along the 3rd direction is small.
1-d	Variation of flow or water quality parameters are substantially along one direction only Minimum computational time
Implicit	Smaller spatial grid size is desirable but do not want smaller time step Problem with large space scale and/or time scale Avoid excessive computational time Efficiency is more important than accuracy
Explicit	Smaller spatial grid size and smaller time step are desirable Problem with small space scale and/or time scale No problem on excessive computational time High accuracy is more important than efficiency
Semi-implicit	Feasible splitting of terms into two groups: implicit and explicit Balance between implicit and explicit schemes
Finite difference method	1-d, 2-d or 3-d modeling More often used in flow and water quality problems Some of these methods only allow for uniform grid size
Finite element method	1-d or 2-d modeling Method itself more easily adapted to irregular grid size
Boundary element method	Water depth very deep
Eulerian-Lagrangian method	Advection-dominated transport problem Unstructured grid

Table 3. Summary of input for the eutrophication problem

Purpose	Project	Tasks
Planning	Euthophication	Water current
		Water Level
		Vertical advection
		Dissolved oxygen
		Biochemical oxygen demand
		Nutrient concentration
		Phytoplankton
		Zooplankton