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Abstracts

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Contents

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Modelling and simulation of demand driven logistic supply chains: Generic simulation model and model building blocks

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Keywords: Supply chain modelling, discrete-event simulation, modular building blocks.

In our research on the modelling of demand driven logistic supply chains (SC) we focus on the design of a generalised simulation model encompassing modular building blocks. This model and building blocks represent important characteristics of a class of SC's in the food-industry. They will allow us to build, implement and use efficiently specific simulation models to support us in solving problem instances in SC's. Results and simulation models of previous simulation projects are used to define the characteristics of SC's to be captured in the models. Currently, we regard SC's consisting of a manufacturer (M), a distributor with a central warehouse (DC) function that supplies retail-outlets (RO). Further we identify a transport function (T) to transport products in the SC. In these chains we focus on determining good and operationally feasible scenarios for combined goods- and information flows and decision processes.

Earlier simulation models have been implemented in ExSpect, a simulation language based on timed and coloured Petri nets and based on an ontology that we developed in earlier research. The building blocks that we have designed are implemented using the simulation tool Arena and SIMAN for a number of reasons. First of all Arena is a software package that provides for good and extensive functionality for constructing simulation models using reusable building blocks and hierarchical modelling and for using and reporting about constructed models. If we enhance this environment with specific model building blocks we anticipate to arrive at a robust and efficient tool to generate and use simulation models that may support to solve decision making problems associated with our type of SC's. Secondly, we intend to make a comparison between ExSpect and Arena related to ease of use and appropriateness.

Central in the design of specific building blocks for our problem domain will be the ontology that we developed in earlier research, which has been extended slightly with an extra semantic layer. This ontology thus functions as a design-framework for each building block resulting in blocks having a uniform structure and interface. This approach resembles a system- theoretic approach of constructing simulation models containing systems and hierarchies of sub-systems. However, the ontology can be used for reviewing more aspects of the simulation process. It can also be used to evaluate the appropriateness of the simulation language that will be used. If a required ontology can not been mapped on the concepts of the simulation language, it might be wise to choose a more appropriate language. This will diminish the chance of complicated model translations and will enhance model structure validity. The consequences of the choice for

Arena and SIMAN as simulation language will be evaluated. In this way the ontology functions as a formal blueprint for the conceptual and simulation model and its building blocks.

At this moment several generic building blocks that represent characteristics of a class of SC's have been designed by using the business-process ontology. In turn these building blocks have been used to construct a specific simulation model of an existing SC consisting of the following actors. First, we identify a manufacturer (M) with processes for ordering and supplying products to the DC. Secondly, we identify a distributor (DC) with processes for ordering at and receiving and storing products supplied by M, further an inventory control process at the DC, and finally order processing and delivery to satisfy demand from retail outlets (RO). Thirdly, we discern retail outlets (RO) that sell products to customers, order products at the DC and subsequently receive supplied goods to fill up shelves in the store. In order to adequately model the operational behaviour of a complete SC for an assortment of products we need insight in differences in behaviour of actors that perform the same role in the SC (e.g. RO's). We also need insight in the consequences of the timing of and total volumes of activities in the chain. As a consequence, in modelling a SC we select a number of characteristic RO's (in terms of assortments and sales volume) and one Mega-outlet to represent aggregated demand for the remainder of RO's supplied by the DC. In this way we cater for the need to take into account the total volume of operational and decision making activities in the chain. In this context, for instance the business-processes "Ordering of products", "Product write off" and "Expedition" have been modelled as individual building blocks. For the majority of business processes identified it was rather easy to design the necessary building blocks, which indicates the usability of the approach. For modelling the behaviour of the Mega-outlet we have not yet been able to develop adequate building blocks.

Statistical validation of the specific simulation model that we have built has not been performed so far due to the lack of validation data. Therefore, the validity is based on expert-knowledge using field-experts which analysed the model-behaviour. Furthermore validation is done by comparing the behaviour of the model with earlier validated simulation models of the same system. Both approaches indicate that a valid model has been developed. Our experiences so far indicate also that designing and building a generic simulation model and building blocks using ARENA is a good approach to improve both the quality and efficiency of specific modelling processes.

In our contribution we will pay attention to the ontology that we use to model SC's, to the generic simulation model and its building blocks and to experiences gathered so far.

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CLOCWISE - Constraint Logic for Operational Control of Water Systems

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Keywords: Constraint Logic, Water Systems, Operatioanal Control

The paper presents software and solver methodologies applied in the recently developed package *CLOCWiSe*. The package, outcome of an EC-funded project, offers integrated tools for on-line monitoring, management and operational control of water supply and distribution systems under uncertainty in mathematical models and measurement data. Both the software structure and numerical solver are designed based on Constraint Logic Programming paradigm. This allows to achieve an ease in using, maintaining and expanding the package and also provides for desired efficiency in solving hybrid mixed integer and combinatorial problems of high complexity. There are two main modules in CLOCWiSe:

SCHEDULER/CONFIGURATOR:

- Generates optimal pump schedules and maintenance schedules in one turn and guaranteed consistent with all constraints, like consumer demands, pump flows, tank capacities, energy tariffs, task priorities, availability of resources, emergency conditions and operational strategies.
- Schedules can be sanctioned and reused.
- Schedules may overlap in time and may have different time resolutions, allowing hierarchical approaches; for example, week schedules consistent with refined day schedules.

ESTIMATOR:

- Handles uncertainty in system inputs and model parameters, quality measurement and modelling errors in a natural way by using sets rather than probability density distributions.
- Provides estimates with robust bounding intervals, based on integration of all available a priori and measurement information.
- Integrates all information into one estimation scheme, giving a soft sensor of excellent performance.
- Can be used off-line as a network simulator or on-line for monitoring water quality throughout a network.
- Can be used for fault detection or for finding best location of hard sensors in a telemetry system.

The paper presents relevant fundamentals of the CLP and describes briefly the above functionalities. Results of applications to real life water supply network are presented.

Discussion of an interactive approach for multiobjective mixed-integer linear programming based on an application

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Keywords: Multicriteria analysis, mixed-integer programming, applications

In this communication, we use a location problem to discuss the potentialities of an interactive multicriteria reference point approach for multiobjective mixed-integer linear programs (MOMILP). The application concerns the selection of sites for processing facilities of hazardous materials and the determination of transportation paths and the quantities of hazardous materials shipped from the sources to the facilities. The problem involves several criteria such as cost and populations under risk.

The interactive method proposed aims to provide a simple protocol to interact with the decision maker (DM), not demanding too much information about his/her preferences, and aims to reduce the computational effort, namely by taking advantage of computations previously performed for producing new nondominated solutions.

These ideas also underlay our previous research on the development of an interactive method for multiobjective pure integer linear programs. That method [1] combines Tchebycheff theory with cutting plane techniques. At each interaction, the DM must specify a reference point (aspiration levels for the criteria) or just the objective function he/she wants to improve in respect of the previous nondominated solution. In the latter case, the reference point is automatically adjusted and new nondominated solutions are obtained through a directional search. Cutting planes, which are used to solve the pure integer Tchebycheff scalarizing programs, facilitate the incorporation of sensitivity analysis used to adjust the reference point for the next computing phase.

However, this approach is limited in practice due to the numerical difficulties carried by cutting plane techniques. Moreover, it only addresses multiobjective pure integer programs. Hence, we have further investigated a new approach based on branch-and-bound techniques, which could also deal with mixed-integer programs. A new challenge emerged to profit from computations previously performed within a branch-and-bound context.

The interactive multiobjective approach we have developed for MOMILP [2] and whose potentialities we discuss in this communication, combines branch-and-bound techniques with Tchebycheff theory. This approach is specially interesting to perform directional searches since postoptimality techniques were implemented to adjust automatically the reference points projected throughout a directional search.

Let Z* be a starting criterion reference point. A Tchebycheff scalarizing program P(Z*) is solved by branch-and-bound, yielding the nondominated solution that is closest to Z* according to the Tchebycheff metric. Whenever the DM selects an objective function, say Fj, he/she wishes to improve with respect to the previous nondominated solution, the reference point is automatically adjusted by increasing the component j of Z* leaving the others unchanged. The reference point is adjusted in order to successively produce new nondominated solutions - directional search - more suited to the DM's preferences. This stage involves an iterative process of sensitivity analysis based on the information on provided by the terminal nodes of the branch-

and-bound tree. It determines a larger enough Dj such that all the reference points between Z* and the one given by adding Dj to the component j of Z* lead to the previous nondominated solution but, a slight increase over Dj, produces a different nondominated solution.

Furthermore, the postoptimality techniques enable to profit from the previous branch-and-bound tree as a starting point to compute the following nondominated solutions. Whenever further branching is required, an attempt is made to first reduce the tree by operations of simplification - cutting deeper branches rather than simple pruning - to avoid an evergrowing tree. These features enable to reduce the computational effort involved in computing phases.

For details of this approach, see [2].

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Software demonstration on an interactive approach for multiobjective mixed-integer programming

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Keywords: Software, Multicriteria analysis, mixed-integer programming

An interactive multiobjective reference point method based on branch-and-bound techniques has been implemented using the DELPHI developer for Windows 95/98. The main ideas behind this approach are presented in a regular communication of the CSM'99 Workshop.

This computer application includes a spreadsheet-based problem editor, computing routines and graphical means to interact with the DM. The dialogue with the DM is mainly based on asking him/her to specify a new reference point or an objective function he/she wishes to improve with respect to the previous nondominated solution. The DM can also restrict the scope of the search by imposing bounds on the objective function values. Moreover, the DM may perform a more global search by demanding the computation of the pay-off table and/or some dispersed nondominated solutions - this feature may be of special interest in the initial phase of the decision process.

All the nondominated solutions the DM considers interesting are kept in memory. Numerical and different graphical displays (with several sorter options) are available to show the values of these solutions. Also, a graphical representation of the reference point space for bicriteria and tricriteria (pure) integer programs is presented to the DM. Regions of reference points that lead to the same nondominated solution are successively computed and appended to this graph. All the information that is provided for the DM is of special importance to guide him/her throughout the search process for nondominated solutions.

Internal Consistency as a Design Principle for Integrated Modeling

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Keywords: systems analysis, decision support systems

The RAMCO model has been developed in the framework of a recently concluded multidisciplinary research program. The aim of the project was to develop a scientific methodology by which coastal managers can examine the short- and long-term consequences of their decisions under various hydrological, demographic, and social-economic scenarios. RAMCO is a prototype version of a decision-support system for coastal-zone management. Spatial and temporal dynamics are combined to describe the main (bio)physical and social-economic coastal zone processes. The coastal zone of South-West Sulawesi, Indonesia, served as the area of application. In this region land- and sea-based human activities, driven by rapid population growth and strong market incentives, form a growing threat to vulnerable marine ecosystems such as coral reefs and their associated reef fish stocks.

A systems approach has been followed to arrive at a conceptual framework for the analysis and comparison of different management alternatives. A number of distinct steps can be discerned in the development of the RaMCo model. The model inception phase was aimed at defining the problem and

identifying the objectives and decision criteria of the coastal managers. Then a number of feasible management alternatives were formulated. The third step was aimed at giving a qualitative description of the system, consisting of a network of system elements and interactions. Next, models and data were collected to translate this network in a quantitative system model. The last phases concern the implementation and the presently ongoing validation of the model.

The qualitative and quantitative system design were accompanied by a number of conceptual difficulties. Choices had to be made with respect to the level of detail of the models to be used, the spatial resolution and temporal scales, and the number and type of variables to be included. In our opinion the design of an integrated system model should be based on internal consistency, which

means that the different subsystems are in mutual agreement in terms of accuracy and sensitivity, and appropriate for the output variables described

by the overall system.

The software demonstration will be used to compare the impacts of deforestation and blast fishing on the condition of coral reefs. Deforestation may lead to excessive levels of river sediment discharge and high concentrations of suspended sediment, which in turn can affect coral reefs. Blast fishing is a frequently occuring and widespread fishing method in the region and is particularly destructive. Both processes are described on the basis of monthly time steps in the RAMCO model. Sediment runoff usually takes place during short storms that can be modeled on time scales of hours. However, as coral reefs can withstand high levels of water turbidity for several days it is sufficient to calculate the monthly average concentration of suspended sediment above the reefs. This means that the appropriate time scale for the hydrological model depends on the intrinsic time scale of the dose-response function of the coral reefs.

At the present moment we are planning to conduct sensitivity analyses and uncertainty analyses with the RaMCo model in order to determine its degree of internal consistency. The response of the submodels to different types of

input will indicate whether the aggregation level of the models is appropriate in view of the behavior of the integrated system. Based on the results one could decide to refine or simplify the models in question. This approach may also facilitate the identification of the suitable temporal and spatial scales. The suggestion made is that the concept of internal consistency be further defined and made applicable as a guiding principle for the design of integrated systems. The RAMCO model will be used to illustrate this point.

internet:

http://www.minvenw.nl/projects/netcoast/ramco/

http://www.sms.utwente.nl/vakgr/civt/wh&m/onderzk_whm.eng

Developing a decision support system to match the demand on with the availability of capacities in a hospital.

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Keywords: admission planning, resource utilisation, integer linear programming

The problem context

A hospital consists of different specialties. A specialty is a group of specialists who treat patients with similar health problems. Specialties use the resources of a hospital to treat their patients. For this project, four resources of a hospital are taken into consideration:

1. operating theatre facilities
2. nursing personnel
3. beds not in the Intensive Care
4. beds in the Intensive Care

Patients who enter a hospital place a demand on the different resources. In general one can distinguish two types of patients: emergency patients and elective patients. Emergency patients do not have to wait before they are admitted to the hospital because they need immediate treatment. Elective patients however are scheduled and usually have to wait before they are admitted. Elective patients can be categorised according to the demand they place on the resources of a hospital. Patients who belong to the same category require, on each day of their stay, almost the same amount of capacity of the four different resources.

Many hospitals have difficulties with controlling the occupation rates of their expensive resources and the waiting time before elective patients are admitted to a hospital. In fact they have problems in matching the demand on with the availability of their capacities. The demand on capacities can be controlled by the admission of elective patients. Emergency patients also require capacity but unfortunately they cannot be scheduled. Capacity should be reserved for the treatment of emergency patients. The availability of capacities can be controlled by adjusting capacity levels of resources.

Optimix: A tool to solve the matching problem

We developed a software tool called 'Optimix' to support decisions about these matching problems on a tactical level. Optimix formulates the matching problem as an integer linear programming (ILP) problem and a software package called 'MOMIP' is being used to solve this ILP-problem. The user can solve the matching problem in an iterative way with the aid of Optimix. A description of this iterative procedure is given below.

INPUT

The user should specify information about:

- The capacity of the four resources that is available for elective patients.
- The target capacity utilisation of the different resources.
- The relative importance of the resources.

- The length of the planning period.
- The number of patients for each category that needs to be admitted within the planning period (target patient throughput) in order to control the waiting time of elective patients.
- Certain restrictions on the admission of patients.

The target capacity utilisation can be smaller than 100 percent to cope with deviations from the actual and the expected demand on capacity. Optimix uses only expectations of the resource requirements per patient category. It doesn't take variations within categories into account. Therefore it is important to define enough categories to limit the variation in the demand on capacities within a category.

The program uses the specified information above and information about the required amount of capacity per resources, per patient category.

OUTPUT

The program calculates an optimal admission profile. An admission profile records for each day within the planning period and for each category, the number of patients that will be admitted. With an optimal admission profile we mean a feasible profile that results in the smallest possible weighted deviation between the realised and the target resource utilisation. The deviations are weighted according to the relative importance of the resources. An admission profile is feasible if

- The total capacity of the different resources that is available for elective patients is not exceeded.
- The target patient throughput is met.
- The given restrictions are not violated.

Patients who are admitted according to this optimal profile will require capacity of the four resources. The program calculates the expected utilisation of the four resources based on the optimal admission profile. The user has now the possibility to compare the target and the realised utilisation levels of the four resources, given that a feasible admission profile exists. Based on this comparison one can decide whether or not to adjust the amount of capacity for the different resources for the coming months or the throughput of elective patients. If one decides to adjust the capacity levels and/or the throughput of patients then another cycle trough this procedure is needed.

The Validation of Optimix

Two tests were conducted to validate Optimix. In the first test the program had to solve a couple of real-life matching problems that occured at an Orthopaedics specialty at a hospital in the Netherlands. In the second test, the program is being used at different specialties during a 6-month period. The results from the first test show that Optimix is able to solve the matching problems in a short time. Almost 95 percent of the problem instances were solved within 5 minutes using a standard PC. The first test has been finished but the second one is still running.

The weighted deviation between the target and realised utilisation of the total capacity that is available for elective patients is used as a performance measure to validate the program. To measure the performance of the matching process in a hospital one can use the measure mentioned above and the standard deviation of the waiting time of elective patients. The waiting time of elective patients is the time between a patient's request for treatment in a hospital and the date on which the patient is actually admitted to the hospital.

Conclusions and recommendations

Matching the demand on with the availability of capacities in a hospital is in most cases a very complex problem. We developed a software tool called 'Optimix' to support decisions about these matching problems. Although the results of the first test look promising we still have to wait for results of the second one to obtain a better prediction of the performance of Optimix. Not only is the performance of Optimix important but also its role in the matching process as a whole. Hopefully the second test can give more insight about

- the amount of money that can be saved through a better utilisation of the resources,

- the reduction of the standard deviation of the waiting time of elective patients,

when Optimix is used in the matching process of the demand on with the availability of capacities in a hospital.

Further research is needed to determine

- The target capacity utilisation of the different resources.
- How much capacity should be reserved for the treatment of emergency patients.
- How variations of the resource requirements per patient category can be incorporated in Optimix to determine the robustness of a certain admission profile.

A Multi-agent System for Strategic Planning

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Keywords: Strategic Planning, Distributed DSS, Distributed AI Multi-agent Systems, Blackboard Systems, Intersection

Over the last few years, there has been increasing interest in intelligent agents, distributed artificial intelligence and distributed systems. Coupling this with the increasing focus on data warehousing and decision support systems raises the issue of how these different capabilities can be integrated to create advanced decision support systems. The paper describes a cooperative, distributed system where the user aids in solution formation and the intelligent agents possess strategic, domain-specific knowledge, they communicate using blackboards and message passing to solve a problem in strategic planning. A two-phase model has been proposed to represent the distributed decision-making process for strategic planning: (1) The phase of coordination by plans (top-down task decomposition) and (2) the phase of coordination by retroaction (bottom-up integration). This system is supported by a separation between meta-knowledge and domain knowledge and by a hybrid architecture using message passing and blackboard communication. The system described is evidently a so called multi-agent system. It consists of the three types of elements: the agents, the blackboards and the constraint base. (1)Three types of artificial agents–strategic agents (STAs), decision-center agent (DCAs) and specialist agents (SPAs)–cooperate at three different hierarchical levels corresponding to the three levels proposed in our framework. (2) Four types of blackboard are represented to allow communication between agents: the problem blackboard (PBB), the domain blackboard (DOBB), the compatibility blackboard (CBB) and the strategic blackboard (SBB). (3) The constraint base contains the economic and environment constraints of the domain. An Example illustrates how the multi-agent system works in the domain of strategic planning.

Simulating Macroeconomic Impacts of Natural Catastrophic Shocks with the World Bank's "RMSM" (Revised Minimum Standard Model)

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Keywords: Macroeconomic modeling, natural catastroph

Background

Rising natural catastrophic losses are emerging as an economic issue. Comparing the 1990s to the 1960s, the number of catastrophes has increased five-fold, and the damages have increased by a factor of nine (Munich Re 1999). Some of this increase is due to changes in population distribution (more people living in flood-prone regions, for example) and the rising value of infrastructure in harm's way. Evidence is emerging, however, which links windstorms and floods (each accounting for about one-third of total catastrophic damages) to changes in global climate. Warmer surface and ocean temperature results in increased moisture absorption in the atmosphere, and increased moisture absorption leads, in turn, to increased precipitation in the form of floods and windstorm events. Therefore, the worsening catastrophic loss trends of recent decades may be a harbinger of more serious problems to come.

Costs of windstorm are borne primarily by countries in the developed world, costs of flooding by countries in the developing world, and costs of earthquakes are evenly divided between the two regions. In the end, each region bears approximately US$ 35 billion per year in direct costs of natural catastrophes. However, inter-year variation in both the total level of losses and their regional distribution can be large. Of total worldwide economic losses of US$ 65 billion in 1998, close to half were related to a single event in the developing world – flooding of the Yangtze River. When Hurricane Mitch (the second largest catastrophic event of the year) is figured in, two-thirds of global losses were in the developing world (Swiss Re, 1999). While the interregional distribution is variable, one thing is not: based on income disparities, the per capita burden of catastrophic losses is dramatically higher in developing countries.

Natural catastrophic losses significantly impair development programs by absorbing domestic savings and eroding international development assistance. For example, the Asian Development Bank has estimated that between 1988-98, 5.6% of ADF loans were for disaster rehabilitation. In 1992, nearly 20% of the ADF loans were for rehabilitation assistance related to natural disasters (Arriens and Benson 1999). The World Bank has estimated that in Mexico up to 35% of its lending earmarked for water project infrastructure during the past decade has been diverted to pay for the costs of Mexican natural catastrophes. Access to public infrastructure comprises a large component of the wealth of the poorest households and rural infrastructure projects (roads, irrigation, and electrification) have been found to be highly effective in reducing poverty (World Bank 1994). Thus, programs and policies to minimize natural catastrophic losses, to improve public and private responses, and to institute appropriate risk transfer mechanisms will have a high anti-poverty impact.

The first step in designing such measures is estimating economic costs of natural catastrophic losses at the national level.

Estimating macroeconomic costs of natural catastrophes

For most countries in the world, there exist time series data on direct damages caused by natural catastrophes. Typically these data refer to the value of capital (mostly infrastructure and residential structures) damaged. However, surprisingly little work has been done on translating these data into estimates of total direct and indirect economic costs.1 We have, in a previous paper (MacKellar et al. 1999) posed the problem "What is the opportunity cost, in terms of foregone GDP growth, of damage to the capital stock caused by natural catastrophes?" In this paper, we examine the inverse of this problem: "Given a planned GDP growth path, what additional investment resources must be mobilized in view of the fact that the capital stock is periodically reduced by natural catastrophic losses?" The country considered in this exploratory analysis is Argentina.

We rely on RMSM ("Revised Minimum Standard Model"), a World Bank economic/financial programming model which emphasizes sources-uses accounting consistency. In RMSM, GDP growth is an exogenous assumption. A Harrod-Domar production function is implicitly inverted to solve for required investment expenditure; i.e., assumed GDP growth is combined with an assumed incremental capital-output ratio (ICOR) to solve for required investment. The resources to finance this investment are then calculated in accordance with a set of assumptions on model closure and saving rates.

Natural catastrophes, by destroying capital stock, increase the investment expenditure necessary to achieve a given increase in output because some of the investment is going simply to get the capital stock back to where it was prior to catastrophic damages. The key to our simulation approach was thus adjusting the ICOR upward in each year based on the catastrophic damages drawn from a described loss distribution.

We employed the Private Closure, in which government consumption and government investment are set exogenously as proportions of GDP and the foreign resource balance is predetermined. Private investment is calculated as required total investment minus government investment and the residual variable in the national income accounting identity is private consumption.

RMSM and catastrophe modeling

How does this lend itself to modeling macroeconomic impacts of natural catastrophes? The key lies in the concept of "replacement investment." The impact of a downward shock to the capital stock (which we assume to be spread uniformly across all capital) is to raise investment expenditure required to attain targeted GDP growth because some of the expenditure is absorbed by replacing destroyed capital. With this approach, ICOR is a measure of the efficiency of investment expenditure and natural catastrophes reduce that efficiency.

This approach literally assumes that all costs of natural catastrophe come directly out of households' pockets. In reality, it is much more probable that many macroeconomic variables bear some of the burden:

- Government consumption expenditure is cut.
- Unplanned foreign borrowing takes place to reduce the consumption cuts which would be necessary to finance replacement investment.
- There is monetary expansion with a resulting inflation tax (falling mostly on those who have no need to borrow) as government exerts pressure on the banking system to expand lending.

We illustrated impacts of the first two of these by introducing a small "catastrophe module" into the RMSM model which apportioned the need for greater financial resources resulting from

catastrophic losses between lower government consumption, higher foreign borrowing (corresponding to a more negative trade balance) and lower private consumption. The catastrophic risk exposure indices calculated were foregone public consumption, foregone private consumption and change in the ratio of debt service to exports. Again, the presentation focused on cumulative distributions calculated on the basis of the Monte Carlo simulation, not on means.

Directions for further work

It is proposed to continue working in the framework of the Bank's RMSM model. RMSM already plays a role in the policy dialogue. It is a flexible accounting shell (including a state-of the-art financial module) into which special-purpose modules designed to deal with natural catastrophic losses can be inserted.

In a detailed commentary on IIASA's modeling work, Professor Thomas Schelling of IIASA and the University of Maryland argued that pre-catastrophe production functions are likely to differ from post-catastrophe production functions. To take an example, assume that the pre-catastrophe ICOR is 5.0 (one unit of output growth requires 5 units of net investment). This reflects, by assumption, a balanced portfolio of capital investments in which the marginal product of capital has been equalized across projects. Now say that a natural catastrophe selectively destroys part of the capital stock while leaving the remainder untouched. Then the marginal productivity of capital in the impaired sector will be higher than it was before the catastrophe (projects to replace damaged equipment will have a very high payoff in total GDP terms) and the marginal productivity of capital in the undamaged sector will be lower. Thus, the ICOR for investment projects in the sector which was damaged will be below 5 while the ICOR for projects in the sector that was untouched will be above 5. Assuming that the investment project portfolio was optimal before the catastrophe, the average ICOR (across sectors) post-catastrophe (and pre-replacement investment) will be less than the average ICOR before the catastrophe. Thus, the RMSM simulation presented by IIASA tends to overestimate the financial resource requirements to get the economy back on the planned GDP growth path.

Our experience in doing the Argentina analysis, point to two work items:

- exploring in more detail the relationship between catastrophes, infrastructure, and GDP, and
- exploring the reactions of household saving, the trade balance, and the monetary sector to catastrophic losses.

Study of Value Integration Types in Real Applications of Autonomous Decentralized Service System (ADSS)

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Keywords: Information Services, Value Integration

Overview: ADSS is a software architecture which is aiming at service systems such as electronic commerce based on large scale network systems. Since 1997, the technological development has been promoted as one of the activities of OMG(Object Management Group), the international consortium of object oriented technology. ADSS comprises with 3 players, Requester, and Provider, and Mediator. Requester requests and consumes services. Provider provides services to Requesters according to the requests. Mediator forms Community where Requesters and Providers share correlated interests and mediates services between Requesters and Providers. Also Mediator federates services with other Mediators for extending the service capabilities.

Value of Mediator: Mediator is an essential player in ADSS. It has capabilities of both Retailer and Broker which are defined in TINA(Telecommunication Information Networking Architecture) business model. So far, in TINA business model, values of these capabilities are not clarified so that the following values have been assumed in order to specify the functions of ADSS. (1)Community Management Mediator deals with membership management for both Requesters and Providers in the Community so that it reduces cost of trust formation between the members. In addition to this value, Mediator guides and makes the Community coherent by Dynamic Brokering Method. (2)Service Integration Reconstruction of value chain is one of the fundamental means for creating new business. Integration of existing services is a part of reconstruction of value chain and this integration can be realized by Mediator. From the view point of information technology, three types of integration, presentation integration, function integration, and data integration can be observed. Mediator equipped with these integration capabilities provides value for creating new business.

Study of Value Integration Types in Real Applications: Development of applications of ADSS is running in parallel with architectural development. These include ITS(Intelligent Transport Systems), care management information systems for aged society, and recycling information systems. It is found that expectation of people who are developing these real systems to the ADSS Mediator is highly sophisticated even though presentation integration for selling packed travels has been getting popularity in real business environment.

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Cutting Stock Planning System for Cellophane and Plastic Film Manufacturing

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Keywords: Cutting stock, heuristic, production planning

Finishing operations in the cellophane and plastic film industries include slitting customer orders from wider production rolls. The production rolls are frequently slit using a chart of patterns selected in an attempt to minimize trim loss as well as the number of setups. In practice, an over-emphasis on short term minimization of trim loss and number of setups can lead to a deterioration in longer term yield. Further, cutting stock methods typically assume fixed production roll widths. For many film manufacturers, however, there is a range of possible production widths for each type of film. This allows production widths to be chosen in conjunction with the generation of slitting patterns in order to better aid planning of the production process.

The presentation will describe a computer system developed to assist the charting functions at a U.S. cellophane manufacturer. This manufacturer's slitting operations included primary and secondary stages. In the primary slitting area, production rolls were slit into larger customer widths, with smaller widths being reslit in a secondary slitting area. The heuristic approach developed for this manufacturer generates patterns which incorporate both primary and secondary slitting. Alternative charts of patterns can be generated to examine the tradeoffs in short and longer term objectives. The system can be used to determine good production roll widths for a given slate of customer orders as well as to generate charts of patterns in the finishing area.

Decision Support for Telecoms Operators - The Data Warehousing Approach

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Keywords: Decision support, data warehousing, telecommunication

It can be observed an increasing demand for industrial and business applications of decision support systems (DSS). It stimulates intensive research on DSS. We can distinguish two mains areas of the DSS development: model based decision support systems and data warehousing approach.

The presentation will focus of application of data warehousing based decision support systems in telecommunication industry. The companies have built various database systems since the beginning of development of database management systems However, this data bases supports operational tasks. Nowadays, there is the need to integrate data from variety of sources. This can be achieved by building corporate data warehouse. The fundamental concept behind data warehousing is to give decision makers better access to corporate data. Data warehouse is subject-oriented, integrated, time-variant and nonvolatile. The first feature of the data warehouse is that it is oriented around the major subjects of the enterprise. The operational applications were in contrast designed around processes and functions. This significantly improve value of information for decision making. The second feature of data warehouse is that data found within the data warehouse are integrated. The integration shows up in many different ways - in consistent naming conventions, in consistent measurement of variables, in consistent encoding structures, in consistent physical attributes of data, and so forth. The third feature of data warehouse means that all data in the data warehouse is accurate as of some moment in time. This characteristic of data is very different from data found in the operational environment, where data is accurate as of the moment of access. The last most important feature of data warehouse is that is nonvolatile. The consequences of this feature is that there are only two kinds of operations that occur in the data warehouse - the initial loading of data, and the access of data. There is no update of database a normal part of processing.

The sources of data in the presented application are the billing data. The various analysis of this data by OLAP tool will be presented.

Decision Support and Distributed Computing in Groundwater Management

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Keywords: decision support, distributed computing, groundwater management

The contribution deals with three different types of planning and decision problems in groundwater management: (I) to find the optimal design for a steady-state groundwater control problem, which leads to the necessity of solving a nonlinear mathematical optimization problem under constraints, (II) to find the optimal trajectory or strategy for a management problem over a given time horizon and under given constraints and (III) to find the solution of a feedback control optimization problem for operational management.

The basis for the solution of the three mentioned problem classes is formed by coupling the FEM-simulation system FEFLOW for groundwater flow and mass transport modeling (s. [Di96]) with the workbench OpTiX for for distributed optimization and cluster computing (s. [GrBa98]). The combination of FEM-simulation with optimization leads to a tremendous need for computing time. The solution of this problem will be presented by using distributed computing on a cluster of workstations. This allows to reduce the computing time by one to two orders of magnitude in comparison with a classical sequential approach. First in the paper the general architecture of the software system for distributed solution will be presented and the effect of adaptive loadbalancing for task distribution discussed. The software-integration of the simulation system FEFLOW with OpTiX based on the interface management system IFM will be illustrated.

The distributed solution methods and the algorithms for the above mentioned three classes of optimization problems (I) - (III) will be presented and its efficiency discussed. Especially the concurrent use of different algorithms (the hybrid concept) will be shown. The results will be presented by discussing three case studies: (I) to minimize the amount of water to be pumped out to keep a certain groundwater level, (II) to find the minimal pumping strategy for a given area over the time horizon of one year and for upper constraints for the groundwater level at certain measurement points and (III) to find the optimal control levels and control activities for the problem (II). To give an understanding of the complexity of the decision problem classes, the groundwater simulation model is based upon about 20,000 finite elements.

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Risk-Based Decision Analysis for Crop Protection

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Keywords: influence diagrams, warning systems, weather damage

Several ways of managing risks are known in agricultural production; enterprise diversification, production and marketing contracts, hedging in futures, and crop insurance, for example, are used in practice. There is, however, a need to support the evaluation and selection of production techniques for protecting crops. The purpose of this research is to present an approach to crop protection using decision analysis on the warning system for cool weather damage.

After the catastrophic damage to agricultural production (especially to rice production) from cool weather in 1993, the warning system for cool weather damage has been built to obviate the disaster in northern Japan. The objectives of the development are to help rice producers make better decisions under uncertainty and to assist the extension service in assessing the effectiveness of risk protection techniques. The system contains the warnings that are revised every week, crop situation including forecasted occurrence of plant disease and predicted growth of rice, and weather observations such as precipitation, air temperature, and sunlight; the information is delivered through the Internet. Although the system is still under development, it is expected that the decisions such as water management, fertilization planning, and disease control will be improved in the planning phase and in day-to-day practice.

Risk-based decision analysis is performed as a method to effectively utilize the information and to support decisions; the water management decision is analyzed as an example. The characteristics of the decision problem are summarized as follows:
(1) there are no techniques to perfectly avoid the cool weather damage,
(2) rare events may occur in addition to normal fluctuations in yield, and
(3) evaluation criteria are multiple.
Thus, influence diagrams are employed to clarify the causal relationship in the decisions and to design the forecasts as an integral part of the decision problem; moreover, a probability weighting function is introduced to treat the occurrence of rare events and two criteria (yield and working hours) are used for the evaluation. Although it is necessary to consider the relationship between the Bayesian approach and the behavioral (descriptive) model, the method of this study can examine the effects of the content and accuracy of forecasts and attribute weights on the selection of technologies.

Possibilistic Data Envelopment Analysis by Interval Input-Output Data

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Keywords: DEA, efficiency, possibility, necessity, interval data, linear programming

Data envelopment analysis (DEA) is a useful tool to evaluate the relative efficiency of systems, i.e., decision making units (DMUs) with multiple inputs and outputs by given input-output data [1,2] and has been applied to various fields of organizations, hospitals, banks, factories and offices. In the conventional DEA, the input-output data are assumed to be precise. However, the data are sometimes observed with a noise and/or with the inaccuracy. Such uncertainty and/or inexactness affect on the efficiency evaluation since the efficiency is often sensitive to the data fluctuation.

From this point of view, sensitivity and stability analysis [3-5] was developed in order to obtain the input/output stability region within which the efficiency of a specific efficient DMU remains unchanged. The techniques except the one proposed in [5] can treat changes only in the specific efficient DMU's data. Only a region satisfies a sufficient condition for the preservation of efficiency is obtained by those methods except the one proposed in [4].

As the other approaches against the data fluctuation, stochastic and fuzzy DEA techniques have been developed representing the data fluctuation by a probability distribution and by a fuzzy set, respectively. In stochastic DEA, chance constrained programming approaches [6,7] are applied to DEA to examine whether the probability of the event that a specific DMU is efficient is not less than a given probability degree. This approach can treat simultaneous changes in all DMUs' data but, generally, the reduced problem is a non-convex programming problem and difficult to solve it.

On the other hand, in fuzzy DEA [8,9], fuzzy mathematical programming approaches were applied to the linear/linear fractional programming problem of the traditional DEA to evaluate the efficiency score. However, a part of the obtained fuzzy set of efficiency scores may improperly exceed 1 without any connection to super-efficiency score [10]. The authors [11] has proposed two fuzzy DEA techniques based on possibility theory [12]. We defined the possibility distribution of efficiency score in a natural way and extended the efficiency concept to possible and necessary efficiencies. The closed relation between those two approaches are shown.

The possible and necessary efficiencies are defined as direct extensions of efficiency based on the possibility theory. However, the efficiency is defined by a domination relation and a production set. Thus, it is possible to extend a domination relation and a production set to the case of imprecise input-output data so that we can extend the efficiency by this indirect way.

In this paper, assuming interval input-output data is given, we extend the efficiency by the indirect way. The production set is extended in a natural way as a set of interval input-output data. On the other hand, there are several ways to extend the domination relation to the relation between interval input-output data based on possibility theory. Moreover, by the logical combinations of extended domination relations, we obtain a lot of domination relations. Corresponding to this fact, a lot of extended efficiencies are obtained. However, it is shown that 25 kinds of extended efficiency among them are essential, namely, all extended efficiencies are

obtained as logical combinations of the 25 extended efficiencies. Strong-weak relations among those are investigated and utilized for qualitative efficiency evaluation.

Furthermore, it is shown that 15 among the 25 extended efficiencies can be evaluated by the simplex method and the others can be evaluated by solving lexicographical optimization problem which can be solved by iterative applications of the simplex method. Each solution gives an improvement guide for the evaluated DMU to be efficient in the sense of the employed efficiency. While the proposed method is developed based on the additive model [2] of DEA, an efficiency score to each extended efficiency is defined based on the solution of the corresponding mathematical programming problem in order to quantify the proximity from the efficiency.

The proposed approach is novel in the following sense: (1) the proposed approach can treat simultaneous changes in all DMUs' data and the mathematical programming problem to evaluate the efficiency is convex and relatively easy to be solved, (2) moreover, an improvement guide can be obtained from the solution to the mathematical programming problem, (3) while the previous approaches to data fluctuation provide only quantitative analyses, the proposed approach provides both qualitative and quantitative analyses, (4) and hence, in order to achieve a better efficiency, the analyst/decision maker can establish a goal as an extended efficiency in which sense the DMU is evaluated inefficient.

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Multiple-start local search intensified by learning

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Keywords: local search, travelling salesperson problem, combinatorial optimisation, population based metaheuristics

The paper describes multiple-start local search (MSLS) method intensified by knowledge induced from previously generated solutions. The method uses a population of solutions composed of local optima only. The initial population of local optima obtained by local optimization starting from random solutions. In the following phases, statistically significant features of the current population are found. The features represent induced knowledge about properties of good solutions. New solutions are constructed by combination of the significant features. Local search is applied to any newly created solution. The method is applied to travelling salesperson problem (TSP). In this case, the knowledge about properties of good solutions is represented in the form of frequent arcs and frequent sub-paths composed of a number of consecutive arcs. New solutions are constructed by a randomized procedure that combines frequent arcs and sub-paths into a feasible solution. It is shown that the use of starting solutions created in this way significantly improves performance of local search, i.e. it reduces time needed to achieve local optimum and allows obtaining better local optima.

Human-Centred Life-Cycle Methodology for the Development of Model-Based User Interfaces

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Keywords: Human-machine interfaces, life-cycle of systems development, systems engineering, software ergonomics, model-based designer support, human-centred life-cycle methodology, user participation, task analysis, rapid prototyping, usability testing, model-based user interfaces, supervision and control, chemical distillation

Software systems engineering approaches such as the life-cycle methodologies (see, e.g., Sage, 1992) turn out to be valuable guidelines for the development of user interfaces. Generally however, it seems to be more appropriate to combine these systems engineering life-cycle procedures with end-user participation and rapid prototyping in a systematic way. This leads to a human-centred life-cycle methodology for the design and development of user interfaces and, especially, of human-machine interfaces. The objectives of user participation reveal a surprising multitude of aspects. Most of these aspects depend on the viewpoint, e.g., whether they are judged by the management, by the end-users or by the designers (Johannsen et al., 1995; Johannsen et al., 1997b).

Any user-oriented design of interactive software products, such as human-machine interfaces, should start with definitions of user classes, overall goals and means for their achievement, as well as with task analyses, in order to have a solid basis for user requirements and systems specifications, particularly also for the functional specifications of the human-machine interfaces. User requirements should consider the goals-means-tasks relationships, and should be based on a task-oriented perspective.

The stages of the development/design life-cycle require different forms of user participation. The functional specification for Human-Machine Interfaces (HMI) depends on the goals and goal structures prescribed for the human-machine system, on all kinds of technological and intellectual means of accomplishing these goals, and on the tasks to be performed by the human users with the purpose of achieving the goals by appropriate usage of the available means; see also Johannsen (1997a).

The tasks to be performed by the human users are based on certain scenarios, i. e., the situations and contexts of the human-machine system that are specified in consultation with expert users during the scenario definition. The different experiences and knowledge of the human users, as well as different normal and abnormal situations and states of the dynamic technical system, lead to different subjectively perceived tasks. Further, the prescribed goals and the means available for their achievement strongly determine the types of tasks to be performed in a certain scenario. A thorough task analysis, combined with knowledge-elicitation techniques, is a strong foundation for the definition of the user requirements, and for the functional specifications of the human-machine interfaces (Johannsen & Alty, 1991; Kirwan & Ainsworth, 1992; Heuer et al., 1993).

During later design stages, it is necessary to organise further expert meetings, with the participation of different human user classes, in order to evaluate intermediate prototype designs

as well as the final product of the human-machine interfaces. The sequence of several intermediate prototype designs and the final systems implementation of the human-machine interface is alternating with their corresponding evaluation stages. The presentational prototype is more of a surface lay-out, followed by an interaction analysis with appropriate user participation in order to gather more inputs for the functional prototype. Several iterative feedback loops from the usability testing of the prototypes may occur in order to further improve the prototypes. Based on the usability testing of the last prototype version, the final design and implementation of the human-machine interface is accomplished, followed by its final evaluation.

The analysis and evaluation techniques for all these design stages comprise scenario definition, organisational analysis, task and knowledge analyses (all with unstructured and structured interviews, walk-throughs and talk-throughs in real or simulated situations, etc.), less formal expert analyses, and experimental sessions with usability testing procedures.

The more traditional levels of human-machine interfaces, such as presentation and dialogue, are separated from each other. The dialogue level deals with the information flows regarding such problems as what information to handle when. The presentation level is concerned with the problems of how to present the information to the human users, and how to transform their control inputs. Both, the presentation and the dialogue levels can explicitly depend in their functionalities on the goals as well as on technical systems or application models, user or operator models, and task models.

The more explicit representation of such models in the human-machine interface leads to more advanced paradigms (Johannsen, 1997b; Johannsen et al., 1997a). A Technical Systems Model contains the knowledge about the goals, the structure and the functions of a particular application. The functionality of this technical systems model internally supports all the other functionalities of the human-machine interface.

A User Model functionality is needed if a certain adaptability to human user classes or single users shall be achieved. A more elaborated user model will always include a technical systems model in order to represent the user's view with respect to the technical system. In addition, knowledge on human information processing behaviour and cognitive strategies has to be represented in a user model by means of algorithms, rules, and, possibly, active inference mechanisms.

Other knowledge-based functionalities of a human-machine interface are Explanation and Justification. The Explanation functionality informs the human users on request about what the components of the technical system (and possibly also of the human-machine interface) mean and how they function. On the other hand, the Justification functionality explains the reasons why a certain decision of the Decision Support System is valid.

More recently, methodologies have been developed which allow to support designers of human-machine interfaces in their design and evaluation activities. The objectives are to enhance the efficiency of these activities and to improve the final interface products. Two methodologies will be described here. The first one is GUIDE by Redmond-Pyle and Moore (1995), the second one is DIADEM by Thomson-CSF (1996). Both methodologies combine systems engineering life-cycle procedures with end-user participation and rapid prototyping. Strictly speaking, the Graphical User Interface Design and Evaluation method GUIDE is restricted to human-computer interaction, i.e., systems without dynamic technical processes. However, many of the GUIDE techniques are also relevant for dynamic systems. Further, this design method is strongly emphasising the presentational issues. On the contrary, DIADEM (Dialogue Architecture and Design Method) is appropriate for all application domains, including particularly all kinds of dynamic industrial processes. Its main focus lies on the dialogue issues, but it includes also the presentational issues.

The design stages of the GUIDE methodology are called lower-level processes. They have specific objectives and deliver well-defined outputs. The methodology starts with defining user classes and usability requirements. Then, task models and task scenarios are produced. The user object model is specified by the designer with the intention to support the development of

an interface in which such a user object model may create effective mental models inside the users' mind. Presentational issues are considered by the style guide. The stage of designing the GUI (Graphical User Interface) is based on all these specifications. It refers to the initial design of the interface and should provide a sound basis for prototyping. Several iterations lead to progressively improved versions of prototypes via respective intervening evaluations.

The first stages in the DIADEM methodology are task analyses which help to identify interactive tasks and user interface requirements. They lead to three parts of requirements specification, namely the description of (1) user objects and object oriented models, (2) tasks and dialogue, and (3) presentations. Task graphs and strategies are used as specific formalisms for tasks and dialogue. The task graphs have hierarchical tree structures and offer a global view of the dialogue functions without any relationships. The strategy graphs describe dynamic relationships of the dialogue. They show a network of transitions between first-level subtasks, interactions by the user, and application calls.

In addition to the formalisms of the requirements specification, DIADEM provides guidelines for establishing a MMI Handbook of the Man-Machine Interface. It contains principles, rules and common choices on presentation and interaction. The MMI Handbook corresponds to and exceeds beyond the style guide of the GUIDE method.

Prototyping scenarios, a software architecture model for preliminary design, test scenarios, the user manual, and estimates of development costs are the main outcomes of the formalised specification with the DIADEM method. Iterative loops of user interface specification, prototyping, prototype evaluation and modification are performed by a co-operative working group. This consists of the project leader, the ergonomist, the specifier, the prototyper, and the user(s), due to the general approach of the DIADEM method.

The presentation at the JISR-IIASA Workshop will explain the above human-centred life-cycle methodology for the development of model-based user interfaces in more detail. A multimodel-based user interface approach and its application to the supervision and control of a simulated process of a chemical distillation column will be exemplified.

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New directions of AIM modeling

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Keywords: climate change, technology, environment, modeling, economic impact

The need to respond to climate changes is now a matter of common recognition throughout the world. After several years of negotiations, agreement was reached on the Kyoto Protocol in 1997 in Japan. The Protocol is regarded as an important step toward meeting the objective of stabilizing greenhouse gas concentrations in the atmosphere. However quantitative targets agreed at the Kyoto Conference were not enough to stabilize them. Considering the emission increases in developing countries, new strategies to reduce the global emissions should be adopted. Integrated Assessment Models are used to estimate the impacts of policies to tackle global warming.

The region that is most in need of the urgent introduction of sophisticated policies to integrate economic development and environmental conservation is the Asia-Pacific region. This region has over half the world's population and by early next century will have a level of economic activity equivalent to that of the United States of America or Europe. The region's growth of energy consumption and the production of environmental loads such as sulfur dioxide and CO2 emissions will be most rapid in comparison with other regions. As a result, the development of effective environmental protection policies is of the utmost importance.

Here we propose new policy needs for Integrated Assessment Models in Asia and new directions of modeling to meet such needs. In order to promote global climate policies, we need to integrate not only climate policies but also other policies such as environmental policies, industrial policies and sustainable development policies. Also spatial ranges will be widened from national levels to local and regional levels. In order to move away from unsatisfactory future towards one in which development is more "sustainable", policy makers in the region are seeking the introduction of integrated assessment processes. The specific needs for them are:

1. Technological assessments to break through the trade-offs between rapid economic growth and serious environmental pollution;
2. Policy linkages to integrate policies on global environmental problems with policies on domestic environmental and social issues;
3. The development of partnerships in the region based on the increasing economic interdependence in the region, particularly for creation of environmental protection policies; and,
4. A recognition of the region's uniqueness and identity that will become a consciousness for environmental conservation.

The AIM model has been revised to estimate critical environmental trends and to evaluate new environmental policy options.

An Electronic Sales Promotion and Merchandising System in Wholesale Industry using Mass-customization Technique

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Keywords: electronic commerce, sales promotion, wholesaler, mass-customization

The sales promotion and merchandising process, most upstream in the flow of inter-company commercial transactions, has been far less automated than other processes, such as the circulation of transactional information, goods, and money. This paper proposes an information system designed to solve the problems for automation of this process, namely, achievement of interactive communication and reductions of network load and the burden of offer preparation.

The activities comprising the sales promotion and merchandising process can be divided into three categories by the nature of trigger. The first category is "proposal of plan", in which the supplier picks products by certain criteria and offers them to the customer. The next category concerns the "Proposal of new merchandise", which means the supplier's offering of new products or new versions of existing products to the customer. The last category is named "Response to retailers' requirements", where the supplier offers the customer a product that meets the requirements the customer has presented.

For automating the process, an electronic sales promotion and merchandising system which has the following features has been developed.

1. In order to realize interactive communication between the supplier and the customer during the offer submission and reaction phases, and in order to incorporate into electronic data on an offer sufficient data for the customer to determine acceptability of the offer, a WWW browser is used to enable interactive communication on a homepage linked to detailed product data.

2. In order to reduce the supplier's burden of offer preparation, the mass customization technique is introduced to rearrange the offer baskets (the sales promotion proposal plans), which is a list of products together with a unique identification such as "Mother's day", "Back to school fare" and so on, recommended by wholesaler.

The electronic sales promotion and merchandising system is constructed from three subsystems; an offer preparation subsystem, an offer notification subsystem, and a reaction treatment subsystem. By using the offer preparation subsystem, the wholesaler user can register new products and organize the standard offer baskets. The standard offer baskets are modified to adapt

to retailer's environment by hand or the mass customization function. For mass customization, several rules including the preferential selection of products of equal size or brand and the addition of the same product category are pre-established. Some of these rules are automatically generated from sales result information by using the data mining technique. The offer notification subsystem create an HTML file of the offer basket based on the specified template. Then, the file is send by a distribution agent or via e-mail. The E-mail reply from retailer or notice through the PUSH channel is automatically received by the reaction treatment subsystem. Then an order information in the replay is translated EDI files.

The proposed electronic sales promotion and merchandising process system has been developed and tested in field for evaluation. This test was conducted as part of the project for developing common electronic commerce infrastructures sponsored by the Information- Technology Promotion Agency of Japan(IPA). One of the participants is Orion Corp., a partner mainly responsible for the management of the MDC (Marketing Data Center) and providing VAN services in the Tokai Region in Japan. The participants are two daily goods wholesalers, two food wholesalers, two supermarket chains and two drug store chains. Products placed under MDC control numbered in about 30,000.

The experiment was done during the four-month period from September to December 1998, with availability of mass customization and other settings under control. Evaluation of the effectiveness was done based on the analysis of logs of system usage and on interviews with the users. The major results are following;

1. The average level of 30 user's satisfaction with the system is 3.3 on an 1-to-5 scale (5 being best).

2. Use of the previous offer basket reduced average time required for preparation of the basket from 7min. to 5min.

3. The work of offer preparation can be done 31% more efficiently by the use of mass customization(25sec.) than customization by hand(38sec.). For the reference, the average time required to make an offer in a conventional way is 94 min.

4. By using the system, the accept rates of products in the offer basket increases 33% compared with traditional way(51.5%). Though, there is no difference on the accept rates of products in the offer basket between the use of mass customization(68.5%) and the non-use(66.7%).

5. Evaluation of the quality of mass customization by 15 wholesalers salesmen is 2.7 on the average on 1-to-5 scale (5 being best).

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Towards manipulation free procedures for decision support in negotiations

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Keywords: modeling, negotiations, multicriteria decision support

The paper relates to methods and techniques for negotiation and mediation support with use of computer based DSS.

A negotiation process is in general very sensitive for possible manipulations - cheating of the negotiating sides. The same can be observed in a number of negotiation support systems presented in the literature. There are of course examples of manipulation free mechanisms for very specific problems, see e.g. Groves, Ledyard (1977). They proposed the solution of so called Free-Rider problem in the case of allocation of funds for public goods. The mechanism is based on punishment idea realized in the so-called "double payment". However in general case the problem of constructing manipulation free interactive procedures for negotiation support is still open. This problem is discussed in the paper.

A class of negotiation situations is considered in which there are several parties - players, each having multiple objectives and conflicting interests. It is assumed that a mathematical model is given which describes the set of admissible decisions of the players, and allows calculation of their payoffs as dependent on assumed values of the decision variables. The payoffs are measured by multiple criteria, in general different for each player. Due to practical reasons the criteria are not aggregated to any utility functions of the players. The payoffs are analyzed in multicriteria spaces of the players. The model does not include preferential structure of the players. The model implemented in a decision support system is used for decision analysis. Using the model the consequences of different actions of the players can be derived and compared. This model should not be mixed up with the class of models describing entire negotiation process.

Ideas of multi-objective modeling and optimization applied in negotiation and mediation support have been discussed among others in the papers by Wierzbicki (1983), Wierzbicki, Krus, Makowski (1994), Krus (1996). In the papers by Krus, Bronisz (1992, 1994), Krus(1996), Krus, Bronisz (1996) game theoretical solution concepts have been proposed which can be used in interactive procedures supporting unilateral as well as multilateral analysis of the game and mediation process. The concepts fulfill some properties - axioms which according to the ideas of the game theory assure in some sense fairness of the final payoff.

In this paper the problems of constructing manipulation free procedures are discussed. It is considered among others how the properties of the solution concept applied in the procedure can prevent possible cheating of the players. It is shown that the solutions formulated for a multicriteria game are not straight forward extensions of the classical solutions. The selection of the proper solution concept is not simple. There are also open questions regarding the interactions of the players with DSS, the access of the players to information and others.

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Convergence towards Consensus, the Power Game, and Certain Procedural Questions

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Keywords: decision making, game, compromise solution

We illustrate the convergence towards consensus, simultaneously controlled by the power game and by certain procedural rules, via a decision process in the smallest possible decision making body: a married couple. They face a house selection problem. There are four options, ranging from cheap to expensive, from down-town to rural, with varying distances to the schools for the children, with varying styles, etc. In the attempt to find a compromise solution the husband assigns increasingly more power to his wife. Nevertheless, the weighted judgement procedure does not assign dictatorial power to her. An important procedural question, to be considered simultaneously, is: when to compromise? Throughout or at the end of the decision process? The problem illustrates the complexity of group decision making with its underlying power game, and it highlights the role of a chairperson who controls the agenda of the decision process.

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Multicriteria analysis of non-linear models generated by AMPL

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Keywords: Aspiration-reservation based decision support, multicriteria optimization, modeling, non-linear models

A Decision Support System (DSS) is a computerized tool which helps to analyze a decision problem. For any model-based DSS one can distinguish the following three groups of related modeling activities, underlying methodologies and software:

Model generation: Generation of a *core model* which is a representation in terms of mathematical programming (however, without specification of goal functions) of all logical and physical relations between variables representing the decision problem being examined. The core model implicitly defines a set of feasible solutions but it does not contain any preferential structure of a Decision Maker (DM), which is specified and later modified during the analysis of the model.

Model analysis: Adding to the core model a representation of a preferential structure of a DM. In other words the user selects from the set of all feasible solutions (defined by the *core model*) a subset of solutions that are acceptable and then he/she provides information that is used for further selection from such a subset of one solution that corresponds best to the preferences of the DM. This can be done by the selection of criteria for a multiple-criteria based model analysis, or by the selection of one criterion and additional constraints for a single-criterion optimization. Each method of the representation of a preferential structure for a user has a number of parameters that have to be set by the user in order to formulate an optimization (or simulation) problem. The analysis is often done in an interactive way, thus allowing a user analysis of previously obtained solutions, changing the representation of his/her preferential structure thus formulating a corresponding underlying optimization problem.

Problem solving: Solving of a corresponding mathematical programming problem requires a robust and efficient solver that can handle a corresponding type of optimization or simulation problem in a way that is transparent for a user of a DSS.

The methodology of model-based decision support is described e.g. in [3], which provides also a detailed discussion of various modeling tools, and illustrates the methodology with environmental applications.

The software to be presented deals with an extension of the aspiration-led multiple-criteria optimization based model analysis, which is commonly called Aspiration-Reservation Based Decision Support (ARBDS). Today, ARBDS is one of the most promising techniques for model analysis for decision support. However, one of the major constraints for wide applications of any

method that requires interaction with the user is the lack of modular software tools that can be used for an implementation of a problem specific DSS. Therefore the modular tool, called ISAAP (the name is an abbrevation of: Interactive Specification and Analysis of Aspiration-based Preferences), which facilitates the interaction with the user by providing all the functions necessary for interactive analysis of a problem using the ARBDS methodology has been developed and is documented in [1]. The name ISAAP is an abbreviation of the **I**nteractive **S**pecification and **A**nalysis of **A**spiration-based **P**references, named after the methodological background.

The ISAAP module is a part of the MCMA package which is available from URL: `http://www.iiasa.ac.at/~marek/soft` free of charge for research and educational purposes. Recently MCMA has been enchanced in order to allow for handling non-linear models generated by the AMPL software. A user can now either generate a model using a problem specific generator or use the AMPL package (which is a general purpose modeling environment) to specify a model (either linear or non-linear) and analyse it using the new version of MCMA. This new version of MCMA will be demonstrated during the presentation of this paper, and it will be documented in [2].

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A Dynamic Interval Goal Programming Approach to the Regulation of a Lake-River System

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Keywords: Multicriteria optimization, Goal Programming, Water resources, Spreadsheets

Abstract – We describe a decision support tool for the regulation of a lake-river system. The inflow forecast to the system is updated periodically resulting in a series of dynamic rolling horizon goal programming problems. This involves heavy computation and yet it is succesfully done with the spreadsheet program Excel. The related decision support tool with a graphical user interface is called ISMO. It is actively used by the Finnish Environment Institute (FEI) in the generation of regulation policy alternatives when considered from the different perspectives of the stakeholders.

Introduction

Multicriteria problems with a time dependent structure have started to receive increasing attention in the literature (Szidarovsky and Duckstein, 1986; Kornbluth, 1992; Trzaskalik, 1997; Agrell *et al.*, 1998; Caballero *et al.*, 1998). The management of a lake-river system is a dynamic multicriteria optimization problem with strong control constraints and essential uncertainties (Haimes, 1977). Yet, in the development of new strategies one would need to be able to test them interactively. Here we describe an approach implemented under a spreadsheet environment to solve such a problem.

We use a dynamic goal programming model where both goal points and goal sets are defined. The sets represent acceptability intervals for the water levels. The definition of goals in terms of sets rather than points is a way to introduce flexibility and robustness into the solution. This is particularly well motivated in dynamic problems where the achievement of goals at different time points is restricted by the system dynamics. Then it can be better to softly relax the goal of reaching a number of points and define goal sets around them instead. Allowing such flexibility can make it possible to find a better overall dynamic strategy.

The dynamic multicriteria regulation setting

In complex environmental decision making the understanding and communication of the opinions of interest groups is very important (Keeney, 1994; Marttunen and Hämäläinen, 1995; French *et al.*, 1998) and multicriteria decision modelling helps to separate facts from values (Hämäläinen, 1991). In such problems the evolutionary nature of decision and negotiation support becomes clear. A general framework to approach such multi-party decision problems has been suggested (Hämäläinen *et al.*, 1999) and the negotiation support method used implemented to internet with Java (Kettunen *et al.*, 1999). The framework is also applied in the present lake regulation project. In our case stakeholders whose multicriteria interests have to be taken into account in the policy making include e.g. the power production companies, farmers, environmentalists,

owners of lakefront recreational properties, fishermen, boat owners and lake transportation. The goal programming model developed here is used to generate different regulation alternatives and their impacts for the representatives of these stakeholder groups. Decision analytic prioritizations done by the stakeholders are entered into the project's home pages (Hämäläinen, 1999) for the public to see by using a general purpose MultiAttribute Decision Analysis (MADA) web-based tool called web-Hipre (Hämäläinen and Mustajoki, 1998).

The strategies are defined in terms of six annual goal points for the water levels with lower and upper acceptability bounds, called goal intervals, for each point. The problem is to find the regulation strategy that would minimize the deviations from these goals for given inflow data over the planning period. In the goal interval formulation the distance is measured from the boundaries and it is zero for all points within the interval. The set approach allows flexibility in the vicinity of goals which are the ideals close to which one wants to find the solution.

In the development of new lake regulation strategies one needs to be able to quickly test the effects of changing the goal points. The model is implemented in the Excel spreadsheet program with a customized user interface. This software is called Interactive analysis of dynamic water regulation Strategies by Multicriteria Optimization (ISMO) (Hämäläinen and Mäntysaari, 1998a). The specification of goals as intervals or sets reflects the satisficing approach also used by the lake regulators in practice.

Generation of regulation strategies

Desired target water levels, goal points, are asked at six different points during one year and/or an acceptability interval for each point. The control problem is to stay within the intervals and/or track the goal points as closely as possible. The maximum planning period is four years.

Naturally the solution depends on the inflows, i.e. the weather pattern, assumed. Annual inflows vary considerably and the consequences, i.e. impacts, such as floods and power production, strongly depend on the true water levels and flow rates. Thus the use of average inflows as design data does not make sense, since in averaged data the peak flows always disappear. The planning is in practice done with respect of normal, dry and wet inflow year patterns taken from the historical data.

In real life perfect information on the inflows will not be available. Therefore the generation of the realistic solution for the regulation strategy needs to be based on a model of the real operational regulator and his weather forecasting horizon and data. In this case the operator of the lake-river system has a policy of using a rolling two goal points time window. Moreover, he updates his decisions at each point (approximately 10 days interval) based on the observed inflow data. From the computational point of view this means solving a dynamic optimization problem whenever the rolling time window of planning period is changed, i.e. for each month, and making heuristic corrections to outflow decisions within the month. In ISMO the solution time on a Pentium Pro 200 MHz is in the range of 10-15 minutes for a four year period (Hämäläinen and Mäntysaari, 1998b). This is somewhat too long for extensive demonstrations online together with the stakeholders but still it is acceptable for experts when they develop alternative policies.

Discussion

The early literature on goal programming and multicriteria decision making originated from managerial or business applications (Charnes and Cooper, 1961). Today, however, it looks that environmental problems are becoming one of the most fruitful areas of multicriteria decision analysis. The present project is an example of a methodologically challenging and practically important environmental problem where a dynamic multicriteria model is essential.

How the goal points should be specified to optimize a set of given regulation impacts has not been directly approached. The setting of goal points and goal sets is, in fact, another

multicriteria problem. Here we have followed the traditional goal programming philosophy by assuming that the stakeholders can indeed define them directly.

Recently spreadsheet programs have become an important platform for the development of visual interactive models even for relatively complex problems (see e.g. Mäntysaari and Hämäläinen, 1997). Our ISMO software is clearly a good example of this development. For full description of ISMO see Hämäläinen and Mäntysaari, 1999.

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Extending the MAD Portfolio Optimization Model to Incorporate Downside Risk Aversion

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Keywords: Portfolio Optimization, Mean Absolute Deviation, Downside Risk, Linear Programming

Since the advent of the Modern Portfolio Theory (MPT) arising from the seminal work of Markowitz (1952), the notion of investing in diversified portfolios has become one of the most fundamental concepts of portfolio management. While developed as a financial economic theory in conditional-normative framework, the MPT has spawned a variety of applications and provided background for further theoretical models. The original Markowitz model was derived using a representative investor belonging to the normative utility framework, which manifested in portfolio optimization techniques based on the mean-variance rule. This framework proved to be sufficiently rich to provide the main theoretical background for the analysis of importance of diversification.

The portfolio optimization problem considered in this paper follows the original Markowitz formulation and is based on a single period model of investment. At the beginning of a period, an investor allocates capital among various securities. Assuming that each security is represented by a variable, this is equivalent to assigning a nonnegative weight to each of the variables. During the investment period, a security generates a certain (random) rate of return. The change of capital invested observed at the end of the period is measured by the weighted average of the individual rates of return. In mathematical terms, for selecting weights reflecting an amount invested in each security, an investor needs to solve a model consisting of a set of linear constraints, one of which should state that the weights must sum to one (thus reflecting the fact that portions of available total capital are invested into individual securities).

Following the seminal work by Markowitz (1952), such a portfolio optimization problem is usually modeled as a bicriteria optimization problem where a reasonable trade–off between expected rate of return and risk is sought. In the Markowitz model the risk is measured by a variance from mean rate of return, thus resulting in a formulation of a quadratic programming model. Following Sharpe (1971), many attempts have been made to linearize the portfolio optimization problem. Lately, Konno and Yamazaki (1991) proposed the MAD portfolio optimization model where risk is measured by (mean) absolute deviation instead of variance. The model is computationally attractive as (for discrete random variables) it results in solving linear programming (LP) problems.

There is an argument that the variability of rate of return above the mean should not be penalized since an investor worries rather about underperformance of a portfolio than its overperformance. This led Markowitz (1959) to propose downside risk measures such as (downside) semivariance to replace variance as the risk measure. The absolute deviation used in the MAD model to measure risk is taken as twice the downside semideviation. Therefore, the MAD model

is, in fact, based on the downside risk measured with mean deviation to the mean. However, an investor who uses this model is assumed to have constant dis-utility (a term "dis-utility" is used here to emphasize a fact that an investor is a "utility minimizer") for a unit deviation from the mean portfolio rate of return. This assumption does not allow for the distinction of risk associated with larger losses. An extension to the MAD model proposed in the paper allows to penalize larger downside deviations, thus providing for better modeling of the downside risk averse preferences. The resulting m–MAD model generates efficient solutions with respect to a second degree stochastic dominance rules. At the same time it preserves simplicity and linearity of the original MAD model.

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Probabilistic and fuzzy models in data clustering

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Keywords: cluster analysis, fuzzy model, probabilistic model

Clustering techniques for data analysis and knowledge discovery have recently been remarked by many researchers. A feature of cluster analysis is that various types of mathematical models are available for handling a set of data for objects. We consider probabilistic methods and fuzzy methods for clustering that are concerned with the classical K-means. A method of K-means generates K clusters using K centers in the respective clusters. The algorithm iterates (i) allocation of the objects to the nearest centers and (ii) updating of the centers using the means of the new clusters. Two probabilistic methods are considered: (1) the mixture of normal distributions $p(x) = \sum_i \alpha_i p(x|C_i)$ ($p(x|C_i)$ is the conditional probability given the cluster C_i and $\sum_i \alpha_i = 1$). (2) the deterministic annealing using the Gibbs distribution. The clustering algorithms consist of the iterative estimation of parameters in these distributions. In particular, the EM algorithm for estimating parameters and the Bayes formula $p(C_i|x) = \{\alpha_i p(x|C_i)\}/\{\sum_j \alpha_j p(x|C_j)\}$ are used in the former method (1). Another class of clustering techniques is the fuzzy c-means, where the number of clusters is denoted by c instead of K. The standard method of c-means is an alternative optimization of an objective function with respect to two different kinds of parameters. One is the membership u_{ik} by which the object k (represented as a point x_k in an Euclidean space) is allocated to the cluster i; the other is the center v_i for the cluster i. The fuzzy c-means algorithm is the iteration of (FU) $J(\bar{U}, \bar{V}) = \min_U J(U, \bar{V})$, (FV) $J(\bar{U}, \bar{V}) = \min_V J(\bar{U}, V)$ until convergence, where the objective function is (3) $J(U, V) = \sum_i \sum_k (u_{ik})^m d_{ik}^2$, $U = (u_{ik})$, $V = (v_1, \ldots, v_c)$, and $d_{ik} = \|x_k - v_i\|$ is the Euclidean distance between the object x_k and the center v_i. (Remark: $m > 1$ is called the smoothing parameter; the constraint of the fuzzy partition $\sum_i u_{ik} = 1$ for all k for U is assumed. The optimal solutions $\bar{U}$ and $\bar{V}$ are easily obtained using the Lagrange multipliers. We omit the details.) Recently, the authors have proposed the use of other objective functions: (4) $J(U, V) = \sum_i \sum_k \{u_{ik} d_{ik}^2 + \lambda^{-1} u_{ik} \log u_{ik}\}$; (5) $J(U, V) = \sum_i \sum_k \{u_{ik} d_{ik}^2 + \lambda^{-1} u_{ik}^2/2\}$ in (FU) and (FV). It can be shown that the method using (4) is made to be equivalent to the deterministic annealing (2) by appropriately setting parameters, although these two are based on different types of probabilistic and fuzzy models. Fuzzy classification functions for the methods (3)–(5) have moreover been proposed by the authors. A fuzzy classification function is a fuzzy rule defined over the whole space that interpolates the memberships of the objects. For example, the membership u_{ik} with the center v_i is given by

$$u_{ik} = [\sum_j (d_{ik}^2/d_{jk}^2)^{\frac{1}{m-1}}]^{-1}$$

while the corresponding classification function is

$$U_i^{(3)}(x) = [\sum_j (\|x - v_i\|^2 / \|x - v_j\|^2)^{\frac{1}{m-1}}]^{-1}.$$

In the probabilistic methods, the classification functions are probabilistic rules by which an object is allocated to clusters. Thus, in method (1), the classification function is $U_i^{(1)}(x) = p(C_i|x)$ which is given by the Bayes formula. Since we have the methods (1)–(5), the respective classification functions are denoted by $U_i^{(1)} \sim U_i^{(5)}$. Methods (1) and (2) thus use probabilistic rules while methods (3)–(5) provide fuzzy memberships to the clusters. Theoretical properties of the clusters are derived from the the classification functions. Some of them are as follows. (P1) If probabilistic or fuzzy allocation to clusters is transformed to crisp allocation by the maximum degree: point x is allocated to cluster i when $U_i^{(\ell)}(x) \geq U_j^{(\ell)}(x)$ for all $j \neq i$, $\ell = 1, \ldots, 5$. Methods (2)–(5) then provide the nearest allocation rule, the same as that in the K-means. In other words, the region $R(v_i) = \{x : U_i^{(\ell)}(x) \geq U_j^{(\ell)}(x), \forall j \neq i\}$ is the Voronoi set with the center v_i. (P2) The maximum value of $U_i^{(3)}(x)$ is attained at $x = v_i$ and $\lim_{x\to\infty} U_i^{(3)}(x) = 1/c$, whereas for $U_i^{(2)}(x)$ (and equivalently, $U_i^{(4)}(x)$), $\lim_{x\to\infty} U_i^{(2)}(x) = 1$ when $R(v_i)$ is unbounded and $x \to \infty$ inside $R(v_i)$. In contrast, $\lim_{x\to\infty} U_i^{(2)}(x) = 0$ when $R(v_i)$ is bounded. (P3) $U_i^{(2)}(x)$ is quasi-convex. (P4) $U_i^{(5)}(x)$ is piecewise linear. There are many variations of the fuzzy c-means taking linear structures into account (e.g., the linear regression), and the above methods are extended to those variations. For example, the fuzzy c-regression can be studied likewise. Another problem of L_1-space clustering can be handled in the same manner.

An Intelligent Optimization Technique for Unknown Objective Functions

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Keywords: Additional Learning, RBF Networks, Genetic Algorithms, Engineering Design

In many practical engineering design problems, the form of objective function is not given explicitly in terms of design variables. Given the value of design variables, under this circumstance, the value of objective function is obtained by some analysis such as structural analysis, fluid mechanics and thermo-dynamics. We call such an objective function "Unknown Objective Function" in this paper. Usually, those analyses takes much computation time. Therefore, methods requiring only a small number of analyses are needed for optimization with unknown objective functions.

In this paper, we suggest a method which makes optimization in parallel with forecasting the form of objective function. Techniques of machine learning can be applied for forecasting the form of objective function. To this end, in this paper, we use a radial basis function network (RBFN) which is one of artificial neural networks. Furthermore, genetic algorithms are applied for optimizing the forecasted objective function.

The procedure is continued until a reasonable solution is obtained. As the generation elapses, we add two new data for relearning the form of objective function. One of them is selected from a neighborhood of the current optimal value. This neighborhood should be controled depending on the covergence process. The other one is selected to be far from the currenct optimal value in order to give a better forecast of the form of objective function. The former additional data gives more detailed information near the current optimal value. The latter data prevents from converging to local maxima (or minima).

The effectiveness of the suggested method will be shown through numerical examples.

Nitrogen travel distance in EMEP Eulerian and Lagrangian acid deposition models.

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Keywords: air pollution modeling, Eulerian model, Lagrangian model, model uncertainty

Up till 1998, EMEP routine calculation were carried out with the 2-D Lagrangian model. This trajectory model operates with a horizontal resolution of ca. 150km x 150km. The atmospheric boundary layer (ABL) is represented by a single layer in the model. EMEP Eulerian model, on the other hand, operates on a finer grid (ca. 50km x 50km) and has twenty vertical layers. The ABL is represented by ten vertical layers. Since 1999, the Eulerian model replaces the Lagrangian one in EMEP routine calculations.

The differences in the design of the two models lead to different performance of the two models. While both models generally compare well with available measurements and with each other, the computed deposition fields show differences, which stem from differences in resolutions and from small differences in the chemical scheme and physical parameterizations. We investigate the differences between the deposition fields computed by the two models by taking as a benchmark the travel distance from an emitting country. For several emitting countries in Europe, we calculate the mass deposited within a year as a function of distance from the emitting country. Countries of various size are taken into account, as well as countries with different ratio of low to high (stacks above 100m) emissions.

This investigation should help to interpret the country-to-country exchange and country import-export budgets computed by the EMEP Eulerian model as compared to those computed with the Lagrangian model. Finally two questions will be addressed: how to evaluate the uncertainty of the main model results, and how to evaluate the compliance of individual countries with emission control agreements and protocols. Finding quantitative answers to these questions is still an unresolved problem in transboundary air pollution modeling.

The Workflow Simulation System with the Flexible Output Customization Function

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Keywords: workflow, discrete simulation, customization

At present, Japanese companies need drastic business reorganization to make the work of several departments or companies more efficient to survive keen competition. In BPR(Business Process Reengineering), which is one of the methodologies for drastically re-composing and improving the business process system, the workflow management system attracts a great deal of attention. The workflow management systems supply definitions and perform execution and management of a business processes.

In introducing a workflow system, a quantitative analysis of the business process is needed for evaluation of the current business process. The business process is estimated by various criteria, for example "working time", "jams of work items in each work", and so on(the work item is the representation of the work to be processed). It is not until work items are processed in the context of a business process that these criteria can be calculated. Therefore, the criteria are obtained by simulation. A discrete simulation is applied for the workflow model simulation[1]. The workflow model is a kind of structured model. The order of work execution in a business process is expressed by the workflow model. Simulating is materialized in the processing of work items by executing the program defined in each node and transferring in the context of the structured model. At each node, the property value which belongs to the node itself or the work item is overwritten. As a result of the simulation, the log of work items is stored, and each criterion can be calculated. So far, the workflow simulation system prepares only fixed criteria so that it is impossible to calculate other kinds of criteria. Therefore, users can't obtain special criteria, for example "the average working quantity of each worker", which users desire for BPR. On the other hand, although the generalized simulation system can calculate all kinds of criteria, users must learn to master this new tool for simulation and develop the module of a workflow model. Therefore, a great deal of users' labor is necessary.

The purpose of this paper is to propose a simulation system which enables the modeling of a business process by the workflow model and to output optional data for BPR with minimal setup. It has been developed with Microsoft Visual C++. In a workflow simulation, work items are transfered to a node. In order to calculate the optional criteria, it is necessary to add properties to work items and nodes, and to exchange the variables with the program which calculates their values. Moreover, it is taken into consideration that the program is developed independently of the simulation system with the language which users are familiar with. These two functions, which are "the function of adding optional properties to a node or work item" and "the function of calling an external program out of the system", are introduced.

The function of adding optional properties to a node or work item: Nodes and work items can have list type data which consist of "the name of the property" and "the type of the property", in order to calculate optional criteria for BPR. Users can access this

list type data through the GUI of the system and input optional properties easily. "The name of the property" is entered through the keyboard, and "the type of the property" is selected from three types, which are "integer type", "real type" and "string type". Finally, pushing the add button with the mouse attaches the optional property to nodes or work items.

The function of calling an external program out of the system: In order to call up an external program prepared by users and to transfer values of arguments and functions between the system and external program, the system uses the function "ShellExecute", supported by Microsoft Visual C++. The external program generates calculation results as a text file. The system takes calculation results from the file and substitutes a value for the specified property. Users must develop the external programs whose input and output are described in the specified format. The external program is put in the registered folder. In the customization window for calling up a program provided by the system, users can select a program from the list of programs in the folder, and select arguments and return values from the list which show properties added by users themselves.

This system has the default outputs, "work item's arrival and departure time in each node", "jams of work items in each node in temporal order" and "the average of turn-around time" without special setup.

The following example is applied to the simulation with the proposed system. Let us suppose the new criterion "the average working quantity of each worker". The working quantity means each worker's working quantity and is decided by the level of work, which is a property of a work item. In order to calculate "the average working quantity", the following are customized in addition to the definition of the business process.

- addition of the property "the level of work" to a work item
- coding the external program which decides the value of "the level of work", and linking between the start node and the external program
- coding two programs(one decides the working quantity, the other calculates the average of the working quantity), and linking between each activity node and these programs.

Just adding the above setup enables the calculation of optional criteria for BPR.

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A Genetic Algorithm Based Method with Tournament Selection for Constrained Multicriterion Optimization Problems

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Keywords: Multicriterion Optimization, Genetic Algorithm, Tournament Selection

Several Genetic Algorithm (GA) based methods for solving multicriteria optimization problems have been developed recently (see review paper by Fonseca & Fleming, 1995). Most of these methods use the fitness function to evaluate the population for the next generation. For highly constained optimization problems the use of the fitness function causes some difficulties in selecting the solutions for next generations. In this paper a new method for solving multicriteria constrained optimization problems is presented. The method uses the tournament selection mechanisms which do not require evaluation of fitness values in order to create a new population of chromosomes for the next generation.

To solve multicriteria optimization models the Pareto set distribution method (see Osyczka & Tamura, 1996) is applied. The general idea of this method is as follows. Within each new generation a set of Pareto optimal solutions is found on the basis of two sets: the set of Pareto solutions from a previous generation and the set of solutions created by GA operations within the considered generation. The new set of Pareto solutions thus created, is distributed randomly to the next generation for half of the population. The remaining half of the population is bred by randomly generated new strings.

The tournament selection method used together with this Pareto set distribution method can be briefly described as follows:

- if both chromosomes represent infeasible solutions the one which has better feasibility, i.e., the one for which constraints are less violated, is taken to the next generation.
- if one chromosome represents a feasible solution and another one an infeasible solution, this one which is feasible is compared with the existing set of Pareto optimal solutions. Only for the feasible solution the values of the objective functions are calculated.
- finally if both chromosomes represent feasible solutions, the objective functions are calculated for both solutions and both are compared with the existing set of Pareto optimal solutions.

The comparison of the existing set of Pareto optimal solution with the feasible solution means that the latter can fall in any of three categories: (i) It is a new Pareto solution which dominates some or at least one from set of Pareto solutions found so far. In this case dominated solutions are removed from the set and the new Pareto solution is added to the set. (ii) Although it is a new Pareto solution, it does not dominate any of the existing Pareto solutions. In this case the new solution is added to the set. (iii) It is not a new Pareto solution, thus there is no change in the set of Pareto solutions.

Note that using this method the objective functions are calculated only for feasible solutions. This makes the process of calculations more effective especially for problems for which the objective functions are computationally expensive functions.

The method is mainly aimed to solve design optimization problems. Two examples of such problems are discussed in the paper. The first example deals with designing a beam with the criteria: the volume of the beam and the static displacement at the end of the beam. The

second example describes a robot gripper optimization model in which the criteria are: the difference between maximum and minimum gripping forces for the assumed range of gripper ends displacement and the force transmission ratio. For this example both objective functions are the computationally expensive functions because for the given vector of decision variables their values are evaluated using special procedures. Both examples show the effectiveness of the proposed method.

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Ensemble Modeling for Complex Perceptions

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Keywords: Shinayakana systems approach, fuzzy data analysis

The shinayakana systems approach proposed by Sawaragi takes into account the limitation of our ability to objectify the real world, the limitation of our ability to understand indirect observation, and the limitation of our ability to analyze things objectively. Therefore, in addition to the utilization of accumulated knowledge, it makes good use of human beings as much as possible. The main task of the shinayakana systems approach is to develop an environment of modeling and thinking support to enhance the human abilities.

Sawaragi's systems thinking in complex systems analysis emphasizes the role of participation of relevant people in modeling and decision-making. This requires the development of soft mathematical techniques to deal with fluctuation between complex perceptions of people, since human evaluation for complex systems varies depending on circumstances as well as value judgment.

A set of qualitative data obtained by subjective evaluation of an object usually has a large variance reflecting tastes and preferences of individuals. The data structure usually comprises three phases in subjective evaluation. They are objects of evaluation, people to evaluate objects, and measures that are quite often words, mainly adjectives. For instance, in the semantic differential technique, the pairs of adjectives are prepared as measures of evaluation, and the subjects are asked to mark a level between each pair of adjectives by watching the prepared objects.

The traditional statistical techniques, including factor analysis and quantifying method, can be applied to identify interrelations between adjectives, and relations between adjectives and design elements. But, these statistical methods neglect important aspects of subjective data, such as non-linearity and non-additivity of relations, or vagueness and ambiguity of words.

The fuzzy-sets theory has been applied to multivariate data analysis, and nowadays, fuzzy data analysis is widely used in various fields. The possibilistic regression analysis is one of the most successful applications of fuzzy concept and fuzzy logic. There are also many research activities to apply fuzzy-sets theory to other areas in multivariate data analysis.

However, there is still room for consideration in defining fuzzy sets based on the given data set and in applying the extension principle to modeling of aggregating functions. In multivariate data analysis, the squares of original variables often have an essential role. Operation of fuzzy numbers sometimes leads a result incompatible with our intuition when membership functions are defined on the original variables.

In applying the fuzzy logic to multivariate data analysis, the explosion of vagueness easily occurs when aggregating plural variables. An explanation that the resulted vagueness shows a possibility of future is understandable, but, on the other hand, a decision-making becomes difficult. The defuzzification like in fuzzy control is not always acceptable in decision-making.

In this presentation an ensemble modeling technique is proposed, which, at the same time, preserves the positions of individual opinions in the model parameter space. First, an average multivariate model is identified, then by a data mapping technique, the individual data is mapped into the parameter space of the multivariate model. This mapping preserves the relative positions of individuals in data in some sense. After data mapping, membership functions are determined in the parameter space.

For example, a fuzzy factor loading is defined as a fuzzy number in the factor space through the data mapping technique, that is, words are identified as fuzzy objects in the factor space. In a linear regression model, the regression parameters are determined as a fuzzy vector whose center corresponds to the ordinary regression parameter vector identified by using the average data.

A notable fact of this approach is to express the positions of individuals in the parameter space of multivariate models, preserving the relative positions in the original data space. The idea is applied to factor analysis and quantifying method, and in the latter application membership functions are identified for forward and backward inferences.

This soft data analysis is useful when the information of average and individual difference is both required. Such cases are often encountered in decision-making of complex social problems.

Technological Risk and the Management of Uncertainty: The Role of Decision Analytic Modelling

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Keywords: Decision analysis, risk management, precaution, ambiguity, uncertainty

In this paper, we consider the use of decision analytic modelling as a vehicle for supporting the management of technological risks, with an emphasis on settings where the application of the precautionary principle seems warranted. We also clarify related concepts - such as resilience, adaptability and flexibility - and argue that in the absence of scientific evidence, it may be appropriate to conduct the analysis at the level of strategic qualitative factors of this kind. The key conclusion from this paper is that decision analytic models hold considerable potential, as their construction 1) enforces a systematic appraisal of the risks involved and 2) communicates the implications of incomplete knowledge about scientific facts or the stakeholders' value concerns. This notwithstanding, these models are subject to the same fundamental limitations that apply to any formal modelling endeavour in the presence of considerable uncertainties.

Dynamic Model Construction for Naturalistic Decision Making

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Keywords: naturalistic decision making, interface agent, decision analysis

The introduction of complex and powerful automation to a variety of high-tempo high-risk domains has led to unexpected difficulties which are the result of an increased need for, but lack of support of, human-machine communication and coordination[12]. That is, new computerized and automated devices create new burdens and complexities for the individuals and teams of practitioners responsible for operating and managing high-consequence systems. Wherein, cognitive behaviors and strong affective elements come into play, and unanticipated interactions between the automated system, the human operator and other system in the workplace begin to emerge, causing serious deficiencies that can become apparent after system is delivered and is put to work.

So far many researchers have pointed out such brittleness of automation systems, and to tackle with these automation-induced problems, a concept of *human-centered automation design* has been launched. The ability to accept responsibility and to find innovative ways to fulfill these responsibilities is a unique human characteristic. Herein the design philosophy is "people are in charge" or "human-in-the-loop". The key question is then how to design an artifact system in which a human and an automated system can coexist and collaborate with one another.

In this paper, we investigate into an architecture of an *interface agent*, which is a semi-intelligent computer programs that can learn by continuously "looking over the shoulder" of the user as he/she is performing actions against some complex artifacts and is expected to be capable of providing the users with adaptive aiding as well as of alternating the activities instead of a human [4], [5]. In this sense, an agent has to coexist with a human user so that it can evolve by itself as a human user's proficient level improves and can stimulate a human user's creativeness coordinately by changing its role dynamically as a human's associate, rather than to replace the human user with itself.

As for an design principle of such an agent, we introduce a currently emerging view on the decision making. This is a shift from a *classical normative decision making paradigm* toward a *naturalistic decision making paradigm*. The latter has concentrated increasingly on the proficient experts' situation assessment ability and their ways of looking at a situation and quickly interpreting it using their highly organized base of relevant knowledge. That is, these are abilities to recognize and appropriately classify a situation. We call this style of decision making as a *recognition-primed decision (RPD)* model after Klein [3]. The distinguishing feature of the RPD model from classical decision models is to attempt to describe how people bring their experience to bear on a decision and how they are able to continually prepared to initiate workable, timely, and cost effective actions. Especially we are interested in modeling their capability to act proficiently under severe time pressure (i.e., under emergency); to identify the situation quickly and accurately and to act promptly with less time and effort to act.

The important aspect of the above naturalistic decision making is to identify a decision modeler (i.e., a decision model developer) with a problem solver (i.e., a user of the model). This is quite essential departure from the conventional decision analysis. The decision maker, who

is an actor, has to manage all of the following activities by himself/herself; situation awareness (i.e., being aware of what is the problem), framing and developing a decision model to solve the problem, solving the model to find the solution, and executing the solution. Usually, these activities are not always performed sequentially, but continuous efforts for modifying (and/or sometimes abandoning) and evaluating/validating a current model and evaluating are required. In a word, an agent has to manage its own activity of "modeling life-cycle". Since these activities should be done within a single resource-bounded agent under severe time pressure, an ability of managing these multiple activities is essential to guarantee an agent's performance.

In this talk, we investigate into a recognition-primed decision model of an interface agent, that is embedded inside the human-artifact interactions and has to work as an intelligent associate for a human user/operator in a time- critical situation like at an emergency. We first construct a general probabilistic reasoning model (i.e., an *influence diagram* [1]) as an agent's decision model that derives an appropriate operation inferring the most plausible plant anomaly type by getting partially observable symptoms from evidential observations obtained so far. Then, we extend this normative model to a naturalistic decision making model by investigating into the following issues [7],[8],[9],[10],[11], [13];

- how to link prior experiences to an activity of decision framing
- how to determine an appropriate granularity of the model
- how to validate an activity of decision analysis per se.

In the symposium, formulation of the above agent's decision making activities as well as its application to an agent that intervenes between the machine autonomy (i.e., an autonomous mobile robot) and a human operator and coordinates their tasks are presented.

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Good Modelling Practice

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Keywords: simulation modelling process, modelling life-cycle, quality- assessment, evaluation of modelling products

Introduction

Modeling and simulation is nowadays a standard tool in the toolbox of many workers in the different fields of applied sciences. In The Netherlands several hundreds of modelers are involved in modelling for water management. But modelling might be a routinely applied method to investigate problems, it is not straightforward, but rather subjective, depending on the modelling team and its skills. Therefore one often refers to it as to the 'art of modelling'. This artistic and creative label sounds as a positive designation, but it stresses the unscientific and ambiguous aspects of modelling.

The major risks of modelling are related to the many choices that have to be made, the complexity of the problem and the object system at hand, often inadequately supported by an incomplete and controversial theoretical body of knowledge. This results in many uncertainties in the model and in its results.

Recently several newspaper articles discuss the arbitrariness of making policy based on models without a proper reference to and quantification of uncertainties involved. Most scientists engaged in modelling and simulation are aware of these problems and many initiatives have been developed to improve the quality of models and modelling. The approach discussed in this paper is one of the most comprehensive examples.

Quality improvement

In software engineering quality management is quite common practice, but in the field of modelling and simulation it is often restricted to verification and validation issues. Scholten & Udink ten Cate (1999) have proposed a Simulation Maturity Model (SMM), comparable to Humprey's Capability Maturity Model (CMM), which was developed to improve software engineering (Humphrey, 1989). Just like CMM SMM discerns five stages of maturity: ad hoc, repeatable, defined, managed and optimized. In this study the definition stage is the most essential stage, as defining the simulation modelling process promotes the repeatability of the SMP and allows an efficient and effective audit. The definition stage of SMM has been used as backbone of a Handbook Good Modelling Practice, in which the SMP and its products have been defined. This GMP approach has to be accompanied by normal software engineering quality assurance efforts, but at present most of these efforts are based on the ISO-9xxx paradigm, which allows a (too) flexible implementation and does not guarantee anything at the level of GMP and its products.

Towards a Handbook Good Modelling Practice

Many authors have proposed schemes to define the simulation modelling process (SMP). of which several divide the process in activities to build or test intermediate products of the SMP. Most of these schemes lack approval of a large group of modelers. In the last decade the 'Dutch Polder Model', which is based on negotiation and consensus, has realized significant improvements in the Dutch economic situation. Similar to this approach a Handbook Good Modelling Practice has been written, based on the cross-fertilization within the multi-disciplinary project team, an active supervising committee, the strong commitment of the participants in a workshop and, finally, on the efforts of two series of 'field testers' (users, not involved in developing the product).

The Handbook GMP should represent a self-explaining document to support the entire procedure of the SMP. It consists of a clear demarcation of the types and domains of models for which it is intended, a glossary of all concepts, a structured ontology of the SMP, a checklist and summary, a tool to document and archive the many steps and tests in the SMP, the collective experience of large group of modelers on pitfalls and sensitivities in general and for specific modelling domains and finally references to specific literature and addenda on specific problems. The major payoff of developing such a Handbook is its ontology of shared and approved 'simulation and modelling concepts'. The consensus on the shared views on modelling and simulation was a surprise for many of the modelers in the field of water management.

The Handbook will not be a static document, but it will be updated every 6 to 12 months and additional tools will be developed to support its use.

Results

The result of this research project is a Handbook, which is a reflection of the shared views of inexperienced and experienced modelers in all domains of water management and of modelling and simulation specialists. The backbone of the Handbook is the structured ontology, which has been developed by decomposition of the SMP. At the highest level the steps are: (1) starting with a logbook, (2) defining the modelling project, (3) building the model, (4) analyzing the model, (5) using the model, (6) interpreting the results, and (7) reporting and archiving. Some of these steps are further decomposed to a level of a single modelling activity (e.g. determine for which factors the model is most sensitive or check if all model objectives are met). It includes also a series of tests without prescribing with which methods or with which algorithms these tests have to be carried out. These tests comprise of conceptual model validation, some aspects of verification (dimension check, mass or energy balance control), a robustness test, a sensitivity analysis, a calibration, a (historical data) validation, and an uncertainty analysis. In this way the handbook supports all activities related to modelling and simulation and it improves the credibility of the model (with the tests).

The Handbook contains a series of fill-in forms, which facilitate keeping records of the SMP in a logbook. These forms have a 1:1 relationship with the steps in which the SMP is decomposed. In this way it supports a proper handling of the SMP, both for experienced and inexperienced modelers.

The Handbook contains also a shortlist of many commonly made general pitfalls and sensitivities, as well as a list of specific problems with models in the 15 domains of water management (groundwater quality and quantity models, hydrodynamic models, ecological models, etc.).

The appropriateness of the Handbook GMP itself (thus not a model of the SMP) was tested in four ways: a test by a group of experienced modelers, a test by a group of inexperienced modelers, a supervising committee, existing of specialists in the filed of modelling and simulation and finally by the 50 participants of a GMP-workshop. The results of these tests of the handbook were promising and further improvements of the Handbook were based in these results.

A summarizing figure of the SMP definition can be found on `http://www.info.wau.nl/research%20projects/gmp-fig.htm` and the details are given by the handbook (Van Waveren

et al., 1999).

Discussion

There does not exist a simple or universal solution to all modelling and simulation problems, but this Handbook is a tool to increase model quality and the repeatability or better reconstructability of the simulation and modelling process.

Our approach (van Waveren et al., 1999) has drawn attention of many organizations involved in modelling and simulation (e.g. the USA governmental Environmental Protection Agency), despite the Handbook is in Dutch uptil now (an English translation will be published later this year). The major addition planned is a tool to facilitate the record keeping part in a smart way.

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Negotiation Analysis for Constructing Conflict Solving

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Keywords: Negotiation analysis, Constructive conflict, Negotiation curve

Negotiation analysis is emerging for presenting the method to manage the conflict of interest among parties and has been studied by many authors including T. C. Shelling (1960), H. Raiffa (1982), D. A. Lax and J. K. Sebenius (1986), J. L. Mumpower (1991), Sebenius (1992). Although this approach comes from decision analysis and game theory, that is more than those for the fields to be treated and the problem structures to be solved. On the other hand, the concept of the "constructive conflict" has been raised in the field of organization theory and its importance newly is attracting much attention. This paper presents on Paretian approach and its extension a more analytical discussion for treating the constructive conflict solving.

Negotiations generally include the internal value conflict within parties between the competition for claiming individual values by no agreement and the cooperation for creating new values by forming an agreement. We discuss this problem on the utility frontier over the zone of possible agreements, which is assumed to be changeable and also present the processes to search the compromised point where the joint distribution of the negotiators' utility values will be determined. In this context, we assume the negotiators neither to be strident antagonists, nor fully cooperative partners, but to be the "cooperative antagonists," in Raiffa's sense.

We further discuss the utility function for the eligible negotiators from which the utility frontier will be derived and enlarged. The cases for alternative negotiation types are illustrated on a kind of the contract curve, which is called the negotiation curve. It will be pointed that the evolution processes of the perception of the negotiators will vary thorough the value tradeoffs between claming values and creating values the feasible zone of possible agreement and often enlarge it. Thus the utility frontier of both parties will be changed; it leads to the final agreement.

Internal organizational conflicts among groups within each party also are discussed and the internal conflict solving processes are examined in a hierarchical conflict solving.

The way to NSS (Negotiation Support Systems) also is discussed on the probability assessment for possible utility gains.

Multiobjective Combinatorial Optimization for Complex Systems Modeling – Meta-Heuristic Satisficing Tradeoff Method

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Keywords: multiobjective combinatorial optimization, meta-heuristic approach, satisficing tradeoff method, flowshop scheduling

Performance evaluation is usually to be done under multiple objectives in advanced complex systems. Furthermore, in production scheduling, performance evaluation is to be done under combinatorial optimization. Since combinatorial optimization problems are usually NP-hard or sometimes NP-complete, an optimal solution or even a suboptimal solution is hard to find even for a single-objective problem. Therefore, nobody has tried rigorously to solve multiobjective combinatorial optimization problems.

In this presentation an effective meta-heuristic approach is proposed to realize a satisficing tradeoff method for solving multiobjective combinatorial optimization problems. Firstly, Pareto optimal solutions (individuals) are generated by using a genetic algorithm with family elitist concept for a multiobjective combinatorial optimization problem. Then, we try to find a preferred solution of the decision maker based on the satisficing tradeoff method. Usually, a conventional satisficing tradeoff method needs to solve a complex min-max problem in each iteration of the algorithm for a given aspiration level of each objective function. The min-max problem is to minimize maximum value of a regularized regret function. It is time consuming to solve this min-max problem for a given aspiration level of each objective function. In this presentation a new meta-heuristic satisficing tradeoff method is proposed in which we do not need to solve a complex min-max problem in each iteration, but we try to find a min-max solution in the Pareto optimal solutions (individuals) generated by the genetic algorithm. We further revise the min-max solution by using a local search approach such as a simulated annealing method.

As a numerical example of a multiobjective combinatorial optimization problem a flowshop scheduling problem is included to verify the effectiveness of the method proposed in this presentation. In this problem we try to solve 4-objective combinatorial optimization problem. The flowshop has two cascade processes; Process A and Process B. Process A contains two parallel machines; Machine 1 and Machine 2. Process B contains only one machine; Machine 3. There exists no buffer between Process A and Process B. It is necessary to change the set-up for Process A if we need to process different kind of products consecutively. There exist constraints of absolute ordering for semi-products that pass through Process A. There exist constraints of number of semi-products processed in succession at Process B with heavy duty.

Four objectives taken into account are as follows:

1) Minimize the overall processing time
2) Minimize the number of set-ups at Process A
3) Minimize the sum of the change rate of size of semi-products
4) Minimize the penalty for violating the constraints of number of semi-products processed at Process B with heavy duty

Genetic algorithm could generate Pareto optimal individuals taking into account the four objectives described above. For realizing the satisficing tradeoff method the decision maker on this performance evaluation is asked to show ideal value and the worst value for each objective function. In each iteration of the tradeoff analysis the decision maker is asked to show the aspiration level for each objective function. We use Pareto optimal individuals as candidates of the solution for the min-max problem. Since the genetic algorithm with family elitist concept could generate Pareto optimal individuals taken from the wide area of the multiobjective function space, we could expect to find high quality solution by chosing the min-max solution from Pareto optimal individuals generated by the genetic algorithm. Starting from the min-max solution obtained we further try to revise the solution by a local search method such as simulated annealing.

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From Multichoice Cooperative Games to Fuzzy Cooperative Games

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Keywords: cooperative games, multichoice games, fuzzy games, core, Shapley value

Let $N = \{1, 2, \ldots, n\}$ be the set of n players. A classical cooperative n-person game in characteristic function form (with side payments) is specified by a function $v : 2^N \to \mathbf{R}$ with $v(\emptyset) = 0$. In this game each player is assumed either to participate completely in a coalition or not to join in it at all. In other words, his activity level at which he can choose to play is constrained in the set $\{0, 1\}$, where 0 denotes no activity and 1 denotes full activity. Thus the characteristic function of the classical cooperative game can also be defined by $v : \{0, 1\}^n \to \mathbf{R}$. Player i's payoff x_i denotes the value which will be allocated to him when the grand coalition is formed (and of course he contributes to it). Therefore, the whole payoff vector of this game is a simple n-dimensional real vector and several ideas of determining a reasonable payoff vector as a final allocation of what the whole group obtained have been proposed in cooperative game theory (Owen (1995)). Two representative solution concepts among them are the core and the Shapley value. The former is the set of the payoff vectors which satisfy the effciency (group rationality) and the coalitional rationality, and the latter is characterized by some axioms (group rationality, symmetry, dummy player and additivity).

If we allow each player to have a certain number of activity levels, the reward that a group of players can obtain depends on the effort of the cooperative players. We denote the set of player i's activity levels by $M_i = \{0, 1, 2, \ldots, m_i\}$ and a coalition with activity levels by an n-dimensional vector $s = (s_1, \ldots, s_n) \in M := \prod_{i=1}^n M_i$. In this case the characteristic function is defined by $v : M \to \mathbf{R}$ and this game is called a multichoice cooperative game. We should note that a multichoice game is a classical coalitional form game when $m_i = 1$ for all $i \in N$. For this game, player i's payoff is not a single real value, but a vector because it depends on his activity levels. Hsiao and Raghavan (1993) defined the Shapley value for this type of multichoice game. The Shapley value is also based on the four axioms similar to the case of classical Shapley value. On the other hand, Nouweland et al. (1995) extended some solution concepts including the notion of core to multichoice games. The core is defined through extentions of effciency and coalitional rationality. In their analysis, player i's payoff is assumed to depend only on his own activity level but not on the other players' activity levels. Namely they considered solution payoff functions ϕ_i which depends on his activity level s_i, i.e., $\phi_i : N \times M_i \setminus \{0\} \to \mathbf{R}$ $(i \in N)$. However, this is unnatural in some sense and it might be better to consider a solution function which depends on the whole coalition vector s, i.e., $\phi_i : M \to \mathbf{R}$.

In a multichoice game, each activity level of a player is considered to be a degree of his participation in a coalition and therefore a value in the interval $[0, 1]$. Though the number of these values (i.e. activity levels) is finite in a multichoice game, we may assume that each player can take an arbitrary value between 0 and 1. Thus we have arrived at an activitity level vector in $[0, 1]^n$, which was identified with a fuzzy coalition introduced by Aubin (1974, 1979). If a function $v : [0, 1]^n \to \mathbf{R}$ is defined, it is called a characteristic function and specifies a fuzzy

cooperative game. Since m-dimensional vector can be identified with a step function which varies its value at m different points, a multichoice game is regarded as a special case of a fuzzy game.

In a fuzzy cooperative game each fuzzy coalition l is an element in $[0,1]^n$ and a payoff is represented by a function $x : N \times [0,1]^n \to \mathbf{R}$. Namely when player i's activity level is $l_i \in [0,1]$, his payoff is given by $x_i(l)$. Though the history of the fuzzy cooperative game is longer than twenty years, the study of solution concepts is not necessarily sufficient. For example, Butnariu (1980) proposed Shapley value for a class of fuzzy games. However, his class of games is quite unnatural and the definition of the Shapley value itself is not sufficient. As was noted above, a multichoice game is a special case of a fuzzy game and hence the core and the Shapley value should be extended naturally from those in multichoice games.

In this paper we will povide definitions of the core and the Shapley value which depend on the whole activity levels for multichoice games. We will extend them to a class of fuzzy games with the help of the concept of Choquet integral. We will also discuss several properties of these solution concepts.

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Fuzzy Set Approach to Scheduling and Sequencing under Uncertainty

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Keywords: Sequencing, Scheduling, Fuzzy due dates, Fuzzy processing times, Fuzzy precedence

The early theoretical models of practical scheduling and sequencing problems were motivated by needs of decision-making processes in manufacturing and service industries. Similar problems arise quite naturally in other areas, and several recent directions of research have been stimulated by scheduling problems in computer and communication systems.

Most theoretical research has focused on the analysis and solution methods of deterministic problems. As a rule, these problems have the form of the following optimization problem: Given a finite number of jobs to be processed by a finite number of machines, find a schedule that minimizes the value of a given objective function subject to given technological and capacity constraints. The variety of machine environments, job attributes and objective functions is extremely broad, and terminology may vary from situation to situation. For a detailed overview of deterministic sequencing and scheduling, see Lawler, Lenstra, Rinnooy Kan, and Shmoys (1993).

The assumption of the standard deterministic models that all problem data are exact and known in advance is often not justified in practice. Since the early days of scheduling theory, various types of models based on the classical probability theory have been used to deal with scheduling problems involving uncertain or imprecise data. Nowadays stochastic scheduling and strongly related queuing theory are well established research areas with many applications. For a survey of stochastic scheduling, see Righter (1994).

Scheduling models based on probability theory were considered the only sensible models of problems involving uncertain data. Over the past decades, developments in fuzzy set theory and fuzzy logic have provided evidence that uncertainty or imprecision can be modeled also by means of fuzzy sets.

After recalling basic models of deterministic and stochastic machine scheduling, we present major concepts, ideas and recent developments of sequencing and scheduling under fuzziness. We shall primarily focus on problems involving fuzzy due dates, fuzzy processing times, fuzzy precedence relation, or a combination of these fuzzy input data. The resulting problems are special structured problems of fuzzy combinatorial optimization. The complexity and solution methods for typical single-operation and multiple-operation problems are also discussed.

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Combinatorial batching problems

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Keywords: on-line planning, batching problems, combinatorial optimisation

In a combinatorial batching problem a queue of objects must be chopped into batches which are subsequently handled as independent instances of an underlying combinatorial optimisation problem. We study combinatorial batching problems for which the cost structure consists of a start-up cost for each batch, holding costs for each batch-object, and the costs related to the instances of the underlying combinatorial optimisation problem.

We present some examples of on-line combinatorial batching problems like a bin-packing problem.

For on-line combinatorial batching problems, we propose a novel solution approach, based on statistical learning. In order to generate learning examples, we need (partial) solutions to infinite-horizon off-line combinatorial batching problems. We show that these solutions may be obtained with the use of a forward algorithm that solves a sequence of finite-horizon off-line combinatorial batching problems using a dynamic programming formulation.

For the purpose of comparison we also discuss some more traditional approaches, such as taking a fixed batch-size, some simple forecasting methods, least cost per unit of time or per object, and optimising over a fixed (finite) horizon. We present an empirical performance analysis of these approaches using a heuristic to solve the underlying (NP-hard) combinatorial problem. The conclusion is that the approach based on statistical learning outperforms all traditional approaches. This is particularly true if the arrival process has internal dependencies.

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