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Database, computer assisted modelling, nonlinear, integer fuzzy programming problems, analysis.

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This fourth report provides a summary outline of (a) the current status of the work, (b) the set of investigations underway, and (c) future research plans.

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1. Scientific Work

(a) Revision of CAMPS specification and manual
CAMPS system is our main vehicle for investigation. Our recent studies (see below) and experiments with modelling environments have led us to revise some of our original research ideas, method of implementation and research goals. We have accordingly modified our implementation strategy and we are updating the CAMPS manual.

(b) Specification of a new user interface
Our earlier study into relational databases and table manipulation methods have led us to define new ways of capturing and presenting model data. We also defined a stand alone hierarchical menu based user interface for model specification. This is extremely intensive in terms of low level programming. We have now identified a parallel development within frame representations (as structured objects) in knowledge based systems. Thus we have established a better vehicle for model representation and manipulation. A revised user interface is under preparation.

(c) Logic programming for reformulation support
We have carefully studied the work of Williams & McKinnon [1], Jeroslow [2] and examined these against the context of our own work [3.]. We believe the Prolog based predicate logic approach [1] is very attractive and fits in naturally with the KBS implementation stratgey introduced in (b) above; also see next section. We have prepared a preliminary report on this topic (see enclosure (i)).

2. Research Plans

(a) The research plans have remained overall the same, however, based on our findings in 1(b), (c) above we will explore the scope power and applicability of a few KBS shells [4], [5], [6], [7]. We are also interested to explore the related work in *Knowledge Management* Systems [8] reported recently.
(b) We will also investigate how predicate calculus based method can be integrated within our modelling framework. This will be used to support mixed integer programming reformulation strategy.

3. Administrative change

None

4. Other Information

We are preparing for workshops explaining the use of CAMPS to be presented at:
(a) The NAG workshop on optimisationmodelling, June 1988, University of London Computer Centre, London.
(b) EURO-TIMS Conference, July 1988, University of Paris-Dauphine, Paris.

We are under contract to complete a book on Computer Assisted Modelling, which covers the main theme of our research. The contract is with Academic Press.

5. Financial annex

See attached.

ENCLOSURES: (i) Integration of Optimisation Models for Planning and Knowledge Based Systems (ii) NAG workshop (June) slides.

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Enclosure (i)

Integration of Optimisation Models for Planning in Knowledge Based Systems

1. Background

During the fifties and sixties the early days of development of computer science and management science, these two disciplines evolved closely. Packages and software for management applications were seen to be an important area of research and development for specialists in computer applications. Subsequently OR scientists moved towards algorithmic refinements and mathematical theories whereas equally important issues of productivity, implementation and acceptance fell into neglect.

In the late eighties again we have seen a convergence of ideas and a breaking down of the barriers between different and sometimes competing disciplines. Scientists with different backgrounds are participating in multi-disciplinary developments. The major contributions have come primarily from two groups: the information processing and the mathematical modelling specialists.

Mathematical and computer models for decision making have developed independently of each other for some time. In spite of the early promise of mathematical programming (optimisation models) as an all embracing modelling tool, it has sadly proven to be inadequate in practice. This is because the methodology of solving models has progressed far more rapidly than that of formulating them. It takes too long to build, verify and document a (mathematical programming) model.

Over the last ten years researchers in artificial intelligence have made far reaching impact on methods for problem solving. The new perspectives which have been brought about by artificial intelligence can be summarised as follows.

(a) Introduction of the idea that knowledge should be represented in information processing systems. This is because knowledge (experience of an expert) plays a key role in problem solving.

(b) Development of reasoning mechanisms and methods of manipulating knowledge and making inference.

(c) Introduction of explanation procedures combined with natural language (and other) interface facility.

Management scientists who specialise in quantitative models have found that it is possible to introduce ideas from expert systems into mathematical methods. For instance predicate calculus and logic programming can be used to construct (discrete) mathematical programming as well as interactive multi-criteria decision models. The structure and solution of mathematical models can also be interpreted to the problem owner using a reasoning mechanism and assuming an advice giving role. Thus it is possible to combine ideas from these two disciplines. Some research workers in the UK and USA have also investigated ways of combining and augmenting these methodologies: We note that the use of predicate calculus to generate equivalent mathematical programs for logic programming models have been studied by Williams [1] and Jeroslow [2]. Greenberg [3] has over the years developed discourse models which can make advice giving mathematical models a reality.

2. Leading Issues

Brodie et al [4], Sowa [5] and Geoffrion [6], in different ways, have looked into the central problem which is to unify (or at least not compartmentalise) alternative approaches to knowledge representation. Whereas the OR specialists are happy to use mathematics as the vehicle to represent and solve models the AI community have been more concerned with the question of elicitating, representing and manipulating knowledge. The major motivation for this considerable intellectual commitment comes from the belief that knowledge representation is the fundamental problem of modelling and knowledge itself is no less than a model of models. The arguments set out here are closely related to Sowa's work [5]. After a long series of investigation Sowa has presented a framework which unifies the alternative knowledge representation methods.

Brodie et al investigated the scope of unifying AI methods, database techniques, high level programming languages into a single scheme of knowledge representation. Geoffrion has proposed a "structured modelling framework" which captures the above three and adds to it mathematical modelling.

The major conclusions which emerge from these studies are that models are not used only for inference and decision making. They play a far broader descriptive and explanatory role. Thus the issue is to not only construct the model but also to have the capability of explaining it.

3. Present Gaps

We see a number of gaps in the development of intelligent knowledge based systems when applied to quantitative decision problems.

The developments of such powerful advice giving decision support (expert) systems unfortunately have taken place almost independent of successful mathematical methods. There are thus weaknesses in (entirely) knowledge based approaches to problem solving. For many planning problems the mathematical model based approach works much more efficiently and successfully than the knowledge based systems, as the former utilises well established computational algorithms. The well known examples of these techniques are linear and non-linear programming, and graph theory based methods. Indeed model representation by these methods may be looked upon as a kind of knowledge representation.

On the other hand there are many instances of widespread and well founded applications of linear programming and network models. Yet these have not been graduated to a high level whereby these are used to not only compute solutions, but also to provide further support such as problem documentation, diagnostic explanation of inference steps and so on.

There is a comparable gap in the direct quantitative modelling approach. More often these are entirely number based. Thus graphical, pictorial and logical relationships of the model components are not easily communicated. Yet the wealth of information in diverse form can be captured using structured objects, and semantic networks. These possibilities have not been explored at all in the contexts of optimisation modelling. Matrix generators and solution analysers for the latter have widespread applications. Yet these are very simple earlier generation data driven computer programs [7], or very primitive procedural languages designed for this purpose [8].

4. Revised Method of Investigation

We have at our disposal a range of modelling tools covering fuzzy linear programming, linear and integer programming optimisers [10], [11], [12]. We have reviewed the current state of research and relative positioning of a few leading decision techniques [13, 14]. We wish to investigate and find out about knowledge representation and manipulation methods which employ structured objects [4], conceptual graphs [5] and logic programming [9]. We will then adopt a modern expert system shell which supports some or all of these forms of knowledge representation. An outline specification for integrating model generator and model solvers within the shell will be prepared.

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NUMERICAL ALGORITHMS GROUP

Enclosure (ii)

NAG Workshop on Optimisation Tools

Date: 23 June 1988 Venue: University of London Computer Centre

Software systems for the solution of optimisation problems are being used in an ever-widening range of industrial, scientific and commercial applications. The theme of this NAG workshop is the provision of several such systems, each of which offers distinctive problem-solving facilities. You are invited to attend the workshop to learn more about these systems and to participate in discussions about longer term developments. Attendance at the workshop is limited so, in order to book your place, please complete and return the tear-off reply form as soon as possible.

Speakers at the workshop will include:

Professor Harvey Greenberg	(University of Colorado)
Dr. David Sayers	(NAG Limited)
Dr. Cormac Lucas	(Brunel University)
Dr. Mehrdad Tamiz	(Brunel University)
Professor Gautam Mitra	(Brunel University)

The scope and application of the following software systems will be discussed in the workshop:

ANALYZE... This is a system for analysing LP models prior to optimization. The system also supports discourse with the problem owner who wishes to browse through the solution and request the system to provide various explanations about the model.

CAMPS... The system is designed to support construction, investigation and analysis of linear, integer and nonlinear (special ordered set) programming models. A number of model management functions covering data tables, generated models, output solutions, analysis reports, model documentation, are also supported by CAMPS. FORTLP linear and integer programming system is used as the optimisation module within CAMPS to process the generated models.

FORTLP... This is a linear programming system with integer and other nonlinear programming capabilities. It can be installed and run as an integrated optimiser or it may be used as a modular suite of subroutines. The system expliots super sparse data structures and dynamic storage management techniques. FORTLP is designed to be main memory resident and provides efficient and robust performance on 16-bit micros, minis and large main frames.

Facilities in the NAG Fortran Library

The extensive facilities in the NAG Fortran Library for handling linear and nonlinear optimisation problems will be described. Routines are available for a wide variety of cases from solving sets of simultaneous linear equations to nonlinear constrained optimisation.

NAG Workshop on Optimisation Tools Reply Form

I wish to attend the above workshop on 23 June 1988. Please find enclosed a cheque for £20.00, payable to 'The Numerical Algorithms Group Limited'.

Name: .... Signature: ....

Address: ....

....

....

....

Telephone Number: .... Date: ....

Please supply more information on:

FORTLP ☐ CAMPS ☐ ANALYZE ☐ NAG ☐

Return address overleaf.

88 9 7 082

Workshop Programme

9.30	Registration and Coffee
9.45	Chairman's Introduction Professor M.A. Laughton, Queen Mary College
10.00	Design Objectives of CAMPS and FORTLP Systems. Gautam Mitra
10.30	Introduction to CAMPS Cormac Lucas
11.15	Coffee
11.30	Main Features of FORTLP Mehrdad Tamiz
12.15	Discussion
12.30	Lunch
13.20	Introduction to ANALYZE Harvey Greenberg
14.15	Summary of NAG Library Optimisation Facilities David Sayers
15.00	Discussion
15.30	Tea
15.45	(parallel demonstrations

	(DEMO 1	DEMO 2	DEMO 3	DEMO 4
17.00	(FORTLP	CAMPS	ANALYZE	NAG SOFTWARE

About NAG

The Numerical Algorithms Group Limited is a not-for-profit company which develops and distributes numerical and statistical software. Its software products are widely used throughout the world. Much of its work is undertaken on a collaborative basis with experts in UK universities and elsewhere. The principal NAG product is the NAG Fortran Library, a tailored collection of 688 numerical and statistical algorithms, coded as Fortran 77 subprograms. Major new marks of that library are produced on a regular basis. NAG's product range includes statistical packages, other language versions (including Ada) of the NAG Library, and graphical software. Facilities described in the Workshop either are, or may become incorporated into the NAG product range in due course. For futher information about NAG's current activities, products and services, please tick the appropriate box on the reply form:

Please return this form to the address below. Upon confirmation of your booking, further details of the Workshop will be sent to you.

Optimisation Workshop Coordinator
Numerical Algorithms Group Limited
NAG Central Office
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Oxford
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→ Papers
→ Manuals
→ Public Domain

FORTLP and CAMPS

Background

and

Design Objectives

Gautam Mitra

Brunel University

23 June 1988

Contents

1. Background and Support

Persons who have worked on the project:

Gautam Mitra, SCICON, SIA, ICL, UNICOM, Brunel
Ken Darby-Dowman, Polytchnic of Central London, UNICOM

Mehrdad Tamiz, Brunel PhD student, Research Fellow (SERC)

Cormac Lucas, Brunel PhD student, Research Fellow (SERC and lately US Army)

Joseph Yadegar, Brunel Research Fellow (SERC, 1986)

Indirectly Joaquim Judice, Frank Ellison

- Background research and earlier implementation in 1970's

- Present generation of software and R & D since 1983

- Continued support of NAG in development and stringent testing: Dr S Hague, Dr S Hammarling, Dr A Brown

2. Design Objectives of FORTLP

- A modular suite of subroutines
  - stand alone
  - algorithm construction

- Fully portable and takes advantage of 16/32 bit word structure

- Incorporates most of the proven features of sparse simplex methods for large LP

- Includes (mixed) integer optimizer with tree search

- Close to industrial standard and a test bed for experimentation

- Available in the public domain

- Past Developments:

  - Exploiting super sparse data structures

  - Elimination form of inverse with Block Triangularization and factorization; eta splitting - Markowitz merit count and threshold pivoting

  - Sparse update procedure

  - Adaptive pricing, pricing with dynamic scaling

  - Comprehensive tree development and search procedure for integer

- Future Directions

  . Incorporation of interior search procedure within the simplex framework

- Karmarkar's method

  . Beale, Hattersley, and James Crash procedure.

- Exploiting Parallel processors

  Coarse grained parallelism with shared memory

  . Parallelize major sparse simplex steps

  . Parallelize interior search method

  . Parallelize integer search procedure

3. Design Objectives of CAMPS

Developments in modelling support systems

- . Data driven special purpose interpreters

- . OMNI/MAGEN, GAMMA3
  Generation in column sequence

- . As above but with row or equation
  specification

  DATAFORM, MGG/RWG

- . Procedural Languages
  GAMS, UIMP, MGRW, ULP, MAGIC

** See Fourer ... 1983

- . Network based approaches
  LOGS

- . Witzgall and McClain (NBS)
  AMPL ... AT&T Bell Laboratories
  LINGO ... Schrage

- Modern approach

  Replace the language based model specification by:

  Interactive, menu driven and screen form based method for communcation/model generation.

  - Menus for command options and screen forms for data entry

  - Modelling process is captured in the system's structure

  - Information flow and model management facilities to support the use of PC as a modelling work station

- Implemented using a mixture of C, FORTRAN and the screen package CURSES

- Portable across:

  PC-DOS

  UNIX

  VMS

  and others

- Future Directions

  . Reformulation of problems stated in near natural language. Logical forms to mixed integer programs and special ordered sets

  . Analysis of bounds, statement of fuzzy linear programs

  . Inclusion of 'ANALYZE'

Thus the process of model investigation

. construction of model

. analysis of model prior to optimization

. analysis of model after optimization together with the solution

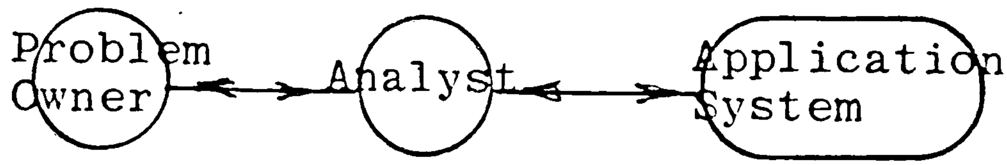
. discourse with the model

is fully integrated.

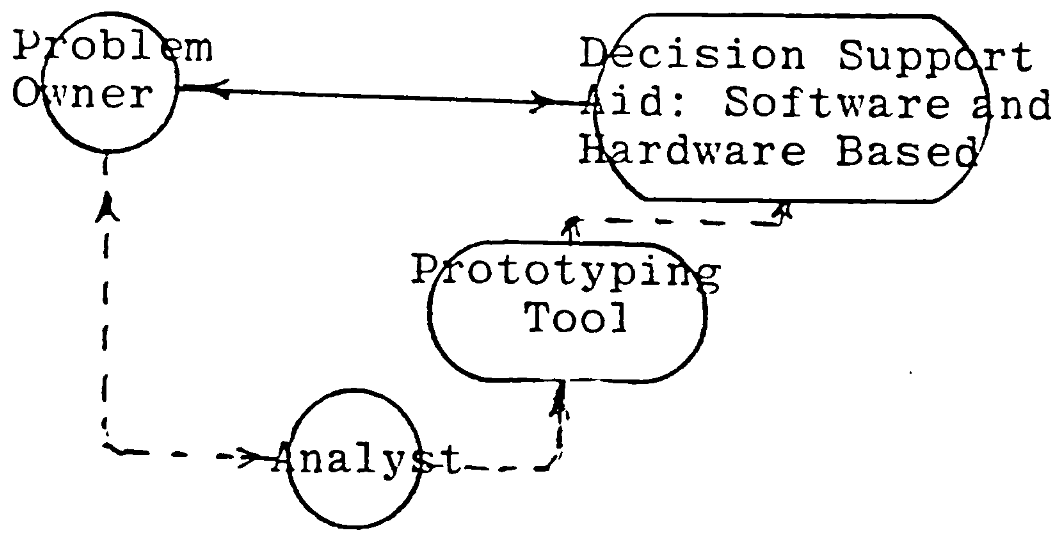
- Introduction of programmer's interface:

  The objective is to construct a range of non-standard applications which exploit the modelling capability of CAMPS.

- o Roles of problem owners and analysts in dealing with applications.



- o Role of the analyst in constructing Decision Support Software.



4. An Evolutionary Path: Development and Testing

Knowledge based system shells:

A super high level implementation method.

Knowledge elicitation ... Model conceptualization

Knowledge representation ... Model formulation

Knowledge manipulation ... Model reformulation

- Methods of knowledge representation

  Procedural Methods

  Declarative Methods

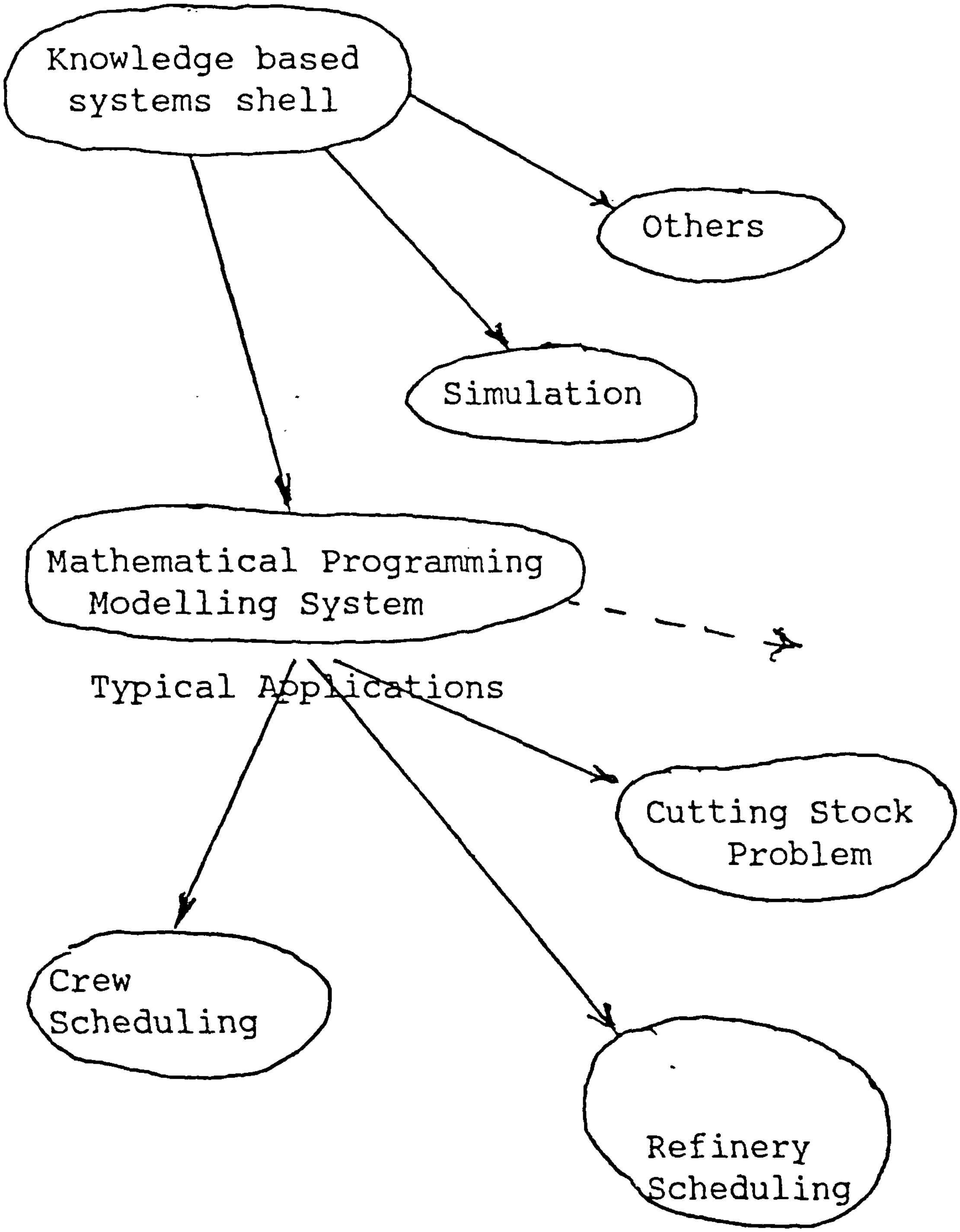
    First order logics

    Production rules

    Structured objects

    Semantic networks

  can be available within a single shell.



Involvement of analysts/users/problem owners at different levels