Modeling Languages: Applications to Optimization

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Outline

- Modeling process
  - steps
  - benefits
  - alternatives

- Algebraic modeling languages (AML)
  - characteristics
  - advantages
  - drawbacks
  - writing style
  - future tendencies

Steps in Developing Optimization Models

- Problem identification: information exchange and coordination between "planner" and "modeler"

- Problem specification: mathematical representation of external world

- Optimization problem formulation
  - Variables, objective function and constraints
  - Characterization of the problem (LP, MIP, NLP)
  - Problem size (rows, columns, non zero elements), matrix structure

- Computer program implementation and validation

- Detailed interpretation and analysis of the results

- Extensive use of the model and model maintenance

Modeling

Science

- Analysis and relationships between data
- Assumptions
- Approach to problems
- Problem solutions
- Algorithms

Art

- A view of reality
- Style in model and documentation
- Elegance and simplicity
- Creative use of tools

Benefits of the Modeling Process

- Provide a dialogue, information exchange
- Organize thinking about the problem
- Organization of data
- Share assumptions and results

Alternatives for Developing a Model

- General purpose programming languages (C, FORTRAN)

- Matrix generators and report writers

- Block schematic modeling languages (MIMI)

- Spreadsheets (EXCEL, QUATTRO PRO)

- Algebraic modeling languages AML (AIMMS, AMPL, GAMS, LINGO)

Characteristics of AML

- Designed to make the construction and solution of mathematical programming models more straightforward for programmers and more understandable to users of models from other disciplines

- Provide a high-level language for the compact representation of large and complex models

- Improve substantially the productivity of modelers and greatly expand the extent and usefulness of mathematical programming applications

- Increase the time available for conceptualizing and running the model, and analyzing the results

Characteristics of AML (...)

- Modeler focused in modeling instead of coding

- Structure good modeling habits by requiring concise and exact specification of entities and relationships

- Based on unambiguous statements of algebraic relationships

- Allow changes to be made in model formulation simply and safely

- Model descriptions independent of solution algorithms

- Models developed and documented simultaneously

Advantages

- Natural separation of model and data

- Easy coding of different data instances of an optimization problem

- Problem formulation independent of the size, easy generation of prototypes and of large scale problems

- NLP problems are as easy as LP problems

Advantages (...)

- Solvers can be exchanged without difficulty. New versions or new solvers can be tested
- Easy formulation modification to improve the solution time (specially useful in MIP, NLP and large LP)
- Easy implementation of advanced algorithms
- Portability among platforms and operating systems
- Documentation and code maintenance made easy

Drawbacks

- Not convenient for casual users of very small problems
- Inadequate for very huge problems where the complete problem can not be physically generated

Elements of Writing Style

- Separation of data, model and results in different files
- Clean source code, indentation
- Illustrative comments
- Specification of units in data, variables, equations, results
- Initialization of variables
- Use of descriptive names
- Systematic use of capital and small letters
- Check of set domains

Future Tendencies

- Implementation of stochastic optimization problems
- Column-wise constraints specification
- Direct link to external databases and spreadsheets for input/output
- Call to external functions (C, FORTRAN)
- Windows-like interfaces
- Analysis of matrix structure
- Intelligent solver selection

Uses of the AMPL Modeling Language in Solving "Balanced" Assignment Problems

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GAMS Modeling Language Applied to Stochastic Optimization

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Questions

- Do modeling languages encourage the use of optimization models in the industry?

- Are they fast enough to substitute production-grade optimization models?

- From your point of view which is the major advantage/disadvantage of AMPL and GAMS?

- Are some type of problems more conveniently solved by one or other modeling language?