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Modeling systems and optimization

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ABSTRACT In this paper we describe such systems by modeling modern software troubleshooting support operational research. These systems include: The modeling languages, solvers for solving the model database, interfes by user, and the interface between the individual elements of the system. The modeling systems cyber part of modern infrastructure, and thus allows a wide application operational research methods. Solving optimization problems will soon be a possibility of a large number of users, not only specialists in the field of mathematical programming and operations research.

KEYWORDS : optimization, modeling, operational research.

Introduction

Modeling involves conceptualization of decision problems and the abstraction in a quantitative or qualitative form. In the case of the mathematical model, it includes identifying the dependent and independent variables and the model equation, or the inequality, which describe their relationships. In this process, it is important to maintain an appropriate balance between the degree of complexity of the model and presented reality. Simple models lead to simpler handling and faster finding solutions, but the worse the performance of the real problems and can therefore be unacceptable for practical application.

To conceptualize the problem of decision-making, we need a sufficiently rich performance that should be at an adequate level of abstraction cover all objects and constraints of decision problems. This performance should also have the property of the solution, or the possibility of finding the optimal or satisfactory solution.

The modeling systems software implementations that include: The modeling languages, solvers for solving the model database, the interface towards the user and interface between individual elements of the system. Contemporary by modeling systems enable efficient conceptualize a broad class of decision problems with what they face today's managers. Moreover, including solvers for different types of models, managers are able to quickly and easily come up with a solution to their problems.

If, for example, the maintenance manager meets with the problem of deployment of workers per shift, he should recognize this as an individual case, a more general scheduling problem for which there are well-developed algorithms and their implementation to software that can be directly used to solve the existing problems of decision making. However, for efficient use of these algorithms is necessary formulated a mathematical model in the form that allows the software to connect the mathematical model, the data needed for its solution and the appropriate solver to be used in solving the model.

Efficiency modeling system essentially depends on the quality of the mathematical model, which should be presented by modeling using the language and instructions on resolving solver. The operating time solvers and finding solutions can be unacceptably long, the model can not be used to solve practical problems of making greater dimensionality.

In the light of use by modeling system, the cycle of modeling comprises the steps shown in fig. 1:

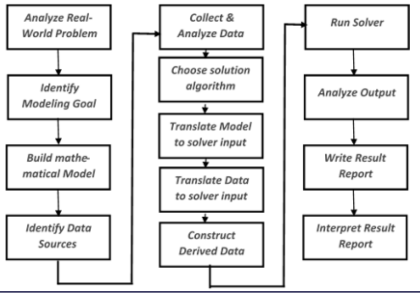

Fig.1. The cycle of modeling.

However, the steps in the cycle modeling are interacting with more links than it can be concluded from the sequentiality steps from the previous image [Neumaier, 2003]. Better insight into business modeling can be done using the display in Fig.2, which shows a graph where the nodes describing the information to be collected, sorted, analyze and organize. Arches graph showing the flow of relevant information between different sources that is bidirectional and describes the interaction of the two sides.

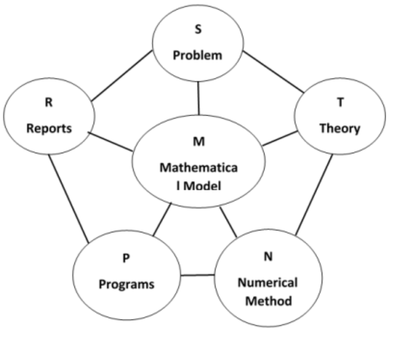

Figure 2. Graph of information sources in the cycle modeling

Assuming the role modelers problem plays educated researcher operational semantics of nodes in the above diagram is as follows:

- **S. Problem.** The problem under consideration comes from the real world and in the formulation of the problem requires close cooperation with managers who are beneficiaries of solutions for a given problem. The first hurdle that needs to be overcome is the establishment of a common language that allows two-way communication managers and operational researchers and minimize the possibility of misunderstanding on both sides. The modeling rich semantics of the language is a great help in solving the problems of communication.

- **M. Mathematical model.** The mathematical model is clear and precise formulation of the problem by modeling the written language. The mathematical model consists of variables that represent different objects the decision problem for a given level of abstraction of the problem and relations, usually equations and inequalities, linking variables. Model often contains target modeling and requirements for its minimization or maximization.

- **T. Theory.** To build a useful model, the modeler must know the theoretical basis of the problem being modeled and, of course, the theory of mathematical structures that are used in building the model. Choosing the right structure of the mathematical model can significantly shorten the operating time solvers, and solve practical problems. This, in particular, applies to models nonlinear problems and problems with integer variables, because good choice "branch and bound" strategy, good initial values and scaling values of variables can significantly affect the operating time solvers. In general, a model structure of the mixed integer programming (MIP) is that which has a relaxation LP allowable region which is convex and at least as close as a polyhedron, which includes all permissible point MIP problem. In practice this means, for example, that the upper limit of the variable set as low as possible.

- **N. Numerical methods.** No model of practical interest, can not be solved analytically, but must seek numerical solutions, and consider the available numerical algorithms.
- **P. programs.** The software that implements numerical methods and forming the so-called solver, solving a practical model on modern computers.
- **R. Reports.** From the standpoint of practical use model, it is important that managers receive meaningful reports that are consistent with their habits in structuring information and, of course, contain the information necessary for decision making. Often it is appropriate, in the formation of reports use different techniques of data visualization. Well presented reports on the quality model results allow obtaining a higher level of trust managers able to operations research and their applications to real management problems.

The modeling languages

Development modeling language began late 70s when it first by modeling language GAMS [Brooke et al, 1992] that enabled the problem description language that is familiar mathematical notation is used in a model creation, and that language is called algebraically by modeling languages. Description of the model by modeling using language is independent of the solver to be used to solve different solvers and can be used in a single model. U by modeling languages can I model and its data is stored separately in two different structures. In this way, you can create multiple instances of a model using a variety of inputs. Data is often stored in relational databases or "spreadsheet" Excel-type tools, with which by modeling language communicates using ODBC (Open Database Connectivity) connection. Various derived data type gradients, Hesijan, Jacobian, can be obtained by the process of automatic differentiation.

Algebraic by modeling languages can be considered as a new paradigm in programming that combines declarative and procedural paradigm of standard programming languages, [Hurlimann, 1999]. Programming languages can be divided into the following three classes:

- **Imperative languages.** These languages, which are not quite correctly, called procedural languages, followed by (von Neumann) concept computer in which the state of computing describes the contents of memory locations, orders and counter registers. The possibility of explicit links variables and memory locations and sequential execution of program instructions are the main features of imperative languages. The most important representatives of this class of languages are C, C ++, Pascal, Fortran and Java. Basic extension of these languages is an object-oriented programming where variables play the role of the local state facilities.
- **Functional languages.** This paradigm assumes that each calculation is seen as a function that maps an input into a single output. Since each value represents a function, do not use the variable i is not got an assignment, the typical concepts of imperative languages. A typical representative of this class of language Lisp and Scheme.
- **Logical programming languages.** This paradigm, begin 60s, was intended for writing programs theorem proofs. Here each calculation treats as evidence, which is the basic characteristic of the Prologue of the most famous representatives of this type of language. Each program in Prolog consists of nepraznog set of objectives and a set of rules and using modern methods of logical resolution program tries to reach the objective of respecting the set of rules.

All three classes define the language problem in the algorithm, the procedural way. In other words, they do not specify "what is the problem" but "how to solve the" problem, which is why they are called algorithmic or procedural languages. In contrast, by modeling languages describe the knowledge of the problem, define the problem using the appropriate models and usually does not specify how the decision to come and present the so-called declarative languages. The basic question of how to describe what the problem is, in these languages to solve the formal specification of the problem properties.

Formal specification starts with the domain value X (usually, $R^m \times Z^n$ the domain that the Cartesian product set of real numbers and the set of integers). Of this domain is defined by a set of constraints of equations, inequalities and the objective function, which together can be considered as the relation R : X → {true, false}, which determines if x ∈ X. It is said that x permissible solution of a mathematical model:

$$M := \{x \in X \mid R(x)\}$$

if all the constraints are satisfied, ie. if R (x) = True. It is noted that the term solution is permissible in this context is used for a solution that satisfies the constraint, and ensures the optimal objective function, as opposed to the standard definition in the mathematical programming, where the term permissible only applies to the satisfaction of constraints. This specification of the decision problem, ie mathematical model that it represents, is basic for by modeling languages. The consequence of this specification and the absence of any resolution of the algorithm is that it does not guarantee finding a solution, or that it even exists. Fortunately, there is a sufficiently broad class of problems of practical interest (for example, linear programming) for which there are no efficient algorithms for solving them, realized through solvers - software implementation of algorithms.

For declarative languages is typical:

- that the problems are the assertive way
- there is a clear separation of the definition of the problem to solve it, and
- there is a clear separation between the structure of the problem and its data.

Algebraic by modeling languages are a special class modeling language and most of them are designed for efficient specification of optimization problems. Their language constructs provide a description of the problem form:

$$\begin{aligned} &\min f(x) \\ &p.o. F(x) = 0 \\ &G(x) \leq 0 \\ &x \in X \\ &X \subset R^m \times Z^n \end{aligned}$$

In the algebra by modeling language, this model is specified using the following language constructions: meetings, indices, parameters and variables. Conceptually similar Zenit together grouped into a collection. Individual entities in the set is referenced by an index that identifies the elements together. A group of entities (variable, restrictions) can be present and the compact used in the algebraic expressions. Modern by modeling languages allow, in addition to linear and non-linear models specification. The most famous algebra by modeling languages are GAMS, AMPL, LINGO, MPL, Moselle.

For example, in the famous phrase by modeling language AMPL:

$$\sum_{i \in S} x_i$$

is presented as:

Sum and {S} and x [i];

In this way, a formulation very similar mathematical formulation and translating the mathematical formulation of the language by modeling directly and must be resolved only syntax problems.

The next task by modeling the system should solve the problems in translating instance format recognized solver algorithm or solution. This can be done by developing a compact notation ineksiranjem all sets and adding data model. Very often, by modeling system has a so-called. "Presolve" phase, which is used for pre-processing of data before sending the solver to solve, in order to efficiently work solvers. For illustration, consider the quadratic programming model:

$$\min x^T Qx + c^T X$$
$$p.o.Ax \le b$$
$$\| x \| \ge 1$$
$$x \in [l, u]$$

with N N matrix Q, and M N matrix A.

In developing the top model in the compact in the form of indices, we get:

$$\min \sum_{i=1}^{N} (\sum_{j=1}^{N} Q_{ij} x_j + c_i) x_i$$
$$p.o. \sum_{j=1}^{N} A_{ij} x_j \le b_i \quad \forall i = 1, ..., M$$
$$\sqrt{\sum_{i=1}^{N} x_i^2} \ge 1$$
$$xj \in [l_j, u_j] \quad \forall_j = 1, ..., N$$

Knowing the syntax AMPL languages, this model can be presented as:

```
### PARAMETERS ###
param N>0 integer;
param M>0 integer;
param c {1..N};
param b {1..M};
param Q {1..N,1..N};
param A {1..M,1..N};
param l {1..N};
param u {1..N};

### VARIABLES ###
var x {1..N};

### OBJECTIVE ###
minimize goal_function:
sum {i in 1..N} (sum {j in 1..N} Q[i,j]*x[j] + c[i]) * x[i];

### CONSTRAINTS ###
subject to linear_constraints {j in 1..M}:
sum {i in 1..N} A[j,i]*x[i] <= b[j];
norm_constraint: sqrt(sum {j in 1..N} x[j]^2) >= 1;
box_constraints {j in 1..N} : l[j]<=x[j]<=u[j];

################ DATA #####################
data sample.dat;
############################################
solve; display x;
```

Reading the listing above, can be easy to identify the different parts of the model, to which are added to parts of the declaration of parameters and variables, a line which calling sample.dat file data and the last line, comprising a single command for procedural solve calling solver and the order display x which is printed solution.

Other Modeling Languages In Operational Research

Algebraic modeling languages are not suitable in some fields of application in which the simulation rather than optimization, basic methodology approach. Thus, for example, modeling of technological processes and their simulation and requires a different kind of concepts present in the modeling language. For this reason, it is developed and groups modeling language with a rich language capabilities for simulation of processes such as gPROMS and Ascend in the field of chemical engineering and EXTEND for Production Engineering, [gPROMS, 2017], [Ascend, 2017], [EXTEND, 2017].

Extension paradigm modeling makes language and object-oriented language by modeling Modelica, designed for the engineering modeling of complex physical systems comprising mechanical, electrical, electronic, hydraulic, HVAC, and the like components, [Modelica, 2017].

Particularly important from the point of application of operations research methods, the group modeling tongue-in-class logic programming with constraints (Constraint Logic Programming - CLP). This class is intended for modeling language heavy Combinatorial problems, where it is necessary that with the declarative part of the definition of the problem and there is a part that contains algorithmic knowledge. Most of algebraic language model no possibility of performance algorithmic skills, which are exclusively located in the solver. Depending on the solver used by modeling language must provide an additional description of the performance of algorithms. This description is not part of neither model nor the data and different solvers require different information. This information, for example, strategy selection and search, defining scenarios in the case of stochastic program, the initial solution to the problem of local optimization and the like. Combinatorial problems of discrete nature, very often require modeling specijalizovanjih limitations (e.g., limit the type diff all - in the set of variables each taking a different value, or the cardinality - exactly N variable in a given set is taken to be True). This type of limitation does not exist in the construction of algebraic modeling language but must be reformulated by introducing special mixed -celobrojnih restrictions, which complicates the structure of the model and makes solving complex. The best-known languages of this class are OPL, LPL, Aimms.

Software for solving problems - Solver

Solvers are software tools that play an essential role in the system by modeling in the process of solving the model. Due to the diversity of mechanism types: linear and nonlinear integer, mixed-integer and there is a larger number of different solvers which are based on various algorithms.

Almost all solvers are somehow available over the Internet. Many of them are free, but that does not mean that they are useless or bad. The highest number of personal computer users do not know that with the standard EXEL get solver that can solve optimization problems smaller. However, for solving practical problems of large dimensions, when the number of control variables may be the order of millions or tens of millions, must be used in commercial solvers large software company.

Launched the project COIN-OR (Computational Infrastructure for Operations Research) is a non-profit consortium of researchers from industry and universities, which aims to improve the state of use of solvers in solving practical decision problems. This goal is achieved by promoting the development and use of "open source" software for operational research. Among other things, this project maintains a library of software tools that can be used in the construction and optimization of the program, as well as ready-made software packages. Thus, this initiative brings together the following solvers:

- **COIN-LP (COIN-OR LP** solver, open-source)
- **CPLEX (ILOG,** commercial)
- **dylp** (BonsaiG LP Solver, open source)
- **FortMP** (OptiRisk Systems, commercial)
- **GLPK (GNU LP Kit,** open source)
- **COIN-IPOPT** (Interior Point Optimizer, open-source)
- **Mosek (Mosek ApS,** commercial)
- **OSL (IBM,** commercial)
- **SoPlex (Konrad-USE-Zentrum für** Informationstechnik Berflin, for academic use free)
- **Volume (COIN-OR,** open-source)
- **XPRESS** (Dash Optimization, commercial)

Apart from the above in practice is used more and MINOS, MINTO, lpSolve among many others.

Efficiency optimization software has increased in the last ten years to about 15 million order with the help of modern computer and solvers can not solve the problems that are ten years ago were absolutely unsolvable due to limited computing resources necessary to solve the problem. This is great progress significant contribution has given the development of technology, a few thousand times, but several times the contribution made in the field of development theory, and mathematical methods and operations research. In the future we expect further progress in both directions to be managed effectively solve models that will include larger systems correspond better to real situations and will inevitably be more complex than those that are now effectively solved.

Networking And Optimization On The Internet

Practical application of operations research methods play an increasingly important role in decision-making processes, owing to significant advances in the conceptualization of models, algorithms for their solution and software techniques. During the 90s, began to connect the analytical data, organized in data warehouses, models operations research and powerful solver - software tools that implement the algorithms to solve, [Koutsoukis et al, 1999]. Progress in these areas, combined with the increasing use of PCs, is essential for the role of operational research systems to support decision-making in a number of applications: finance, manufacturing, supply chain management and logistics, energy and utilities sector and ecology. In all these areas, operational research has not only become an important part of the information systems organization, but also an integral part of its business processes. In this way, operational research are becoming an essential element in the management of business processes.

In addition to facilitating the exchange of data, it is necessary to solve the problem of exchanging models between different modeling system. It is obvious that the development of this open standard format should be based on XML and MathML-in. This would allow a suitable interface for presentation on the Web model and solve other problems of consistency of interface numbers in the current sing and eliminate errors rounding. The next chapter is devoted to optimizing Web and XML technology and MathML. This would provide a suitable interface for presentation on the web model and solve other problems of consistency of interface.

It is extremely important and the interface to the end user. Tome in recent years given special attention in the context of the so-called business intelligence. This thermal means a set of technologies that enable the collection, systematization, processing and presentation of data required for effective decision-making and management of the organization. The fact that the interface to the end user today represents one of the main interests of producers of information systems indicates that by modeling languages and solvers rather well developed and became available resource of contemporary makers and analysts menadzerimav

Most modeling system is available either as object libraries based on the COM (Common Object Model) and CORBA (Common Object Request Broker Architecture) or as dynamic or static libraries ringer. Object libraries are very flexible way to users directly access all objects and methods necessary for the development of their applications and software have access to internal structures used by modeling the system, such as conferences, data, matrices and vectors model solutions. In essence, users are able to integrate all functions modeling declarative system in your programs written, for example. in C ++, Visual Basic, etc., which significantly raises their quality systems to support decision-making.

Services optimization and other methods of operations research can be effectively delivered via web services that are located on Internet servers and provides users interface with which they can access a set of functions and methods that web service. The acronym ASP (Application Service Provider) in this context means organizations that provide services to women beneficiaries internet infrastructure, ie. manage and deliver applications to multiple users. Description of service is formally and explicitly given so that software systems users can do with them to communicate directly. This means that company users can lease access to the application via the Internet with various modes of payment for the service.

The most famous server to optimize the NEOS. which allows users to submit their problems using Web forms, e-mail or TCP / IP-based client tools (Kestrel) and to choose among a large number of the available solver, [NEOS, 2017]. NEOS solvers covering linear, integer, nonlinear, and stochastic quadratic programming and some support by modeling languages (GAMS, AMPL, ...). General NEOS optimization server architecture is illustrated in Figure 3. This architecture allows NEOS can satisfy the growing number of requests by distributing them to the server farm specialized for particular solvers or by modeling systems.

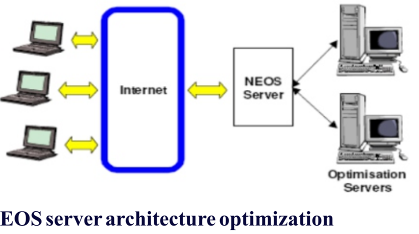

Fig.3. NEOS server architecture optimization

When a user discovers a service that is available on the Internet and understand its description and interface, it can access using XML-based messages that are sent through HTTP protocol and the same way to get a result. The following languages and protocols are the basic technological base Web services:

- **XML** (eXtensible Markup Language) is used as the format of data exchange over the Internet,
- **SOAP** (Simple Object Access Protocol) is a protocol based on XML and is used to call a method that provides a Web service,
- **WSDL** (Web Service Definition Language) is also XML-based language that is used for public disclosure Web service interface, and
- **UDDI** (Universal Description, Discovery and Integration) provides global registry for advertising, retrieval and integration of Web services.

Conclusion

The development of methods of operations research, information technology and the Internet have fundamentally changed the approach to solving optimization problems, analysis and decision-making with the help of computers. Today's decision-makers available resources for solving large and complex optimization tasks that until recently was an unexpected and unimaginable. In order for these opportunities in practice, take advantage, you need knowledge of specific technologies and problems of decision-making as well as some training in the field of computer science and operations research. However, these requirements, especially in relation to methods of optimization are now looser compared to earlier, although at first glance may seem contradictory, given that the problems to be solved and those more complex optimization algorithms. Similarly, the average modern driver who in their car can use the global positioning system to navigate and determine the best path between two points, and never perhaps not even heard of optimization on graphs whose results benefit, since managers will be able to use decision support system that will they suggest the best decisions for coping in the labyrinths of the global market. Those who are first to understand and begin to use will have the greatest comparative advantage.

Reference

1. [Abu Gaben, 2008], "Operations Research Models In Management Information Systems ",F.O.N, Belgrade,2008.
2. [AIMMS, 2017], Paragon Decision Technology, The Netherlands. www.aimms.com
3. [ASCEND, 2017], http://ascend.cheme.cmu.edu/
4. [Banker, 1984], Banker et al, "Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis", Management Sciences 30, 1984, 1078-1092.
5. [Brooke et al, 1992], GAMS - A User's Guide (Release 2.25), Boyd & Fraser Publishing Company, Danvers, Massachusetts,1992
6. [Carlisle et al, 2001], Mathematical markup language, version 2.0, 2001. http://www.w3.org/TR/MathML2/
7. [COIN-OR, 2017], http://www.coin-or.org
8. [Cplex, 2017], Mathematical Programming Optimizer,
9. http://www.cplex.com
10. [EXTEND,2017], http://www.imaginethatinc.com/
11. [Foster et al, 2001], "The Anatomy of the Grid: Enabling Scalable virtual Organizations", International Journal of Supercomputer Applications", 15, No.3, 2001
12. [Fourer, 1993], AMPL, A Modeling Language for Mathematical Programming, Danvers, MA: Boyd and Fraser Publishing, 1993
13. [Geoffrion, 2001], „Prospects for Operations Research in the E-Business Era, Interfaces 31, No.2, 2001
14. [GLPK,2017], GNU Linear Programming Kit , www.gnu.org/software/glpk
15. [gPROMS, 2017], http://www.psenterprise.com/gproms/index.html
16. [Hurlimann, 1999], „Mathematical Modeling and Optimization", An Essay for the Design of Computer-Based Modeling Tools, Volume 31 of Applied Optimization,Kluwer Academic Publishers, Dordrecht, 1999
17. [LPL, 2002] , "A mathematical modeling language, an introduction", Department of Informatics, University of Fribourg, 2002
18. [MINTO, 2017], Mixed INTeger Optimizer, http://coral.ie.lehigh.edu/minto
19. [Modelica, 2017], http://www.modelica.org/
20. [NEOS, 2017], http://www-neos.mcs.anl.gov/neos
21. [NSF,2003], "Revolutionizing Science and Engineering Through Cyberinfrastructure", http://www.cise.nsf.gov/
22. [NSF, 2007], "Cyberinfrastructure Vision for 21st Century Discovery", National Science Foundation Cyberinfrastructure Council, March 2007
23. [Neumaier, 2003], „Mathematical model building" In J. Kallrath, editor, Modeling Languages in Mathematical Optimization, Kluwer, Dordrecht, 2003
24. [OPL, 2017], Optimization Programming Language, http://www.ilog.com
25. [OptML, 2000], Halldorsson et al, "A modeling interface to non-linear programming solvers an instance: xMPS, the extended MPS format,"Technical report, Carnegie Mellon University and Maximal Software
26. [SNOML, 2016], Lopes et al, "An XML-based Format for Communicating Optimization Problems," http://senna.iems.northwestern.edu/xml/presentations/LopesFourer
27. [Ven et al, 2007], "Stimulating Collaborative Development in Operations Research with libOR", Proceedings of the First International Conference on Open Source Systems, Marco Scotto and Giancarlo Succi (Eds.), Genova, 2005
28. [XPress-MP, 2016], Dash Optimization Ltd, England,www.dashoptimization.com