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Integration of Management Information Systems (Cyber Infrastructure) and Operations Research

KEYWORDS: Operation Research, Management Information System, Modeling Systems, Optimization, Infrastructure.

Dr. Mohamed Abu Al-Jibeen

Al Quds Open University , Gaza , Palestine- 2014

ABSTRACT *Management information systems (MIS) summarize data and prepare information reports from transaction data, usually in different functional areas. MIS deals with the planning for development, management, and use of information technology tools to help people perform all tasks related to information processing and management.*

Operations research (OR) is defined as the application of scientific methods for decision making in managing a variety of cybernetic systems

Synergy of MIS and OR is considered in the paper . Modern web based MIS are designed and implemented with the aim of providing data necessary for decision analysis . For rational analysis and finding optimal solution, techniques and tools of modern OR are used . That is why OR is becoming an important part of cyber infrastructure . The accent in the paper is given to modeling systems, modeling languages, solvers, and interface .

1- INTRODUCTION

In recent years, the literature in the English additional languages, the more luck the new term - "Cyber Infrastructure" (CI). Newly created word "cyber" is already entered in everyday language and is used to designate phenomena or phenomena related to high technologies in the information society, such as cyber crime, cyber space and the like.

The term infrastructure has traditionally been related to road, rail, electricity, telephone network and other systems that enable the functioning and development of industrial society. It is known that the development and maintenance of good quality infrastructure is one of the most complex and financially demanding tasks that each society has developed. The new term "cyber infrastructure" for which we will here after use the abbreviation CI, refers to computers and other information-communication technology that can be joined under the name Internet. However, it should be noted that the word cyberspace stems from the Greek word meaning kiberno steer or control (by boat). Therefore, the term cyber infrastructure could be translated as the infrastructure needed to manage and decision-making, which is in the context of this work is of particular importance, as is the fact that modern telecommunications infrastructure is implemented and information technology in the background.

What I mean is the infrastructure and means for the industrial economy, it is the CI for the knowledge-based economy. To the Information Society could have a growth rate that is similar to the rate of growth of industrial society, the CI should enable effective implementation of the following objectives [NSF, 2003].

- Collection of data. The potential of processing large, complex and distributed data sets is a fundamental task that has to solve the information society. Modern CI provides a collection of virtually unlimited amounts of data. Because of congestion resources irrelevant data, it is necessary to provide appropriate mechanisms to develop new models of databases and transmission routes, as well as consider issues of privacy, security and authentication requirements in the new CI.
- Development and distribution operations research tools. Problem solved with a huge collection of data necessary to develop appropriate software tools that implement methods to use this data for making management decisions, it is methods of operations research. The development of these tools is critical to the efficient extraction of information or meaning from large data collections. This primarily refers to the tools that enable modeling and solving very large optimization task analysis and simulation of complex phenomena such as, say, for example, problems of supply chain management and logistics problems in general. The most difficult problems, which in this connection appear, caused by nonlinearity properties, combinatorial complexity, uncertainty - stochastic and high dimensionality. All this requires new approaches to computer support, primarily in the greater use of parallelism in computation, such as grid computing architecture and speeds "Pataskala" (1015 operations per second) [NSF, 2007].
- Development of tools for complex queries. Solving problems facing the modern manager, application integration and analysis of large mass of data from a variety of databases. The data were heterogeneous nature (numeric, text, audio, video) and different formats, which significantly hinders their easy availability and sharing. It goes without saying that the need for tools that allow easy access to diverse data, crucial to the development and success of CI.

2- INFRASTRUCTURAL FEATURE OF OPERATIONS RESEARCH

Operations Research have all the characteristics of infrastructure as a collection of methods, algorithms and software tools that become necessary in the management processes and making good decisions. Basically, the tools of operations research are used to bridge the gap between data, information, knowledge and decision making. Therefore, operational research have a major impact in all the activities that characterize the contemporary developed societies. For a earning potential with operational research is needed CI, and inversely, contemporary CI necessarily must include the results of operational research. For example, in supply chains, CI enables collection of data on suppliers and customers, and operational research data are organized and prepared for management decisions. Or, the financial problems of CI provides access to data from the financial markets, and operational research using appropriate stochastic models prepare financial forecasts and decision. In short, Operations Research and CI harmoniously complement and make effective synergy that makes modern managers make better decisions in turbulent economic developments and policies.

Harmonious development of operations research and CI requirements, in particular:

- development and implementation of algorithms in resolving management such as for example, the logistical prob-

lems that often occur in the supply chain, appropriate software tools become available on specialized Web servers,
- establishment of a library of models and analyzes based on case studies, demonstrating a relatively new approaches to operational research, for example, stochastic optimization and optimization in simulation, to solve important problems in the economy and society,
- development of methodologies and tools to support CI decision-making in real time.

Initial results in this direction can already be seen on the famous NEOS server [NEOS,2007]. However, for the full success of the integration of operations research and CI requires a much greater involvement and integration of multidisciplinary research teams that are operating in addition to researchers and specialists in information technology should include economists, engineers of various specialties, personnel managers, medical and other experts, depending on a particular problem. The reason for the request for such a wide-formed team is the diversity of application of operations research and CI in the economy and society.

Figure 1. structure is illustrated by the integration of operations research and CI as well as the field or so-called cyber domain in which this integration is a large application. In Table 1. shows the function and application examples in various levels of system integration of operations research and CI.

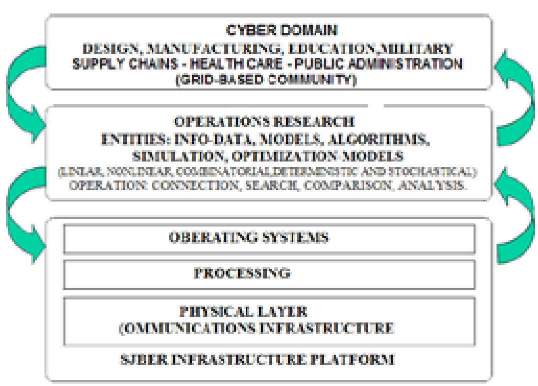

Figure 1 The integration of operations research and CI

System Level	Functionality	Examples
User Interaction & Interfaces	Working level of interaction standards with users and user systems	Interface to various computing environments that enable access from various current and future operating platforms
Applications	Core tools for design, analysis, manufacture and supply chain coordination, etc. (proprietary, open source, and shared)	CADD, structural analysis programs, flow visualization, simulation tools, enterprise management, collaborative communications, optimization, configuration
Community Resources	Algorithms and analytical tools available to the applications and user levels Platform for community tool development & management	Data analysis tools, image processing, statistical analysis functions, data mining, search functions, language translators, optimization languages
System Interoperation Architecture	Low level operating software and standards, security, and communication protocols	Frameworks for interaction, communications, and resource sharing: Data, Information, Models, Knowledge

Table 1: Functions and examples of application integration OR and CI

3. The modelling systems languages and solvers

Modelling includes the conceptualization of the decision problem and its abstraction in the form of quantitative or qualitative. In the case of mathematical models to include the identification of dependent and independent variables and the model equations and inequalities, which describe their relationship.

In this procedure, it is important to maintain an appropriate balance between the degree of complexity of the model and represented reality. Simple models lead to a more rapid handling and finding solutions, but the worse performance of the real problems. For the conceptualization of the decision problem, we need a sufficiently rich representation, to include all objects and constraints of decision problems and to the appropriate level of abstraction. The play, of course, must have the status determination, or the possibility of finding an optimal, or in any satisfactory solution.

Modelling systems, their properties, enabling today, effective conceptualization of a large class of decision problems with what they face today's managers. Moreover, including solvers for various types of models, managers are able to quickly and easily come up with a solution to their problems.

Modern modelling systems have been implemented as a software support analysis and decision-making, which includes modelling languages, solvers and interface to the data, and to other elements of the CI. Modelling systems allow efficient conceptualization of a large class of decision problems with what they face today's managers. Using their managers are able to quickly and easily come up with a solution to their problems.

The modelling system can be defined as a computer system with the following capabilities:

* to formulate the decision problems in formal language, by modelling languages like modern programming languages,
* the possibility of automatic translation formally described as a problem in the form required by today's standards solvers,
* the ability to call the activation of computations, and
* the possibility of translating the results obtained from the shape of the computations in the form of reports suitable for use by managers.

The modelling languages

Ideally, the modelling system should have a powerful modelling languages, which enables successful modelling of the various classes of problems that can be used for general purpose solvers that cover a wide class of decision problems. However, it can not be expected that the practical implementation of modelling systems, especially their modelling languages, have the characteristics of ideal systems. Therefore, today we have two standard approaches to building modelling systems:

* the modelling languages developed, specifically, specializing in the application but with a large number of software instructions that allow easy modelling of decision problems characteristic of this, a narrower field of application, and
* the modelling language designed for decision-making problems in a wide field of application, but that their presence only achieve generality, primitive linguistic construction.

Algebraic model language are not suitable in some areas of application in which the simulation rather than optimization, the basic methodology of access problems. For example, modelling of technological processes and their simulation requires a different kind of present concept in modelling languages. Therefore, the group developed and modelling languages with a rich linguistic capabilities for simulation

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of processes such as gPROMS and ASCEND in the field of chemical engineering and production engineering for EXTEND, [gPROMS, 2007], [ASCEND, 2013], [EXTEND, 2013].

Expending paradigms and modelling language makes object-oriented modelling languages modelica, designed for engineering modelling of complex physical systems containing mechanical, electrical, electronic, hydraulic, HVAC and similar components, [Modelica,2007].

Form the point of applications research methods is particularly important place and a group of modelling languages in the class of logic programming with constraints (Constraint Logic Programming – CLP). This class is intended for language modelling difficult combinatorial problem, where it is necessary that the declarative definition of the problem exists and the part that contains the algorithmic knowledge. Most of algebraic modelling languages present no possibility of algorithmic knowledge which are exclusively located in the solver.

Depending on the used solvers modelling languages must provide an additional description of the performance of algorithms. This description is not part of any model or data and different solvers require different information. This information, for example. Search strategy and selection, definition of scenarios in the case of stochastic programs, the initial solution to the problem of local optimization and the like. Combinatorial problems often require a specialization modelling limitations (limit all types of diff –the set of variables, each taking a different value or cardinality – exactly N in a given set of variables takes the value True). This type of restriction does not exist in the structure of algebraic modelling languages but must reformulate the introduction of special mixed-integer constrains, which complicates the structure of the model and makes the solution more complex. The best-known languages of this class are the OPL, LPL, AIMMS.

Software for solving problems – solvers

Solvers are software tools used to solve optimization problems defined by the appropriate mathematical model. They play an important role in modelling systems on process models. Given the diversity of types of models: linear, nonlinear integer, mixed-integer there exists a variety of solvers which are based on different algorithms.

Project COIN-OR (Computational infrastructure for Operations Research) is a non-profit consortium of researchers from industry and universities, which aims to improve the condition of using computations in solving practical decision problems. This goal is achieved the promotion of development and use of software for operations research. Among other things, this project maintains a library of software tools that can be used in the construction of optimization programs, as well as finished 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-Zuse-Zentrum fuer Informationstechnik Berflin, free for academic use)
- Volume (COIN-OR, open source)
- XPRESS (Dash Optimization, commercial)

In addition to these in practice is used more and MINOS, Mint, lpSolve them nogo many others.

Figure 2. shows the hierarchy of tools included in the application of operations research methods to support decision-making process. At the lowest level decision maker is actively using the system to support the selection of the best decisions. At the middle level of operational researchers and specialists in the database are responsible for developing and maintaining the model and instance data. At the highest level of experts to solve the model are responsible for obtaining instances of the model solutions. The degree of user interaction gradually increases from higher to lower levels of hierarchy.

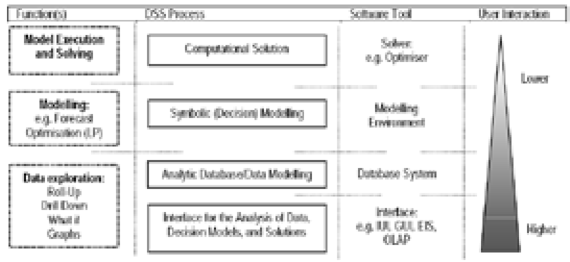

Figure 2 - Hierarchy of software tools in decision-making

4- Optimization on the internet

Development of software tools for implantation methods of operations research that are now available in the form of software components from the internet, along with the development of distributed applications has led to new approaches in the development of decision support systems [Geoffrion, 2001]. Figure 3. shows the historical perspectives of the interaction of operations research and information technology.

Today most of the elements model system is available or as object libraries based on COM (Common Object Request Broker Architecture) or as dynamic or static library call. Object libraries are very flexible way, to all users directly access the objects and methods necessary for the development of their applications. Users can have access to internal software structures used in modeling systems, such as meetings, information, and vectors of the matrix model solutions. In fact, users are able to integrate all the functions of declarative model system written in their programs, for example, in C++, Visual Basic, etc., which significantly raises the quality of decision support systems.

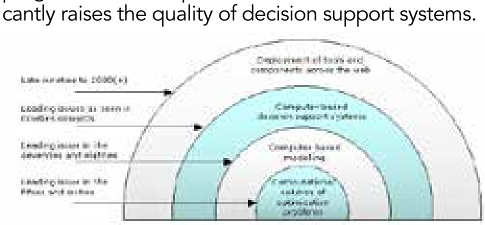

Figure 3. Historical perspective of interaction OR and IT

Best known for server optimization is the NEOS. that allows users to submit their problems using Web forms, e-mail or TCP / IP based client tools and to choose between a large number of available solvers, [NEOS, 2007]. NEOS solvers covers linear, integer, nonlinear, quadratic and stochastic programming and support some modeling languages (GAMS,AMPL,...). General NEOS optimization server architecture is shown in Figure 4. This architecture allows the NEOS can satisfy many requests by distributing them to the server farm for certain specialized solvers and modeling systems.

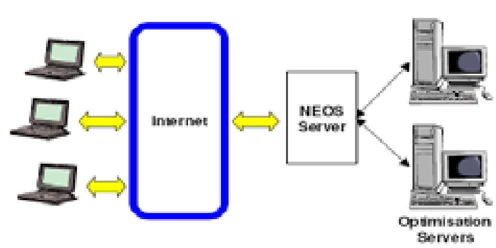

Figure 4. NEOS optimization server architecture

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Another example is the internet server optimization AURORA financial management system designed to address issues of financial planning using optimization method, in particular stochastic programming [Pfug et al, 2000]. Its purpose is to provide decision-making in the field of finance based on optimization models, the planning portfolio of securities, asset management and other problems. Optimization algorithms based on decomposition of dynamic stochastic optimization problems of large dimension. The system is based on a distributed architecture of server-type grid, with Web services as the main elements of the decision support system, [Foster et al, 2001].

In considering the issues of optimization on the internet it is important to know the phenomenon of ASP (Application Service Provider) which refers to organizations that provide services using the internet infrastructure , ie. manage and deliver applications to multiple users. This means that used company can rent access to applications over the internet with various modalities of payment for the service. This process will, in essence, the software is delivered as a service, usually with the help bpauzera (Internet Explorer, Fire fox, etc.) or the client.

Optimization services and other operational research methods can also be effectively delivered via the web service located on internet servers and display interface to users which they can access a set of functions and methods of the web service. Description of service is formally and explicitly given to software systems users can directly communicate with him. When a user detects a service that is available on the internet and understand the description and the interface, on him be accessed using XML based messages that are transmitted through the HTTP protocol and how to get the same result. The following languages and protocols are the basic technological base of Web services:

- XML (eXtensible Markup Language) is used as a data exchange format 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 publication of Web services interfaces, and
- UDDI (Universal Description, Discovery and Integration) provides a global registry for advertising, finding, and integration of Web services.

In the design optimization of distributed systems based on Web services, must be considered formats of communication between system components and communication components of the user. The user may want to access, say, modeling languages, or just a solver, or to both. To this end, the following four components may interact in a distributed syste :

* model in modeling languages,
* analytical data model requirements,
* an instance of the model (coefficient matrix), and
* results of optimization (information for decision making),

Need to create their XML form. Particularly large number of studies in this direction was to represent instances of the model in XML format [OptML, 2000], [SNOML, 2001], in order to MPS format for instances of linear programming model and the SMPS format for stochastic programming instance replacing the XML standard. It discusses the possibility that the model itself, rather instance which present in the form of XML, namely the language MathML [Carlisle et al, 2001].

Therefore, to improve the compatibility of the model in modeling language and solvers, it is necessary to adopt a standard representation of an instance model. It is important to distinguish between the model and its instances. The model is abstract algebraic representation model and its instance is an explicit description of the objective function and constraints. For example, an instance of linear programming model can be represented as a list not zero coefficients vector of the objective function and constraints and limitations of the matrix.

One of the important problems in the development of new algorithms solving the operations research library is formed test cases that will enable relevant comparisons of different algorithms. Test problems are usually presented in the form of text files without any semantic information about what each number represents, which can lead to various problems. Input programs are often misunderstood as some elements of the input causes erroneous results. Another problem is that the test examples are scattered on the internet and hard to find. Therefore, it is running a project where libOR test examples stored in XML format so that their validity checks using XSD (XML Schema Definition), which is constructed for each type of problem, [Wen et al, 2005]. The advantage of using XML format for test cases that test examples include semantic information, so that the examples and easy to read and easier to remove errors.

5- Conclusion

In this review paper describes the synergy MIS and OR who rely on the information infrastructure of the Internet. Models and methods of operations research are increasingly present in the Internet and that CI is fully received demanding functions of decision support systems. On the other hand, the application of operations research for solving real problems in the organizational systems that the geographic spread and base their business on the intensive use of the Internet, have been possible without CI.

Optimization today is not only a technological advantage the companies that use it, but also a significant factor for survival in the market. This fact has encouraged the development of optimization software to its effectiveness in the last ten years has increased by about 15 million times. It has made a significant contribution to the development of technology, several thousand times. But several times the contribution made in the field of development theory, and mathematics and methods of operations research. In the future we expect further progress in both directions in order to effectively solve models that will include larger systems, prefer real situations and inevitably be more complex than those that are now effectively solved. In addition, it will continue with the development of a software interface to the user so that the effective use of models and results will be available to a broader range of decision makers.

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