IBM ILOG OPL and Its Application in Teaching of Operations Research

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Abstract

In this paper, firstly, application areas of Operations Research are introduced. Some computer tool-kits used to solve OR problems are outlined, together with some programming languages, which can be used to model and solve the optimization problems. Secondly, an optimization programming language-IBM ILOG OPL is presented. Background knowledge about a high level programming language, data structure in OOP and relational database will facilitate the process of learning due to its highly abstract syntax and semantics. The connection between background knowledge and OPL is illustrated in detail. Lastly, the typical problems that IBM ILOG OPL can solve are introduced. This paper highlights the language features of OPL, focuses on its powerful data processing capability and application in teaching of Operations Research.
Keywords: *OR, OPL, teaching*

1. Introduction

Operations Research aims to solve decision-making problems in areas including engineering, social economy, scientific management, industry & agriculture production and military [1] (Baocong JIAO & Lanping CHEN, 2007). Generally, classic OR focuses on illustration of algorithm methodology such as linear programming, integer programming, dynamic programming, graph and network etc. With the rapid development of computer technology, applicability and practicability of OR are getting more and more attention. Some specialized computer tool-kits are developed to solve OR problems without the need to design and implement an algorithm with a programming language such as C, C++, Java, FORTRAN etc. And these software tool-kits, for instance, WinQSB and ORS, are playing more and more important role in teaching OR due to their usability and practicability. On one hand, those specialized tool-kits simplify modeling, solving and evaluating processing. On the other hand, data need to be tailored to satisfy the requirement of the software tool-kits, resulting in less flexibility [2].

Another computer-related skill involved in teaching OR is high level optimization programming language, including Lindo/lingo, AMPL, Matlab and IBM ILOG OPL etc. Solving problem with these optimization languages contribute to better understanding of OR methodology since users must present the models with specific programming language explicitly [3].

2. Requirements

For a practical OR problem, data may exist with different format and layout. Engineers need do some data preprocessing, including data selection, data transformation, and data

restructuring, validity of which decides the validity of model. IBM ILOG OPL protrudes itself among all OPLs in those aspects.

IBM ILOG OPL is endowed with unique syntax and semantics, apart from absorbing the essences of many programming languages, including tuple (struct), associate array, set, logic constraint and loop structure. Learner will acquire better learning efficiency when equipped with the following background knowledge.

2.1 Background Knowledge in General Programming Language

IBM ILOG OPL implements basic data type including int, float, string, Boolean, interval and sequence. Meanwhile, IBM ILOG OPL has complicated data structure, such as range, array, set and tuple. Data, array, set of tuple type qualify IBM ILOG OPL a powerful language in solving complicated OR problem, in which, data structure is complicated, data format and layout is diversified. Hence, background knowledge about a general programming language will make learners understand IBM ILOG OPL better and faster.

2.2 Background Knowledge in Relational Database

For a sophisticated model, logic structure and its physical implementation of logic structure of OPL determines the complexity and adaptability of OPL model, which determines declaration and initialization of data, definition of objective function and expression of constraints. Reasonable design of logic structure and implementation of data structure lead to an easy, understandable and more adaptable model.

IBM ILOG OPL implements self-defined type-tuple to define single data, set, and array of tuple. The methodology of tuple, which is analogous to tuple of relational database, is counterpart of entity of conceptual model and relation of logical model and table of physical model. Programmers can manipulate data of tuple type as much as records in rational database. Usually, data in different tables or worksheets need to setup a relation to form a new set of new tuple type according to some specific rule through all kinds of joining operation, such as cross join, conditional join etc. Engineers can guarantee the entity integration such as domain integrity, referential integrity and use-defined integrity through manipulating OPL syntax. Aggregation operator, such as max, min, sum, can be used in forming objective function, constraint, which are analogous to aggregation functions of relational database.

For a practical modeling, raw data is usually stored in database. The records in a database exist in the form of set data of tuple type. Generally, this kind of data is not compatible with data requirement of modeling, data transformation is needed to transform set data into usable data. Generic indexed array and generic indexed set and associate array equip IBM ILOG OPL with powerful capacity to transform data from one form to another to meet the need of the model.

In expressing objective function and constraints, data are usually grouped into a group according to some field of a set, which is called slicing. Aggregation operators including summation, production, and min, max are usually applied on a numerical field of each group of sliced data that need to satisfy some constraints. This operation is more effective when OPL model uses sparse storage data structure to store model data. The whole thinking process corresponds to the ideology of grouping in SQL. Slicing operation is necessary in modeling

complicated optimal problem. Having some background knowledge about relational database will significantly lower down the difficulty of grasping slicing skill in OPL.

2.3 Background Knowledge in OOP and Data Structure in OOP

IBM ILOG not only implement OPL language which focuses on modeling- expressing data, decision variables, objective function and constraints, but IBM ILOG script language to combine model and data and interact between them, which is mainly used to data prepossessing, data post-processing and flow control. IBM ILOG Script language is an implementation of JavaScript. In data preprocessing, model parameter can be configured. Model data can be initialized. In data post-processing, optimal solution can be displayed or transformed to a form that is easy to verification or inspection. Flow control is used to drive the model to run in a consecutive way, during which, model data can be added, modified and deleted. Furthermore, solution comparisons and analysis between different data can be done to solve more complicated problem.

Some OR problems cannot be solved only through setting up mathematical model and OPL model. IBM ILOG Script language can interact with IBM ILOG OPL model, so to solve some complicated OR problems. TSP problem has always been a hard problem with high complexity. By designing complicated data structure and implementing some specific algorithm to manipulate the intermediate data in flow control, together with data pre-processing and data post-processing and loop control with IBM ILOG Script language, TSP problem can be solved in IBM ILOG OPL. The data structure in this model is a weighed network and the algorithm which aims to search the circle in this network is implemented. Data structure knowledge in OOP will significantly speed up the understanding of IBM ILOG Script language, make it a powerful complementary language tool in modeling complicated optimization problems. So, knowing some OOP definitely will benefit the application of IBM ILOG Script language.

3. Applications

IBM ILOG OPL and Script language can be integrated into all branches of Operation Research. The problems which can be formulated into Linear programming, integer programming, graph and network analysis can be solved by cplex engine. Dynamic programming which can only rely on implementing an algorithm with a high level programming language, now can also be solved by IBM ILOG Script language. Some complicated application with optimal methodology in it, which can not be solved simply through other Optimization language in the past now can be solved through IBM ILOG Script language through controlling the flow of OPL model. Even some algorithm, which can be exclusively implemented with high level programming language in the past, now can be implemented, for example, Traveling salesman Problem, Center of Graph etc. (Lixin zhao & Lishuan Hu, 2015). Schedule problem is a special sort of optimal problem which has extensive application in real life. Schedule problem and combinatorial optimization problem can be solved by CP engine.

Apart from solving the optimal problem itself, with IBM ILOG Script language, high-demanding sensitive analysis besides fundamental sensitive analysis can be implemented due to integrating IBM ILOG Script language with IBM ILOG OPL together.

4. Conclusions

Operations Research is an important fundamental course in many disciplines, aiming at developing quantitative analysis skill of engineers in all fields. IBM ILOG Optimization Programming Language and IBM ILOG Script Language facilitates solving optimal problem with computer. All kinds of engineers can solve the optimal problems in their field without the need to know the underlying mechanism of optimization and to learning a general programming language. More importantly, IBM ILOG OPL model has strong adaptability, which enable it to be extended to relevant application with ease. IBM ILOG OPL has been used to solve the optimization problems for many fortune 500 enterprises. A large number of universities globally are using the solution from IBM ILOG OPL. So, integrating IBM ILOG OPL into OR makes theory and practice complemented with each other, enhance each other, makes students more competitive in their career.

Acknowledgement

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