Chapter 12

Bridging the Gap Between Theory & Practice in Optimum decision Making

This is Chapter 12 of "Junior Level Web-Book *Optimization Models for decision Making*" **by Katta G. Murty.**

"Optimum Decision Making" is known by a variety of names, the most common seems to be Operations Research/Management Science (abbreviated as ORMS), which we will use.

In ORMS, theoreticians have focussed their attention on developing algorithms that can be rigorously proved to be efficient by mathematically accepted efficiency criteria. This seems possible only for very specialized problems which are highly structured.

Unfortunately, most real world problems lack this type of structure, and the special features needed to develop a mathematically elegant algorithm to solve them. Also, most real world problems are often far too complex, and it is very difficult to fit them into a single elegant mathematical framework. Having to deal with such problems in their daily work, practitioners get frustrated that none of the techniques developed by theoreticians applies directly to their problems.

So, over the years a kind of animosity has developed between the two groups (theoreticians, practitioners). In fact this is what they say about each other:

Practitioners say that Theoreticians **do nothing practical**

Theoreticians say that Practitioners **do practically nothing**.

Ever since my graduation, I have been working in both theory and practice of optimization methods. So, I belong to both the groups, and have learnt to appreciate the admirable features in, and the limitations in the work of both. After all, in the ideal, the ultimate goal of all human endeavor is to make this a better world, which essentially depends on the decisions we make.

In this brief final chapter, my goal is to share with you some of the lessons I have learnt as a practitioner, and to explain my view of the role of theory in real world decision making.

1. **Single versus Multi-objective features:** Elegant algorithms have been developed in theory, only for some single objective decision making problems. In practice, most real world decision making problems require the simultaneous optimization of several conflicting objective functions (i.e., they are really multi-objective problems), for which there is no elegant theory. This itself requires some heuristic modeling approaches to model those problems using approximate single objective models.

   Multi-objective modeling is beyond the scope of this book, but it will be discussed in the sequel, Volume 2 of this book at Master's level.

2. **Intelligent modeling essential:** Techniques developed in ORMS theory are extremely important tools for tackling real world decision making problems, but to get good results they have to be used intelligently along with apropriate heuristic modeling approaches. For some problems, no single theoretical technique may be adequate, several techniques may have to be used in combination with each other.

   Decision making without using ORMS techniques essentially boils down to evaluating very few (often one or two) alternatives, and selecting one among them for implementation. Often this leads to bad decisions, and bad decisions are being made daily because of it.

   So, effective decision making needs a good knowledge of the details of various ORMS techniques, and modeling approaches. The daily work of all engineers, management and business personnel involves decision making at some level, so it is very important for all students planning to enter these professions to acquire this knowledge.

   Since this book is aimed at the Junior level, some higher level modeling approaches have not been discussed here. That's why, even though we have tried to illustrate each technique with several modeling examples, we have not presented any instances comparing standard versus intelligent modeling. Some of these will be shown in Volume 2 of this book.

3. Heirarchical approach: Many real world decision making problems tend to be large scale problems involving numerous decisions at many levels, and sometimes even over several periods on a long planning horizon.

To guarantee finding the truely optimum solution for such a problem, theoreticians try to fit the whole problem into a single mathematical model. But sometimes even constructing such a model turns out to be impossible. Even if such a model is constructed, there is usually too much uncertainty in the values of data elements at later levels or periods. This data may depend on feedback from decisions at earlier levels or periods, and uncertain events that may occur as a consequence of them. The only practical approach to handle these problems may be a heirarchical approach in which the subproblem in each level or period is studied by itself, using the feedback obtained from decisions made earlier.

4. Substitute objective functions: In some real world decision making problems, optimizing the original objective function may be a hard problem for which there is efficient algorithm. If there is another objective function satisfying:

- it is highly correlated with the original objective function
- optimizing it subject to the original constraints is a much simpler problem for which there is an efficient algorithm

then it is called a *substitute objective function* to the problem. We can take the solution optimizing this substitute objective function, as a reasonable solution for the original problem. This is called *the substitute objective function technique.*

5. Heirarchical decomposition with substitute objectve functions for each stage: This technique is based on the heirarchical approach in 3, together with the substitute objective function technique in each stage as necessary. For applications of this technique see ([Murty, Djang, "The US Army National Guard's Mobile Training Simulators Location and Routing Problem", *Operations Research*, 47, no. 2, Mar-Apr 1999, 175-182], [Murty, Liu, Wan, Linn, "A Decision Support System for Operations in a Container Terminal", *Decision Support Systems*, 39, no. 3, May 2005, 309-332], [Murty, Wan, Liu, Tseng, Leung, Lai, Chu, "Hongkong International Terminals Gains Elastic Capacity Using a Data-Intensive Decision-Support System, *Interfaces*, 35, No.1 Jan-Feb 2005, 61-75]).

6. Relaxation: If the original problem is hard to solve because of a few hard constraints in it, temporarily ignoring those hard constraints leads to a relaxed problem that can be solved efficiently. In fact this is the main strategy on which the branch and bound approach for integer and combinatorial optimization problems is based.

This technique tries to obtain good solutions to the original problem, using appropriate relaxations and then trying to modify their optimum solutions.

7. **Heuristic algorithms:** When there is no efficient algorithm to solve the original problem, this technique uses a heuristic algorithm to obtain good solutions for it.

   The importance of heuristic approaches in modeling, and heuristic algorithms to get reasonable solutions to the model cannot be overemphasized.

In summary, there is a wide gulf between the problems that theoretical techniques can handle, and real world problems; as illustrated in the following figure. The things that serve as a bridge across this gulf are: *intelligent modeling, heuristic modeling approaches, heirarchical decomposition, substitute objective functions, heuristic algorithms, and relaxations.* So it is important that students not only learn the details of theoretical techniques, but also become familiar with these *bridging techniques* if they are likely to seek careers in practice.

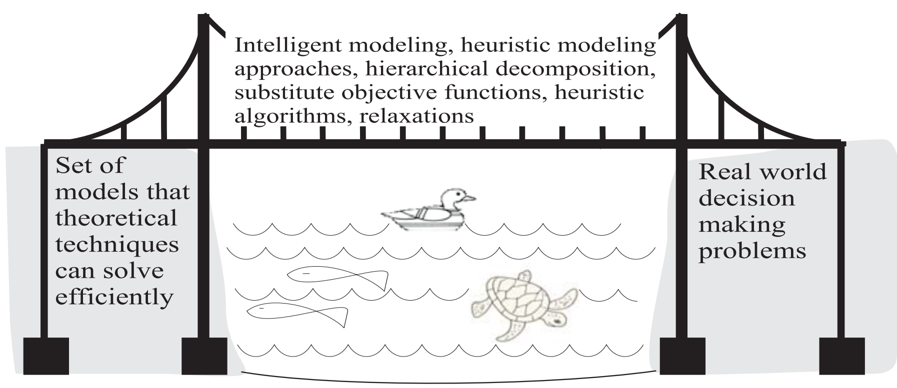

Figure 12.1: "Mathematical models for which we have theoretically efficient algorithms" and "real world problems we encounter in practice" are like the two banks of a very large river wirh a wide gulf between them. "Intelligent modeling, heuristic modeling approaches, heirarchical decomposition, substitute objective functions, heuristic algorithms, relaxations" serve as a bridge for this gulf.

12.1 References: Selected Books for Further Reading

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