Cyberinfrastructure, Operations Research, and Entreprise-wide Applications

Roger J-B Wets, *University of California, Davis*

Almost every field of human endeavor has profited from the development of solution procedures for decision making models, in particular, the methodology developed for linear and nonlinear programming models. However, almost all important decision making problems are, in reality, *decision making problems under uncertainty.* Ignoring uncertainty often carries a very high price: the solutions generated by an over-simplified 'deterministic' version of the problem often aren't robust and are sometimes seriously misleading. By treating all environmental parameters as completely known, deterministic decision making models produce unreliable decisions: they seek solutions that are ideal, but which are valid only if a very specific situation is actually realized. Some of the main reasons for ignoring uncertainty include: technical limitations in computing power, the lack of an appropriate optimization methodology, and the unavailability of user-friendly standards for describing uncertainty. In particular, this is the situation in a large collection of problems that arise in Design, Manufacturing and Services.

Dealing with uncertainty in an optimization model, involving those applications as well as many others, requires dealing with the following issues

- large scale optimization methodology and the validation of approximation schemes,
- make the interaction between model-building, in particular the description of the undertainty, user-friendly; this might require the building of appropriate modeling languages
- provide solution analysis benchmarks, since approximations will be required in a substantial number of 'practical' implementations.
- finally, have a 'central' processing unit that coordinates the development of the different component of the cyberinfrasturcture.

This idea—that a decision needs to 'hedge' against an uncertain future—highlights an inherent feature of models for decision making under uncertainty: the complicating role of system dynamics. In other words, some decisions are made prior to observing the uncertain components of the problem and, usually, another round of *recourse* decisions will make adjustments after the values of these uncertain parameters have been completely, or partially, realized. The most important and challenging class of such decision models are those where the uncertainty is only revealed in stages, with the possibility that some corrective action (or recourse decision) can be made at each stage. It this challenging class of problems that should be the focus of the project being considered.

Implicitly, the methodology I suggest developing is based on that of *stochastic programming*, a well-documented approach to decision making under uncertainty. The canonical stochastic programming application takes a planning model and couples it with a model for the dynamic and stochastic nature of the data and decisions. Typically, the planning problem might well have been developed using an external logistics planning application, whereas the stochastics might have been obtained from some statistical software package. A fundamental aspect of stochastic programming is this emphasis on seamlessly linking planning processes with *high-performance tools for analysis.*