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Applications to Industrial problems

* Introduction

mathematics has been called the language of science mathematics is used to solve many real-world problems in industry, the physical science, life sciences, economics, social & human science, engineering & technology, for ex. mathematics was used to build many of the the ancient wonders of the world such as the pyramids of Egypt, the Great wall of china the hanging gardens. of Babylon, the Taj mahal of Agra & the like.

Early modern industrial engineering modeling tools were developed by Taylor, the Gilbreths and Gantt. They proposed procedures to Improve operations and check the progress of multiple work activities. the early project management techniques included project evaluation and review techniques and the critical path method. These are still used today to help manage large project

Early mathematics (computations, statistics and accounting) has been applied to operation problems in administration and in managing technical activities by public administration, engineers & managers The focus of this contribution is on the use of mathematics to solve industrial problems we disuss as well the many areas of mathematics

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variety & industrial problems to which mathematics has come to aid.

* Types & models
some mathematical method are used to generate possible candidate decisions or solutions to problems other models can be used to evaluate particular, possible sets & decisions (see suri, 1985)

* Generative models
Mathematical techniques such as linear, integer, dynamic & nonlinear programming generate solutions to particular problems. other generative models in clude differential equations, network flow models decision analysis, number theory, tabu search, genetic algorithms, fluid dynamics & game theory. Generative models help to resolve complex situtations and can provide candidate solutions. Assumptions always have to be made that simplify the problem, in order to get a solution. Assumptions can make the original problems unrealistic. often the simplifying assumptions may have no bad effect on the applicability & a found solution. modeling skills help a person to develop a model that can really be used by industry.

* Evaluative models

other types of mathematical models can be used to evaluate solutions to various industrial problems according to different, relevant performance measures. some evaluative model include queueing models and queueing network theory, petri nets, decision models data envelope analysis, simulation & perturbation analysis. many of these are discussed in subsequent sections.

models and solution Algorithms

It is Important to distinguish models and solution algorithms. A model describes a situation. models are a representation of a problem. A solution algorithm finds one (or more) solutions to the situation or problem. There could be a variety of algorithms or methods to solve the problems For example, as well see soon, the total cost equation is a model for an inventory problem. we could "solve" this model either using calculus, or by setting up a spreadsheet Just by graphing it in excel.

Industrial Deasign problems.

These and other mathematical models have been used to solve a variety of industrial. problems. some industrial design problems include the design of aircraft and automobile and the ~~deg~~ design & a manufacturing system (using closed queueing networks or simulation for examples)

* Industrial planning problems

Many types & planning problems are solved using mathematics. Aggregate planning problems involve making decisions on workforce and capacity over a long period & time, say over a year's time period. See Nahmias (2005). These decisions are made assuming a forecast & demand & provide constraints on the actual day-to-day operations. Many such real, large aggregate production planning problems are solved using linear programming.

In automated manufacturing a variety & planning problems need to solved before actual production can begin. In particular a set & part types has to be selected to be machined over some upcoming period & time. (Integer programming can be used to select a candidate set & part types. Simulation or queueing models or petri nets can be used to evaluate candidate solutions (set & part types) according to the appropriate measures & performance)

The cutting tools required for each operation & each selected part type have to be allocated to some machine or machines again, before production can begin nonlinear interger programming has been used to solve such problems. Again, simulation or queuing theory or petri nets have been used to evaluate the goodness of the solutions.

Industrial scheduling problems

There are many types of scheduling problems. The solutions to aggregate capacity planning problems provide constraints to detailed scheduling problems. For ex., the number of workers of different types and different skill levels many have been decided at an aggregate level. These workers need to be allocated to 8-hour shifts over 5-day work weeks, perhaps over shifts/day. Also these workers may need to be allocated to workstations (machines or equipment)

The aggregate production planning problems are actually quite simple because so much information has been aggregated! Linear programming then suffices to provide a good solution.

However, disaggregating & detailed minute by minute scheduling is a very difficult problem because there are usually so many (too many) scheduling possibilities to consider. Unless a workforce scheduling problem is very small, it is very difficult to optimize to find a very good solution. Often, heuristics, or rules of thumb, are used to try to find an acceptable feasible schedule.

The difficulty of the scheduling problems increases when the goods that need to be manufactured are considered. The production of every product type requires many components. The production of every component may require many operations of different types (i.e. milling, drilling, forming & tapping) Each operation (drilling, forming.) requires some time to process it, some workstation to process it and somebody to perform the operation. There is a partial precedence among the operations some operations have to be finished before others can begin; for some operations it doesn't matter which are performed first.

- Various raw materials have to be on hand to begin some operations. These are inventory problems, discussed in the next section. The problem difficulties increase when the due dates for the different products need to be considered. Many different mathematical models have been used to solve both the variety of industrial scheduling problems and to evaluate the goodness of proposed solutions. Of course a wide variety of performance measures exist. Each is appropriate under different circumstances and for different types of scheduling problems.

Mathematical programming.

Mathematical programming has been used often to provide solutions to many industrial problems.

linear and nonlinear programming problems have been described in earlier section. A good example can be found in kim et el. (2003). They develop a life cycle optimization model to determine optimal vehicle life times, accounting for technology improvement & new. model, while considering deteriorating efficiencies & existing models. The model uses dynamic programming. Input parameters include material use, energy, emission factors & fuel economy over a 36- year time horizon.

Baker (2000) describes five nine linear programming problems & solutions. Insights into the problems are provided by analyzing the sensitivity & the optimal soutions. other linear programming problems & their applications are provided in Hillier & Lieberman (2005) & Nahmias (2005)

Decision Analysis

There are many useful techniques to structure problems that have multiple objective. These include multi- attribute utility theory and the analytic hierarchy process. These are useful for when a group needs to make a decision. AHP uses pairwise comparisons & alternatives to help arrive at a" good or best choice".

Figure shows a Flowchart of a decision analysis process. Variations of this chart can be conceptualized.

A survey by Keefer et al. (2004) provide references to many applications of decision analysis methods. Some of these applications include real options, purchasing equipment, new product strategies, telecommunication applications & others.

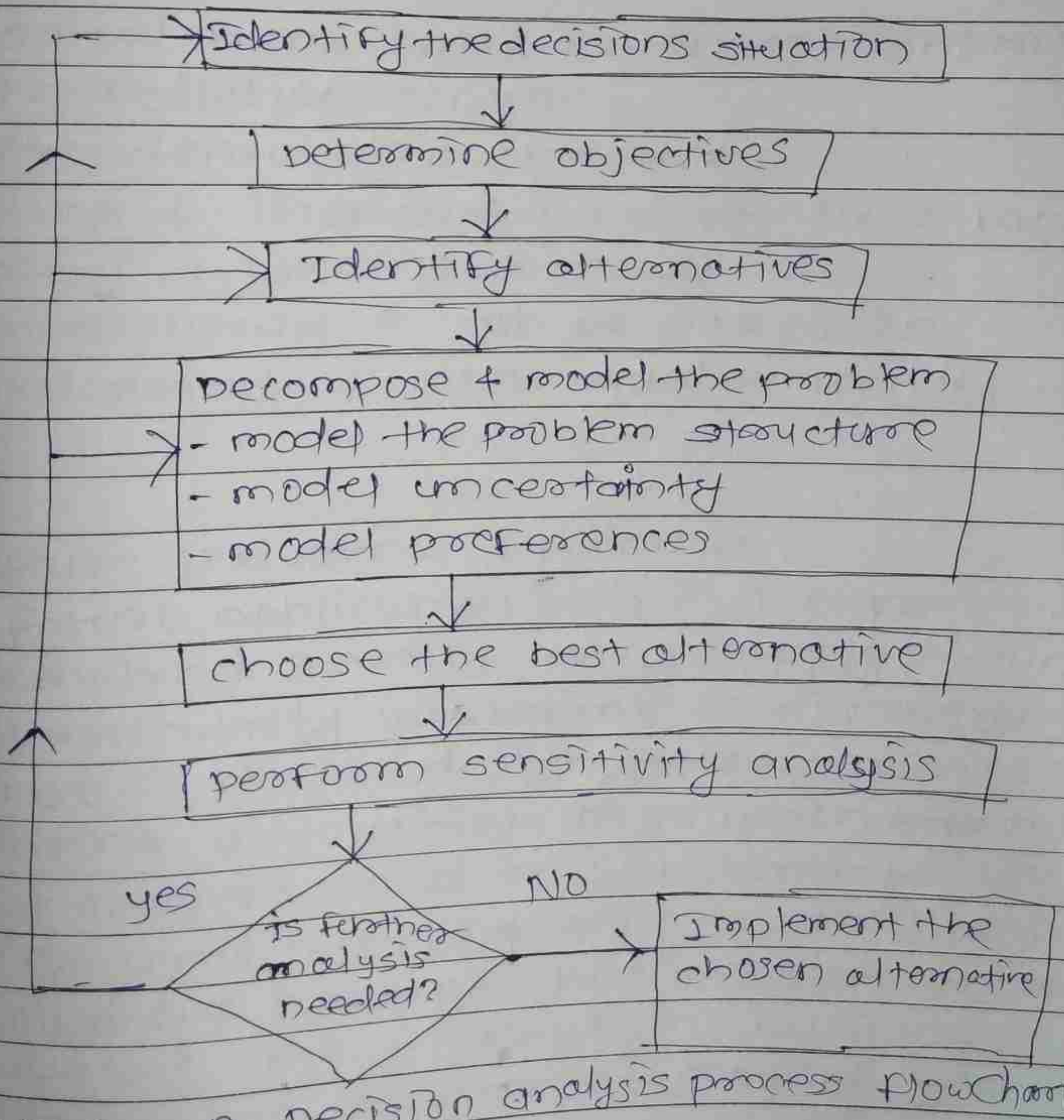

Figure :- A Decision analysis process flowchart.

keeney & Raiffa (1976) provide many examples of decision - making problems under uncertainty. There are often preference for possible consequences or outcomes. some of ~~their~~ their examples.

- Electrical power versus air quality
- Airport location
- Heroin addiction treatment
- medical diagnostics & treatment.
- Business problems
- Hospital blood bank inventory control
- Air pollution control
- fire department operations
- siting & licensing of nuclear power facilities
- safety of landing aircraft
- transporting a job or profession.
- development of water quality indices

A future Industrial Application

A future application falls in the ~~sch~~ realm of homeland security. many supply chains are particularly vulnerable to disruptions because of their design characteristics & operating philosophies. Disruption effects on direct targets could be substantial. Long lasting and rippling effects could be felt throughout multiple business sectors ~~be~~ because of the increase in business interrelations. A current complex JIT environment creates supply chains that integrate many private and public entities with unclear contingency plans and roles in a disaster. JIT also provides insufficient buffers to absorb unusual system disturbances in supply networks. Since most companies operations are not flexible enough for essential quick reponses, disruptions can create bullwhip and queueing effects. The amplification of demand variability from a bullwhip effect can cause increasing ~~ne~~ negative economic effects further upstream and downstream.

References

Baker, K. (2000), "Gaining Insight in Linear programming from patterns in optimal solutions." INFORMS Transactions on Education, vol. 1 No. 2,