Influence Diagrams as a Tool for Decision Support System Design

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INTRODUCTION

This article examines the application of a modeling technique called influence diagramming to decision support system (DSS) analysis. Influence diagrams allow the development of a model of the natural (at least from the perspective of the decision maker) structure of a decision situation. These diagrams are simple to develop and understand, providing the DSS analyst and the decision maker with a useful basis for communication. The diagrams can also be easily translated into specifications detailing the design of a computer-based system. In particular, influence diagrams are well suited to the specification and description of spreadsheet-based models commonly used in contemporary decision support systems.

BACKGROUND

The process of conventional information systems analysis involves the development of a model or a series of models of the system under investigation. The systems analyst has a variety of modeling tools available, most including data flow diagrams, entity-relationship diagrams, use case diagrams, and class diagrams, to describe various aspects of the information system being designed (Avison & Fitzgerald, 1995). Within each methodology, the decision as to which of the available modeling tools is to be used and how detailed to make each particular model is, generally, left to the systems analyst. For example, in an application that is data strong/function weak, an analyst will mostly concentrate on the development of a data model rather than on the development of a detailed process model.

Since the inception of computer-based decision support, it has been generally recognized that the decision support systems (DSS) analyst requires different skills to those needed in conventional systems analysis (Gorry & Scott-Morton, 1971). DSS are usually defined as applying to problem domains that are semi-structured. By definition, this lack of structure means that at the outset of a DSS development effort, detailed systems specifications are difficult to develop. As detailed specifications cannot be produced, the DSS analyst adopts a middle-out design approach (Arnott, 2004; Keen, 1980; Raghavan & Chand, 1989). By building a prototype system, the analyst provides the user with a tangible example of the sort of system that might be developed. The user's reactions to each prototype that the analyst develops helps more fully understand the user's needs and requirements. As this prototyping process continues, the decision support system's interface, functionality, and the models incorporated within the system will be refined.

This process of adaptive development provides an environment in which the decision maker can develop a better understanding of the decision that they are making. Each prototype version of the DSS represents the decision maker's evolving understanding of the problem that they are faced with and the support that they require.

Clearly the development of a DSS by adaptive, evolutionary methods is a necessary and desirable aspect of the development of a DSS. Given this need for evolutionary development, and the impossibility of initially developing program specifications that are complete, what analysis tools are appropriate for the DSS analyst to use when developing a DSS?

There is no simple answer to this question. The conventional systems analyst has available a number of modeling tools and uses which ever of those are appropriate for a given project. The situation should be no different for a DSS analyst. The DSS analyst should

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have available a number of modeling tools that can be used, where appropriate, to assist in the development of the design of a DSS.

In DSS, in general, an understanding of process and of data is not as important as developing an understanding of the nature of the decision process that is being supported. This does not mean that conventional system development techniques such as data flow diagramming, entity relationship diagramming, and UML-models are not useful tools for a DSS analyst. However, additional tools that allow the DSS analyst to model decision structure will also have great value.

Influence diagrams are gaining in popularity in a number of modeling disciplines. As an influence diagram provides "a formal description of [a] problem that can be easily understood by people in all walks of life and degrees of technical proficiency" (Howard & Matheson, 1981) they are likely to be a modeling tool of some value useful to a DSS analyst when developing a model of decision structure.

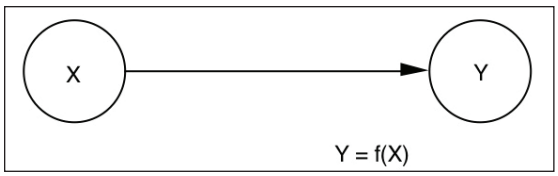
INFLUENCE DIAGRAMS

Influence Diagrams in Decision Analysis

Influence diagrams, which have their foundation in mathematical graph theory, are a form of acyclic digraph. A digraph is a visual representation of a set of nodes, and a set of ordered pairs of those nodes—represented by visually by arrows linking the nodes. Figure 1 illustrates a simple influence diagram that consists of two nodes X and Y and one arc directed from node X to node Y. This diagram should be interpreted as indicating that the value of X has some influence on the value of Y (Owen, 1979), that is Y = f(X). Some prefer the term "relevance" to "influence" (for example, Howard, 1990) arguing the arc directed from node X to node Y should be read as "The value of the variable X is relevant when determining the value of the variable Y."

Influence diagrams are used in systems dynamics, knowledge-based systems, decision support systems, and management science. Relatively new systems of automated reasoning, fuzzy cognitive maps, and probabilistic expert systems also rely on modeling techniques that are based upon influence diagrams. However, the most important application of influence diagrams has been in the area of decision analysis.

Figure 1. A simple influence diagram (after Owen, 1979)



Decision analysis is a structured approach to analyzing a decision situation and making a decision (Keeney, 1992). The most commonly used tool in decision analysis to graphically describe a decision situation is a decision tree (Goodwin & Wright, 2004). Decision trees depict all the possible combinations of decision outcomes to be described. A decision tree allows the explicit representation of two variable types: variables that represent decisions and variables that represent different states of nature (Stair, Hanna, & Render, 2005).

To illustrate the use of decision trees and influence diagrams in depicting and analyzing decision situations, the following problem will be used.

Sunshine Escapes is a company that operates a chain of hotel resorts. They operate two different categories of resort: one aimed at the budget/backpacker market, the other aimed at those travellers looking for deluxe five+ star accommodation. The company has recently been approached with an offer of a parcel of land that they can occupy and develop on a long-term lease basis. The land is located on an island in the South Pacific whose government is attempting to shift the basis of the economy from primary industries (mostly the mining of seabird guano for fertilizer) to tourism. The buzz in the tourist industry is that this currently sleepy island nation, off the beaten track, is going to be the "next big thing."

Analysis by the management team of Sunshine Escapes sees a couple of potential outcomes. If the island government succeeds in fostering a strong tourist industry, then a luxury resort would likely deliver a strong annual profit of $35 million. A budget/backpacker resort would likely return less in the same circumstances ($11 million). However, should the government's plan fail, the luxury resort would loose $10 million, while the budget/backpacker resort would only lose $2 mil-

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