

# PREFACE

An important concept in the design of many information processing systems – such as transaction processing systems, decision support systems, and workflow systems – is that of a graph. In its simplest form a graph consists of a set of points (or nodes) and a set of ordered or unordered pairs of nodes (or edges). If the pairs of nodes are unordered, the graph is called a simple graph, and if they are ordered, the graph is called a directed graph, or digraph. In both cases, the graph represents a network through which materials, people, information, etc. can flow. The difference is whether the flow is restricted to one direction or whether there is no such restriction.

Simple graphs and digraphs allow for the construction of a variety of diagrammatic system design tools – such as entity-relationship diagrams, functional dependency diagrams, data flow diagrams, Petri nets, semantic nets, and the like. We note that most of these tools are representational, not analytical. That is, they provide a convenient and visually appealing format for illustrating information infrastructures, while allowing any subsequent analyses to be performed by the user.

Another problem with such graphical structures is that they usually associate individual information elements and not sets of elements. Yet in many cases it is necessary to associate sets of elements – such as multiple attributes in data relations, multiple variables in decision models, multiple logical variables in decision rules, and multiple documents in workflow systems. Furthermore, it may be necessary to integrate data relations, decision models, decision rules, and workflows into an integrated information processing system. Two multiple-element structures, hypergraphs and higraphs, allow a few such representations, but they have their limitations.

A recently developed graphical structure that overcomes the limitations and shows great promise in modeling information processing systems is a *meta-graph*. Metagraphs are more complex than the graph structures described above, but they allow representation and analysis of more complex systems. Although there is a substantial literature on metagraphs, this is all in the form of journal articles and papers in conference proceedings. There have been no books presenting a comprehensive picture of the foundations of metagraphs and the applicability of these foundations to the design of information process-

ing systems. This book attempts to fill that gap by providing a single and comprehensive treatment of metagraphs.

We begin with a brief introduction to metagraphs. A metagraph is a collection of directed set-to-set mappings. Although this is a simple definition, it leads to several powerful theoretical results and several interesting applications. We then present the material in this book in two parts. The first develops the theoretical results. Although we will include diagrams for purposes of exposition, the emphasis will be on the development of a metagraph algebra. This is a matrix algebra defined over the elements and edges of a metagraph, resulting in incidence and adjacency matrices. This in turn will lead to a more sophisticated view of paths in a metagraph, resulting in the concept of a metapath. We will also be concerned with (1) certain transformations of metagraphs, especially the projection of a metagraph to produce a simpler metagraph, (2) conditional metagraphs, in which the calculations performed early in a metagraph process determine the structure of the later part of the metagraph, and (3) submetagraphs that are largely independent of their containing metagraphs.

In the second part of the book we will examine four promising applications of metagraphs. The first is the modeling of data relations, each of which is viewed as a mapping from a set of key elements to a set of content elements. The second is the modeling of decision models, each of which is viewed as a mapping from a set of input variables to a set of output variables. The third is the modeling of decision rules, each of which is viewed as a mapping from a set of logical antecedent variables to a set of logical consequent variables. The fourth is the modeling of workflow tasks, each of which is viewed as a mapping from a set of input documents to a set of output documents. We will apply the theoretical results of the first part of the book to the application areas of the second part.

We conclude this book by briefly examining several possible extensions of this work. Of special interest is the structuring of the metagraph modeling process, which may enhance the body of work on systems analysis and design (and also software engineering), the development of a metagraph workbench to support such a process, and the possible application of our results, suitably enhanced, to social networks.



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