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978-0-521-55232-5 - Island Networks: Communication, Kinship, and Classification
Structures in Oceania

Per Hage and Frank Harary

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In their previous book, *Exchange in Oceania*, anthropologist Per Hage and mathematician Frank Harary demonstrated that models from graph theory, a branch of pure mathematics, provide the essential basis for analyzing the great variety of exchange systems in Micronesian, Melanesian, and Polynesian societies.

In this new book the authors extend these models and apply them to the analysis of communication, kinship, and classification structures in the island societies of Oceania, presenting the relevant topics from graph theory in a form accessible to the nonmathematical reader. The research problems include the formation of island empires, the social basis of dialect groups, the emergence of trade and political centers, the evolution and devolution of social stratification, the transformations of marriage and descent systems, the historical development of kinship terminologies, and the reconstruction of protosocieties.

Island Networks is at once a unique and important contribution to Oceania studies, anthropology, and social network analysis in general.

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The series *Structural Analysis in the Social Sciences* presents approaches that explain social behavior and institutions by reference to *relations* among such concrete entities as persons and organizations. This contrasts with at least four other popular strategies: (a) reductionist attempts to explain by a focus on individuals alone; (b) explanations stressing the causal primacy of such abstract concepts as ideas, values, mental harmonies, and cognitive maps (thus, “structuralism” on the Continent should be distinguished from structural analysis in the present sense); (c) technological and material determinism; (d) explanations using “variables” as the main analytic concepts (as in the “structural equation” models that dominated much of the sociology of the 1970s), where structure is that which connects variables rather than actual social entities.

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Island networks

Communication, kinship, and classification structures in Oceania

Per Hage

University of Utah

Frank Harary

*New Mexico State University and
the University of Michigan*



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To Claude Lévi-Strauss

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Islands have always gripped man's imagination.

Ernest Sabatier, *Astride the Equator*

The legitimacy of the comparative method does not rest on massive and superficial resemblances. Analysis has to take place on a level deep enough to allow us to discern, at the base of all social life, the simple features that combine into rudimentary systems, which may eventually become the stuff of more complex and more completely integrated systems with entirely new characteristics.

Claude Lévi-Strauss, *The View from Afar*

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Preface

This book is the third work in a comprehensive program of research on applications of graph theory to anthropology. Graph theory is an explosively developing branch of pure mathematics with increasingly important applications to many fields, including architecture, biology, chemistry, computer science, cognitive science, economics, geography, and operations research. It is our belief that anthropology belongs with this company of subjects. Our aims are (1) to solve certain theoretical and methodological problems in anthropology by using the concepts, theorems, and techniques of graph theory; (2) to provide a common framework for structural analysis by demonstrating the applicability of graph theory to a wide spectrum of social and cultural phenomena; (3) to promote connections between various areas of anthropology and between anthropology and other disciplines in which graph theoretic modeling has proven useful; (4) to preserve continuity with the historical tradition of structural analysis in anthropology; and (5) to make graph theoretic models accessible to all structurally minded anthropologists and other social scientists.

In our first book, *Structural Models in Anthropology* (Hage and Harary 1983), we presented graph theory as a family of models for the analysis of social, symbolic, and cognitive relations. We used graphs, digraphs, and networks, together with their associated matrices, to study such diverse topics as mediation and power in exchange systems, reachability in social networks, efficiency in cognitive schemata, and productivity in subsistence modes. We exploited duality laws for graphs and the interaction between graphs and groups to analyze transformations and permutations in myths and symbolic systems. Much of the inspiration for that book, as for all of our research, came from Claude Lévi-Strauss's (1949, 1962) theories, which focus on the logical, combinatorial, and isomorphic properties of kinship and classification systems, prefiguring the application of finite mathematics to anthropology.

In our second book, *Exchange in Oceania* (Hage and Harary 1991), we extended the graph theoretic analysis in *Structural Models in An-*

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thropology to provide an essential basis for the description, quantification, simulation, enumeration, and notation of the great variety of exchange systems found in Polynesian, Micronesian, and Melanesian societies. We used bipartite graphs and hamiltonian digraphs and networks to elucidate the cyclic structure of marriage and ceremonial exchange systems, and markov chains to simulate network flows. We introduced the concept of sex duality in graphs to study systematic variation in kinship structures and used binary operations on graphs, and group theory, to reveal the underlying structure of anatomical and physiological beliefs associated with different types of exchange structures. The theory of relations, which is coextensive with graph theory, provided a means for analyzing the higher-order logical structures implicit in an array of exchange and communication networks.

The present volume introduces a set of graph theoretic models for the study of communication, kinship, and classification networks in Island Oceania. The research problems concern the formation of overseas empires, the social basis of dialect divisions, the emergence of trade and political centers, the evolution and devolution of social stratification, the transformation of marriage and descent systems, the replication of ideological systems, the historical development of kinship terminologies, and the reconstruction of protosocieties. The graph theoretic models essential for the study of these problems are six in number: (1) Trees, including rooted trees and binary trees and the spanning tree of a graph, describe the basic anatomy of kinship and communication networks and taxonomic structures. (2) Minimum spanning tree algorithms provide methods for analyzing clustering and classification in numerical networks and provide models for simulating processes of network growth. (3) Search trees serve as models of stratified descent groups and are the basis of the shortest-path algorithm used in the exploration of evolutionary mazes. (4) Centrality concepts define the different senses of advantageous location in voyaging and trade networks. (5) Dominating sets describe distributional aspects of economic and political power. (6) Digraphs, including semilattices, articulate the underlying structure of evolutionary theories of social organization based on genetic reconstructions as well as formal logics.

Our study broadens the scope of Oceanic anthropology in several important respects: (1) We increase the range of theoretical problems that can be formulated and solved as network problems. The definition of central location in a trade network is obviously a network problem, but so is the derivation of a kinship terminology from a prototype. (2) We provide a common framework for network analysis in anthropology, and in certain types of research in linguistics and archaeology, by showing that all three fields can advance in parallel through the application

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of common graph theoretic models. For example, minimum spanning tree algorithms are equally useful for modeling the evolution of political networks, describing the breakup of archipelagoes into language groups and marriage isolates, and constructing pottery-design networks. (3) In contrast to most research on kinship in Oceania after the time of W. H. R. Rivers (1914a), we give as much weight to marriage alliance as we do to descent groups. Thus in our comparative analysis of social organization in Micronesia we discuss changes from elementary to complex and semicomplex marriage systems as well as shifts from matrilineal to double and patrilineal descent. (4) We exploit and promote connections between Oceanic and Indonesian anthropology, two fields that will inevitably become part of the larger field of Austronesian anthropology. An Indonesianist perspective is implicit in our treatment of Nuclear Micronesia as a “field of ethnological study” and in our support for the idea that much of the Austronesian world represents an eastward extension of Lévi-Strauss’s (1949) Sino-Tibetan axis of generalized exchange. (5) Finally, we restore part of the intellectual tradition of Oceanic anthropology by integrating into our account the important but often overlooked contributions of earlier scholars such as Paul Kirchhoff, Edward Winslow Gifford, Wilhelm Milke, and Leonard Mason. Kirchhoff’s (1955) discovery of the conical clan, Gifford’s (1929) analysis of descent and marriage alliance in Tonga, Milke’s (1938) reconstruction of Proto-Oceanic sibling terms, and Mason’s (1947, 1954) analysis of stratification in the Marshall Islands in Micronesia provide an essential basis for comparative studies of social organization and social networks in Oceania.

In a classic paper, Barnes (1972:5) distinguished between analytical as opposed to metaphorical uses of the network concept. He observed that “a few simple notions taken from graph theory have proved useful in the analysis of social networks, but at present the supply of mathematical tools available far outstrips the supply of social data to which the tools might be applied.” Although this statement is still true, we will show that the applicability of graph theory to real-world networks is far greater than commonly imagined. The applications in this book are highly varied, and the interested reader will no doubt discover analogues to every research problem we present. The entire work is therefore intended as a general contribution to network analysis in anthropology.

With each book we have expanded the range of empirical structures amenable to graph theoretic analysis, as well as the repertoire of graph theoretic and network models for studying them. Thus in *Structural Models in Anthropology* we described abstract trees in a section of the chapter on undirected graphs and used them to analyze mnemonic

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structures. In *Exchange in Oceania* we briefly introduced minimum spanning trees in the chapter on matrices, noting their potential application to simulating the evolution of exchange networks. In this book we devote four chapters to trees, minimum spanning trees, and search trees, giving applications to classification systems, kinship networks, the evolution and devolution of social and linguistic networks, and the structure of stratified descent groups. Clearly, it is possible to write an entire volume just on interesting and useful applications of trees to anthropology. There is a parallel here with the second author's book, *Graph Theory*, published in 1969, which became in 1978-9 the fifth most cited reference in the research literature of mathematics. Virtually every section of every chapter of that book has become a special field of research and is now the subject of a separate book.

Phonetic note: The spelling of proper names and indigenous terms sometimes varies according to author and publisher (e.g., Tui Tonga vs. Tu'i Tonga, Lakeba vs. Lakemba, 'âti vs. 'ati etc.).

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