Preface

It is generally believed that the next generation of computers will involve massively parallel architectures. This thesis studies one of the proposed paradigms for exploiting parallelism, namely the actor model of concurrent computation. It is our contention that the actor model provides a general framework in which computation in distributed parallel systems can be exploited. The scope of this thesis is generally limited to theoretical and programming language aspects of the model, as opposed to specific implementation or application issues.

Many observers have noted the computational power that is likely to become available with the advent of a new generation of computers. This work makes a small contribution in the direction of realizing technology which seems just on the horizon. The possibilities that emerge from the availability of a massive increase in computational power are simply mind boggling. Unfortunately, humankind has generally lacked the foresight to use the resources that science has provided in a manner that would be compatible with its long-term survival. Somehow we have to develop an ethic that values compassion rather than consumption, to acquire a reverence for life itself. Otherwise this work, among others, will be another small step in the global march towards self-destruction.

The research reported in this book was carried out for the most part at M.I.T., where I have been working with the *Message-Passing Semantics Group*. The group is currently implementing the *Apiary architecture* for *Open Systems*, which is based on the actor model. Much of the development of the actor paradigm has been inspired by the work of Carl Hewitt whose encouragement and constructive criticism has been indispensable to the development of the ideas in this thesis.

This thesis has been influenced by other work in the area of concurrency, most notably that of Robin Milner. Although I have shied away from using a λ-calculus like notation for an actor calculus, the transition system developed has a similar flavor. A programming language notation is used for purposes of overall clarity in expressing simple programs.

John Holland has provided both intellectual impetus and moral support over the years; in particular, numerous useful discussions with John have led to a better perspective on ideas in the field. I am also indebted to William Rounds for numerous suggestions, among them to develop a simple actor language and to illustrate its flavor by treating a number of commonly understood examples. My first thorough exposure to object-oriented programming languages was in a course offered by Paul Scott. Conversations with Robin Milner, Vaughn Pratt, and Joe Stoy have provided important feedback. Will Clinger's thesis interested me in the area of actor seman-

tics. Members of the Message-Passing Semantics Group at M.I.T. have created an atmosphere which made the work described here possible. In particular, Johnathan Amsterdam, Peter de Jong, Henry Lieberman, Carl Manning, Chunka Mui and Thomas Reinhardt provided helpful comments. Carl Manning, Thomas Reinhardt, and Toon K. Wong also read drafts of this book. Needless to add, I am solely responsible for any remaining errors.

The work described in here was made possible by generous funding from the System Development Foundation and by the support of the Artificial Intelligence Laboratory at M.I.T. The book is a revised version of a doctoral dissertation submitted to the University of Michigan, Ann Arbor. John Holland and Carl Hewitt served as Co-chairs of the dissertation committee and William Rounds, Paul Scott and Andreas Blass were members. Each of them provided significant comments on the work.

Finally, the time during which the ideas in this thesis were developed was a rather intense time in the lives of my family. Nothing would have been possible without the patient cooperation of my wonderful wife Jennifer Cole. It must be added that it was only due to the high spirits maintained by our son Sachal through most of his short, difficult life that any work at all could have been done by me.

Gul Agha
Cambridge, Massachusetts
July 1986.

ACTORS