TOWARDS A COMPLEXITY THEORY OF SYNCHRONOUS PARALLEL COMPUTATION

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ABSTRACT. This is largely an expository paper on the general theory of synchronous parallel computation. The models of parallel computers discussed include uniform circuit families, alternating Turing machines, conglomerates, vector machines, and parallel random access machines. A classification of these models indicates the need for still more; so "aggregates" and "hardware modification machines" are introduced. The resources sequential time, space, parallel time, circuit size and depth, hardware size etc., are discussed and interrelated. Work in progress at Toronto is mentioned and basic open questions are listed.

1. INTRODUCTION

There is now a well developed computational complexity theory of sequential computation. The precisely "right" computer model is not completely clear, but the main contenders for this model do not differ markedly from each other in their computing efficiency. These contenders are multitape Turing machines, possibly with storage structures more general than linear tapes, and various versions of random access machines. Of these models, the storage modification machine (SMM) made popular by Schönhage [S2] carries the most conviction as a stable and general model of a sequential computer; where we take sequential to mean the number of active elements is bounded in time.

To be sure, there is a feeling that one step of an SMM may be a little too powerful. It is hard to imagine a mechanism for reconnecting a given edge out of a node v_1 in the storage structure to a node v_2 in one step, when the candidates for v_2 from the perspective of the whole computation are unlimited. But the fact remains that if we restrict ourselves to fixed storage

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