LITERATURE RECEIVED

LARGE SCALE PARALLELIZATION OF ALPHA-BETA SEARCH: AN ALGORITHMIC AND ARCHITECTURAL STUDY WITH COMPUTER CHESS

Feng-hsiung Hsu

Ph.D. thesis, February 1990
Carnegie-Mellon University
Report # CMU-CS-90-108

We quote the abstract.

"'Within 10 years a digital computer will be the world's chess champion, unless the rules bar it from competition', so said Herbert Simon, the noted computer science pioneer and Nobel Laureate in economics, in 1957. More than three decades later in 1988, the chess machine Deep Thought finally claimed the Fredkin Intermediate Prize for Grandmaster level performance, still a big step from challenging the human World Champion. Yet, based on the evidence to be presented in this dissertation, the end may indeed be coming within the next 5 years.

Hardware speed has been the main driving force during the spectacular rise of chess computers from duffers to Grandmasterly players within the span of the past decade. Despite frequent claims to the contrary, pushing hardware speed has proven to be a reliable way of improving chess computer performance. This dissertation will look into the past and document the hardware efforts behind ChipTest, 1987 ACM Champion, and Deep Thought, 1988 ACM Champion and the reigning World Computer Chess Champion. It will also glimpse into the future about possible hardware advances and present a new class of parallel search algorithms that promises speedup of the order of hundreds and maybe even thousands. A chess machine capable of evaluating one billion positions per second appears to be feasible with the current technology. Such a machine, projecting from the performance of existing machines, should have a good chance of defeating the human World Chess Champion.

The first half of the dissertation describes the Deep Thought chess hardware and examines some paper designs related to the final effort. Details are also given for the single chip move generator which is the core of the Deep Thought special purpose hardware and offers about three orders of magnitude improvements in speed chip-count ratio over previous designs. A surprise is that the simple move ordering provided by this single chip move generator turns out to be more efficient overall than a far more complicated move ordering proposed in earlier literature.

The second half of the dissertation presents a class of new parallel α-β algorithms that gives speedup arbitrarily close to linear when the game tree is best-first ordered and sufficiently deep. More importantly, the parallel algorithms strictly dominate a weaker form of the α-β algorithm with deep cutoffs disabled; that is, they never search a node not explored by the weaker form of α-β, and usually search far fewer nodes. Simulation results, based on artificial game trees and chess game trees from Deep Thought, will be given to support the expectation that speedups of hundreds and even thousands are eminently feasible. In fact, based on the simulation data, it appears that for all practical purposes, the achievable speedup depends only on the available hardware resources and not on any hard limit imposed on the algorithms."