

Deep Blue II is a parallel system designed for carrying out chess game tree searches.

System Overview

Deep Blue II is composed of a 30-node computer with 16 chess chips per node. The nodes communicate with each other via a high-speed switch. Each chess chip can search 2 to 2.5 million positions per second and communicate with their host node via a microchannel bus.

Deep Blue II is organized in three layers: the master node, the workers, and the chess chips. The master node searches the top levels of the chess game tree using software search, then distributes its “leaf” positions to the workers. The workers, the remainder nodes keep searching for a few levels and delegate to the chess chips. The chess chips search the last few levels of the tree using their embedded algorithms. We notice that the search process is hybridic software/hardware search. The distribution of the search jobs from the master node to the workers is performed in **parallel**. Deep Blue II uses techniques for load balancing, avoiding the master node overloading and sharing data/communication between the nodes.

Chess chip

The chess chip consists of three parts: move generator, evaluation function and search control.

Move Generator

The move generator was a successor of Deep Thought (1980) move generator chip. It also had significant improvements. As an example, the ordering of the generated moves is important: having the best moves first amplifies the pruning during the search in the game trees.

Search control

The search control uses finite number state machines to implement null-window alpha-beta search. The null-window search does not require a value stack, thus simplifying the design. The downside is that in several cases, it is necessary to perform multiple searches. Also, the lack of a transposition table reduces the efficiency. Although the effect is balanced by executing the upper levels of search in software.

Evaluation Function

The Evaluation function consists of fast and slow modes. The fast mode includes computationally simple operations like the piece placement on the board. The slow mode evaluates with more complex chess techniques. When the approximation of the fast mode evaluation is good enough the slow mode can be skipped to save time.

As the evaluation function is implemented in hardware its performance is significantly higher and the “time to execute” is fixed. The drawback is that it is parameterized and configurable but the features are fixed. So, new features cannot be added to hardware evaluation.

Features

There are 54 registers and 8096 table entries: Roughly 8000 **features**. The sum of the feature values is the result of the Evaluation function. The features can be simple as assigning a value to a piece on a square or complex such as giving penalty/bonus to positions according to a very wide database of grandmaster games. Features are either **static** or **dynamic**. Both static and dynamic are initialized at the beginning of a search on the master node of the Deep Blue by the “evaluation function generator”. Dynamic features are adjusted during the search, based on the pieces positioning on the board.

Game database

An extensive set of games used by the evaluation function. A limited and handwritten “opening book” for the beginning of the game featured a static repertoire of moves. A very wide (700k games) “Extended book” is used to assign penalty or bonus to moves that have been played by Grandmasters. Weighting criteria are the frequency of the move, its result, the rank of the player etc. An “Endgame database” is used to evaluate chess positions on boards of five or fewer pieces.

Software Search

Software search is used for the upper-level searches. The algorithm is an extended version of depth-limited alpha-beta search. It is called “dual credit with delayed extensions” which is highly selective and non-uniform. It keeps track of both players’ moves (thus dual) and their credit is built up through a complex algorithm while traversing the search tree (thus delayed). Alpha-beta pruning skips the evaluation of moves with a worse score than their previously examined moves, reducing the search load.