

Deep Blue Review

Deep Blue 2 is famous chess machine developed at IBM, that defeated Garry Kasparov in 1997. Deep Blue 2 is based on Deep Blue 1 that lost to Garry Kasparov in 1996. During that one year evaluation function in chess chip was redesigned, was added repetition detection and new move generation modes. Also chip search speed of Deep Blue 2 was significantly improved: from 1.6-2 to 2-2.5 million chess positions per second. Deep Blue 2 is a complex system that consists of: 28 nodes with 120 MHz and 2 nodes with 135 MHz P2SC processors that communicates via high speed switch. Each node has 16 chess chips. Each chess chip consists of three parts: move generator, evaluation function and search control.

Move Generator in Deep Blue 2 is based on Deep Thought(1980s) with such an improvements: checking evasion moves, generation of certain kind of attacking moves, improved quiescence searching. For move generator it's important to generate best moves first (to improve pruning), so it generates captures first and after that non-captures moves. Evaluation function consists of fast and slow mode. Fast mode include computationally easiest operations and slow scan board by column and evaluate more tricky features. Each has computable weights, so it could be tuned which one to choose. Evaluation function is sum feature values and there are roughly 8000 different features that could be either static or dynamic. Special tool for automatic feature evaluation were used to modify and improve features in Deep Blue 1. Search control implements null-window search that reduces search space and same time allows not to maintain stack to store alpha and beta values. Upper level searches are in software because it has access to transposition table and lower levels could use faster hardware. New feature of Deep Blue 2 is repetition detector that tracks number of displays pieces for last 32 positions and trigger 'no progress' if there is one or zero displacements. 'No progress' positions pruned because of assumption that if there is a good move, it would be used earlier.

Deep Blue software search uses extended version of depth-limited alpha-beta search. It's called "dual credit with delayed extensions". Following principles were added: extend forcing/forced pairs of moves, forced moves are expectation dependent (moves, that is below the current level of expectation in never considered forces), fractional extensions (ffp get smaller amount extension which prevent search exploding), delayed extension (extensions are delayed until multiple ffp's occur in given path), dual credit (two sides accumulate the credit separately, if one side accumulates sufficient credit to cash in for an extension, the other side must give up with equal amount of credit), preserve the search envelope (helps avoid an oscillating search). Credit generation is complicated and depth dependant (the closer is position to the root, the more credit it will have) that makes search fast and not allows it to explode. It includes influencing of previous moves, detecting threats, domain dependency and assigning more credits if less reasonable moves are available.

Hardware search otherwise is much faster and simpler. It carries out a fixed-depth null-window search and uses different search extension heuristics. To work in balance with slow but efficient software search, hardware search carry out only shallow searches. Chess chips also has access to external transposition table, but because of time constraints was never used.

Also big role in success of Deep Blue plays new parallel search algorithm with complex processor hierarchy, synchronization and control distribution. It's hard to debug such system because search is nondeterministic, it's not perfect and could be improved. To achieve better search quality were used manually created opening book with about 4000 positions and extended book that got data from large Grandmaster game database. Also, endgame database were added, but it did not play critical role in matches against Kasparov.