

Deep Blue Summary

Deep Blue is a chess player developed by IBM that beat the World Chess Champion Gary Kasparov in 1997. Deep Blue's success in beating Kasparov was not down to any one factor. The following features of Deep Blue contributed to its success: a single chip search engine, parallel searching, search extensions, advanced evaluation function and use of a Grandmaster database.

Compared to its predecessors Deep Blue II had a number of advantages. The first big advantage was it used a newly designed chess chip which increased the number of features from the 6400 used in previous systems to over 8000 (a number of these features were derived from previous matches with Kasparov). Efficiency improvements were made on the chess chip enabling the per chip speed to increase to between 2 and 2.5 million searches per second. The second major improvement was that it more than doubled the number of chess chips. The third was a set of debugging tools to aid in debugging and match preparation. This enabled Deep Blue II to beat Kasparov 3.5-2.5.

Deep Blue II relies on a single chip, parallel searching mechanism. The system was a 30 node, 480 single chip search engine with 16 chess chips per SP processor. The system is organised in three layers. One chip is designated as master whilst the others are designated as workers. The master chip searches the top level of game tree and then distributes "leaf positions" for the workers to examine. The workers carry out a few levels of additional search and then distribute their leaf positions to the chess chips, which search the last few levels of the tree.

System speed varied widely depending on the board position. More tactical positions (with more consequences) took longer to search (100 million searches per second). For quieter positions 200 million searches per second were possible. This was a 30% to 70% efficiency improvement vs single chip calculations.

Deep Blue used quiescence search, iterative deepening, transposition tables, and NegaScout as search techniques.

This search was limited by a process called "dual credit with delayed extensions". This centres around finding moves that force the opponent to make moves. There is a limit to how much we can search for these forced moves due to the horizon effect. We limit expanding the search tree (delay the expansion) until credit has been accumulated for a series of moves. This is further controlled by a "dual credit" system whereby we limit the credit available such that if either side accumulates credit to cash in, the other side must give it up.

The hardware search carries out fixed-depth null-window search, including quiescence search. The hardware is controlled by a series of parameters. The main ones centre around controlling the depth of search, debugging switches, quiescent search parameters for checking mate conditions, and size of the search.

This combined software and hardware is not without its difficulties. The hardware approach means that new search behaviours cannot be introduced, choosing the best approach between hardware and software is cumbersome and two searches were more likely to lead to the horizon effect.

Deep Blue's hardware computed evaluation function is a sum of the feature values. Its 8000 different features help provide heuristics for score calculation. The evaluation function is composed of a fast and slow evaluation, spotting major evaluation terms quickly and a slow evaluation which scans one column at a time.

The hardware evaluation means that one does not need to continuously weigh up the importance of different features in relation to execution time: it is fixed. This is an advantage but also carries difficulties due to the need to tune all of these features.

Deep Blue made use of a number of databases to aid in calculating moves. This consisted of an opening book of 4000 moves which were optimised for moves that Deep Blue played well. The extended book database of moves enabled Deep Blue to select moves based on previous Grandmaster games. This enabled Deep Blue to award bonuses or penalties to moves that had previously been played in Grandmaster games which aided in the search. There were many weightings to be taken into consideration when applying this database. For example a Grandmaster move that is frequently played is likely to be good. Finally endgame databases were used when fewer than 5 moves remained but this was only used once in the match against Kasparov.