

# Research Review

DEEP BLUE BY THE IBM WATSON TEAM (FUN FACT, DEEP BLUE BEAT GARY KASPAROV IN CHESS IN ONE OF THE MOST FAMOUS AI SPECTACLES OF THE 20TH CENTURY).

This [paper](#), describes some key parts of the Deep Blue® computer chess system that was actually able to defeat the then-reigning World Chess Champion, Garry Kasparov. The following parts, played a major role in the victory from the side of Deep Blue in 1997:

## A massively parallel system with multiple levels of parallelism

The Deep Blue's 3-layer parallel system allows having a large search capacity. It is composed of 30 nodes (30 processor) IBM RS/6000 SP, 1 master node searches top levels of the chess game tree, while the rest of the nodes examine a few more levels in parallel of additional search, and then distribute their leaf positions to the chess chips, which search the last few levels of the tree. Each processor controls 16 chess chips to search the last levels.

The type of search being used by Deep Blue is "Principal Variation" which customizes the parallelization to each node type.

## Hybrid hardware/software search

The Deep Blue search combines a software search, implemented in compiled C code on a general purpose CPU, with a hardware search, encoded in silicon on the chess chip. The chess chip search is controlled by a processor and is limited to shallow depth, while the hardware search is carried out with a fixed-depth null-window search, which includes a quiescence search.

Null-window alpha-beta search speeds up the process to find cut-offs but does not return an exact value. So, when a precise score is required, the controlling processor carries out a binary search. Also, the lack of transposition tables limits the hardware search, while on the other hand it is available to the software search, although chess chips support them optionally.

## Complex evaluation function

The evaluation function is implemented in the hardware side, so the time to execute it is fixed. The negative part is that new features cannot be added to hardware evaluation and software patches can create issues. It sums the values of over 8,000 features (in the Deep Blue II model). Some features as simple as assigning a value to a piece on a square and others far more complex.

Static features are set once at the beginning of a search. Dynamic values are initialized at the beginning of a search and they are adjusted at evaluation time based on the board situation. Much of the time was spent on the creation of features and adjusting their weights.

## Non-uniform search

On top of quiescent search and negascout, Deep Blue introduced a “dual credit with delayed extensions” technique in its software search based on a number of principles such as the following:

- Extend forcing/forced pairs of moves (ffp) which played a critical role in chess.
- Forced moves are expectation dependent.
- Fractional extensions
- Delayed extensions
- Dual credit
- Preserve the search envelope

Deep Blue keeps track of an “extension credit” for each player and path. For each ffp along the path, a player sums a credit, then the search is extended only if a player has added enough credit.