# Deep Blue

## Paper Summary

Deep Blue is the chess machine that defeated the -reigning world chess champion, Garry Kasparov in six-game match in 1997. Deep Blue used novel techniques that contributed to the success:

1. A single-chip chess search engine
2. A massively parallel system with multiple levels of parallelism
3. A strong emphasis on search extensions.
4. A complex evaluation function, and
5. An effective use of a Grandmaster game database.

Deep blue developed a chess chip, and move were generated using Deep Thought move generator, which in turn based on the move generator of the Belle Chess machine. The Deep Blue chip has additional functions, include the generation and checking and check evasion moves, as well as allowing the generation of certain kinds of attacking moves, which permits improved quiescence search.

The Evaluation function implemented in Deep Blue chip is composed of a ‘fast evaluation’ and a ‘slow evaluation’. This way, it can skip computing an expensive full evaluation when approximate value is good enough. Fast evaluation, computes the score for the chess position in a single clock cycle. The slaw evaluation scans the chess board one column at a time.

The search control portion of the chip uses a number of state machines to implement null-window alpha-beta search. The chess search chip, supports the use of an external FPGA (Field Programmable Gate Array) to provide access to an external transpositional table.

The Deep Blue, also has a software search, which is called dual credit with delayed extensions was designed based on various principles to remove unnecessary search, and give more credit to forced move, allowing for fractional extensions, and delayed extensions.

The dual credit was also implemented in the software search, this to solve serious problem that arises on principle variation (PV). The PV represent the current best play for both sides. Preserver the search envelope was implemented in the software search to avoid an oscillating search.

Credit generation mechanisms were implemented to identify nodes which receive credit. The methods used required auxiliary computation in order to gather the information necessary to make extension decision.

The scores used in Deep Blue were composed of two 16-bit signed integers. The regular search score is in one integer, and the tie breaker score is in the other. Therefore, for a draw, the regular search score is zero, and the tie breaker contains either the static evaluation of a theoretically drawn position or the count of moves until repetition, which is also useful choosing draws in the midgame.

Another idea in the Deep Blue, implemented in both hardware and software search, is a pruning mechanism called ‘no progress’. It is based on the assumption that if a move is good for a given side, it is best to play it earlier rather than later. ‘No progress’ is implemented by detecting if the current position could have been reached by playing an alternate move at the same earlier position on the search path.

Deep Blue is composed of a 30 node RS/6000 SP computer and 480 chess chips, with 16 chips per node. The SP nodes communicate with each other using the Message Passing Interface (MPI) standard. Communication is via a high-speed switch.

There were many improvements in the Deep Blue approach, the use of hardware search and parallel search, enabled Deep Blue to perform many deep search and prune it to find the best moves. This enabled Deep Blue to win six-game match in 1997 with the chess champion.