Paper summary: Deep Blue

The paper describes the Deep Blue chess machine that defeated the World Chess Champion Garry Kasparov in a six-game match in 1997.

There are two distinct versions of Deep Blue, one known as Deep Blue I which lost to Garry Kasparov in 1996 and one which defeated him in 1997 referenced in the paper as Deep Blue II.

In Deep Blue II, the team responsible for the project realised that there were a series of deficiencies in Deep Blue I. As result, a new chip was designed with significant enhancements.

Deep Blue is a massively parallel system designed for carrying out chess game tree searches. It is organised in three layers. One of the processors is designated as the master, and the reminder as workers. The master searches the top levels of the chess game tree, and then distributes "leaf" positions to workers for further examination. The workers search few additional levels, and then distribute these leaf positions to the chess chips, which search the last few levels of the tree.

The main characteristics of the search are:
1) **Large searching capacity**, guided by the principles of being highly non-uniform and provide "insurance" against simple errors.
2) **Hardware evaluation**: The evaluation function is implemented in Hardware. This simplifies the task of programming Deep Blue.
3) **Hybrid software/hardware search**. The software search is extremely flexible and can be changed as needed, while the hardware search is parametrized keeping its general form.
4) **Massively parallel search**, with over 500 processors available to participate in the game tree search.

The chess chip has the following main capabilities:
- **Move generation**, which is a turn based move generator, with additional functions such as generation of checking and check evasion moves, generation of certain attack moves and several search extensions.
- **Evaluation function**, which is composed of a "fast evaluation function" and a "slow evaluation function". Fast evaluation function computes a score for a chess position in one clock cycle and contains all the easily computed major evaluation terms with high values.
  The slow evaluation function scans the board one column at a time, computing values for chess concepts
- **Search contro**l, which uses a number of state machines to implement null-window alpha-beta search.

Another important improvement was adding an **Opening Book** to improve the movements in the game. It consisted in a 4000 positions including tactically complex openings and also included positional openings.

The **Extended Book** was also included, and is a mechanism that allows a large Grandmaster game database of 700000 games to influence and direct Deep Blue´s play in the absence of opening book.

The Endgame database was also added to Deep Blue, and includes all chess positions with five or fewer pieces on the board, a well as selected positions with six pieces that included a pair of blocked pawns.

As a **conclusion**, the success of Deep Blue was due to the combination of large searching capability, non-uniform search and complex evaluation function. Other factors also were important to the success, like endgame database, the extended book and evaluation function tuning.
However, there were areas of improvement like the parallel search efficiency, the hardware search and evaluation could have been made more efficient with the use of external FPGA. The use pruning mechanisms might have improved the search and Evaluation function tuning was far from complete