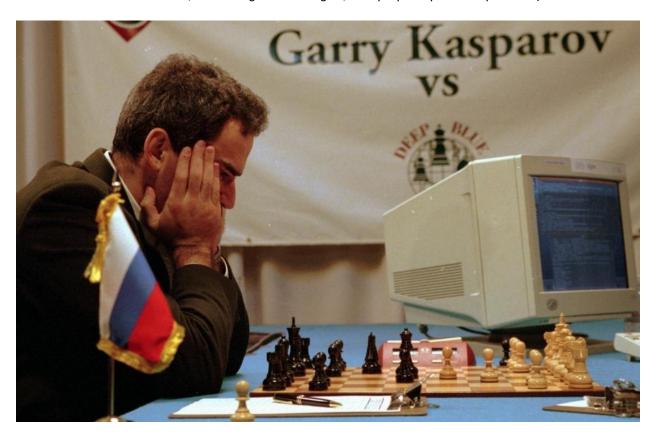# Research Review on the paper: Deep Blue

by Abuhanif Bhuiyan, Feb 2018

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Introduction:

This paper describes the Deep Blue chess computer that defeated the then world champion Garry Kasparov. It was a series of 6 game match held in 1997 with a surprising result of 3.5 vs 2.5, where Deep Blue beaten the best human chess player. Deep Blue is a computer system developed by the IBM research team with several years of research during 1990s. Earlier attempt was named as Deep Thought in 1980s, then in 1995 the Deep Blue-I was built on a single-chip chess search engine. In 1996 Deep Blue-I lost against Kasparov by 4-2 score. With a series of improvement on new chip capable of 2-2.5 million positions per second as well as significant improvement in software finally achieved the historical milestone.

System Design:

Deep Blue was a massive parallel system designed for carrying out chess game tree searches. It was organized in three layers: one master and two workers. Master searches the top level of the game tree then distribute the leaf positions to the workers. Deep Blue design was based on earlier

chess program like quiescence search, iterative deepening, transposition tables and NegaScout. The new characteristics of Deep Blue were: (1) Large search capacity. (2) Evaluation function implemented in hardware. (3) Hybrid software/hardware search. And (4) Massively parallel search.

(i)   ***The Chess Chip:*** The main hardware component was the Chess Chip which had three parts: Move generator, Evaluation function and Search control. Move generator was implemented as an 8x8 array of combinatorial logic. The evaluation function implemented in the Deep Blue chip is composed of "fast" and "slow" evaluation. Search control used a number of state machines to implement null-window alpha-beta search. Hardware search provided several advantages with several limitations i.e. lake of transposition table. The chip could use external support using FPGA, but this feature was not used.

(ii)   ***Software Search:*** The search algorithm "Dual credit" with delayed extension was used. Extended forced pairs move was used with expected dependent. Fractional extensions were also used where applicable. Delayed extensions were used by setting the threshold appropriately. To avoid the oscillating search the search envelop was preserved. There were a large set of mechanism to identify modes that should receive credit. Those are absolute singular, mate threat, influence and domain dependent. Many of these methods required computation to gather information in making decisions. No-progress pruning mechanism is an important improvement in Deep Blue algorithm.

(iii)   ***Hardware Search:*** The hardware search was done by the chess chip using fixed-depth null-window search. The hardware search implemented depth of search, depth of offset search, end game rules assertions etc.

(iv)   ***Parallel Search:*** The Deep Blue system composed of 30-node RS/6000 SP computer with 480 chess chips, with 16 chips per node. Heterogeneous architecture had strong influence on the parallel search. It was implemented by processor hierarchy, control distribution and parallelism.

(v)   ***Evaluation Function:*** The evaluation function was a sum of feature values. Feature values could be either static or dynamic. Evaluation function generator is run only at the root of the search tree. Automated and manual evaluation function analysis was done.

Conclusion:

The Deep Blue success came from many factors. It implemented several new techniques than its predecessors like large non-uniform search, complex evaluation function, end game database, extended book, evaluation function tuning and many more. The rise of the machine and the era of AI took a big leap by the design of Deep Blue and successfully beating the best chess player in history.