

Deep Blue II – The rise of grandmasters

Summary of [Deep Blue – AI 134 \(2002\) 57-83](#) by Yogi

During 1990's many competitive computer chess systems were built, most prominent of them were Chip Test, Deep Thought (I and II) and Deep Blue I. These systems built various revolutionary concepts such as hardware based evaluation function, multi-processing parallel search and chess engine chips. And through this evolutionary design emerged IBM's Deep Blue II which was the first machine of its kind to defeat a then-reigning World Chess Champion Gary Kasparov. The paper presents the following key factors that played a big part in Deep Blue's slow and steady climb towards success:

- Massively parallel system built on 30 nodes (135 MHz P2SC processor each) IBM RS/6000 SP computer. Each node comprised of 1 GB RAM, 4 GB disk and 16 single chip chess search engines. This combined with techniques such as quiescence search, iterative deepening and transposition tables allowed Deep Blue II to search an astonishing 330 million positions per second. This massive capacity was used while following two main principles "insurance against errors by searching a minimum depth" and "highly non-uniform search to reach a reasonable depth". The nodes also had a processor hierarchy that allowed centralized control distribution without compromising parallel search performance
- The chess chip capable of three primary functions:
 - Move generation to use arbitration network and high-value ordering to select single move from all possible options.
 - Programmable evaluation function that could perform both fast (within single clock cycle) and slow (scans the board one column at a time) searches with configurable weights for each. In addition, 54 registers and 8000 programmable stored patterns enabled recognition of many chess moves and the appropriate response.
 - Alpha beta search with programmable search control with repetition detection buffer. This search was relatively simple but very fast compared to the complex but efficient software search. Also, the node hierarchy allowed for partial system performing hardware while host processor performed software search.
- A selective software search that specialized in handling forcing/forced pair (ffp) to avoid non-terminating search / explosion. This is achieved using a credit generation mechanism for both sides and detecting multiple ffp's. Each node/move is analyzed for concepts such as "Singular move", "Influence", "Threat", "Domain dependence" etc. and then granted appropriate credit which accumulates allowing for extension decision. This mechanism was highly effective in maintaining software search efficiency. The search also depended upon knowledge available in:
 - Opening book created by hand by other grandmasters composed of 4000 positions that Deep Blue played well per the nightly test runs
 - Summarized information available at each position of a 700,000game database that helped Deep Blue reach consensus quicker
 - Endgame book that included all positions with five or fewer pieces on board

The authors conclude that Deep Blue's success was not the result of any one factor but combination of all. A system of such complexity, while highly efficient, also comes with its own specific problems in monitoring, debugging and measuring efficiency of the system. For most of the design decisions expert advice is needed from subject matter experts. System is also configured based on opponent being played which makes the knowledge and experience of authors extremely impressive.

Deep Blue II is indeed a grand master and a marvel of its time.