Review of Deep Blue by IBM Watson Team

Deep Blue II is the world-class chess game machine which was a result of multi-year effort, enhancing and improving the series of chess machines developed over these years. The paper describes the Deep Blue II system and the main features that were added to make Deep Blue II the world chess champion.

1. Enhanced chess chip – The new chip had redesigned evaluation function which takes in to account more than 1500 additional features of the game in to account than Deep Blue I, hardware repetition detection of move generation modes and improved chip search speed
2. Double the number of chess chips in the system and newer generation of SP computer to and support higher processing demands
3. Development of software tools to allow for debugging, testing and match preparation.

System Overview

Deep Blue is a parallel system with a 30 (node) processor IBM RS/6000 SP computer and 480 single chip chess search engines, with 16 chess chips per SP Processor. The nodes communicate via high speed switch and one of the processor is designated as master and the remainder nodes are worker nodes. The chess chips can search 2 -2.5 million chess positions per second.

Search functionality – Parallel and distributed

Deep blue utilizes the game search algorithms like alpha beta search with iterative deepening, quiescence search, transposition tables etc. But it is able to achieve large search capacity, highly non uniform search and complex evaluation functions due to its massive parallel system and layering of the search functionality. The master processor searches the top levels of the chess game tree and then distributes the leaf positions search to the worker processors, which further distribute the leaf positions evaluation to the chess chips. This allows for implementing a hybrid software and hardware search mechanism. The software search is flexible and can be fine-tuned that runs on general purpose CPU. The hardware search is encoded in silicon on the chess chip and it is parameterized but the search form is fixed.

Hardware search - Chess chip functionality comprises of move generator, evaluator function and search control. It generates only one move but implicitly computes all moves possible simultaneously. The evaluation function has fast evaluation for instance piece placement, positional features etc. and slow evaluation component, to avoid expensive full evaluation when an approximation is good. The slow evaluation component considers chess concept which involve scanning each column one at a time such as king safety, blockade. The search control is done using state machines and the move stack keeps track of moves explored and allows repetition detection for repeated positions.

Software search – This implements selective search called as Dual credit with delayed extensions. This is based on forcing/forced pairs of moves and dual credit if it is current best play for both sides. The implementation of this is similar to depth limited version of alpha-beta with additional 2 credits parameters passed recursively to check against credit limit and decide whether to give or reduce credit. The credit is generated based on type of node – singular move node or absolute singular move node. The credit generation requires computation in order to gather information and make decisions, but allows for selective search.

Parallel Search: Implemented using processor hierarchy – master and worker processor with control distribution. The initial iteration of search performed at master node does not require much parallelism but at deeper search levels, the search is distributed to worker and chess chips. Long running searches are a problem and must be stopped. The experimental results for parallel search performance is limited and the results depended on the tactical complexity of the positions searched.

Opening book – Deep blue has a opening book comprising of 4000 positions. These positions are positions that Deep blue played well

Extended book – This is a large Grandmaster game database and Deep Blue can choose its play based on the Grandmaster moves if there is no moves in opening book. Deep blue assigns bonuses or penalties to moves in a given position and it carries out the regular search but offsets the alpha beta search window based on bonus/penalty points

Results: The success of Deep Blue depended on many factors, of which large search capability, non-uniform search and complex evaluation function were critical factors. The parallel search, hardware search and evaluation functions can be optimized.