Improving Depth-first PN-Search: $1 + \varepsilon$ Trick

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Outline

Relevant Work.

1994 Allis et al: Proof-Number Search.

1998 Nagai: PDS – Proof Disproof Search.

2002 Nagai: DF-PN – Depth-first PN-Search.

2004 Winands et al: PDS-PN.

2005 Kishimoto et al: DF-PN with heuristic threshold increments.

Outline

PN-Search.

- PN-Search is AND/OR tree search algorithm.
- Uses proof and disproof numbers to find MPN.
- Iteratively expands Most Proving Node.

Recursive formula for the proof and disproof numbers

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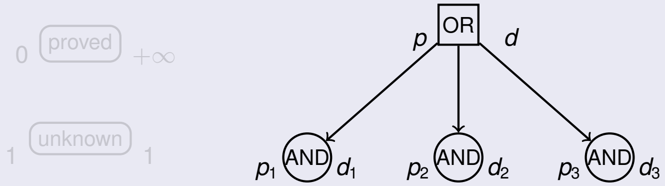

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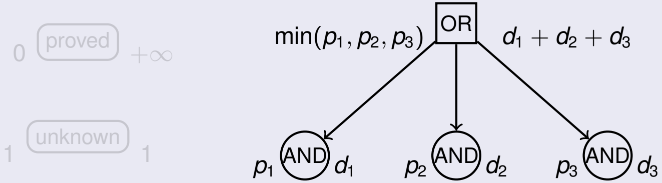

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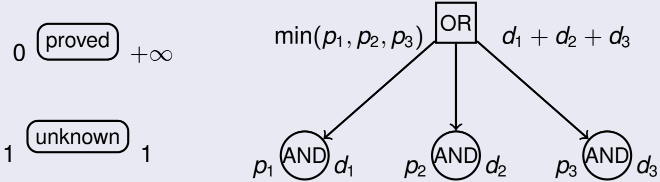

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- Suspend updates as long as MPN is in current node's subtree.
- Uses proof and disproof number thresholds.
- Return condition: $p \geq pt \vee d \geq dt$.

Calculating the thresholds

$p_1 \leq p_2 \leq p_3$

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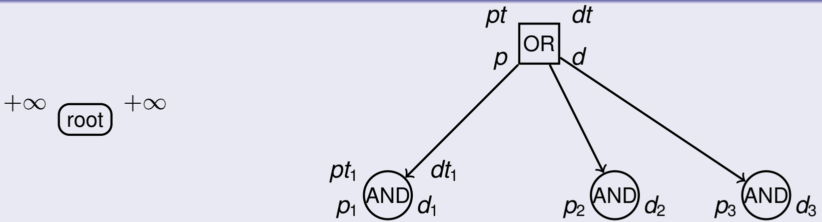

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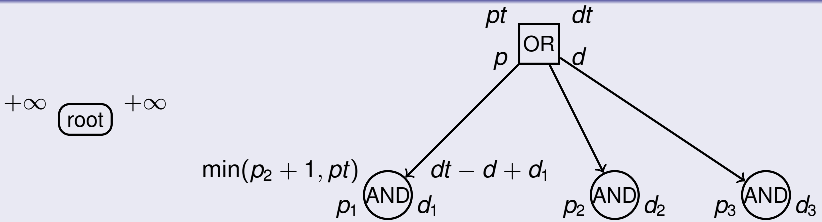

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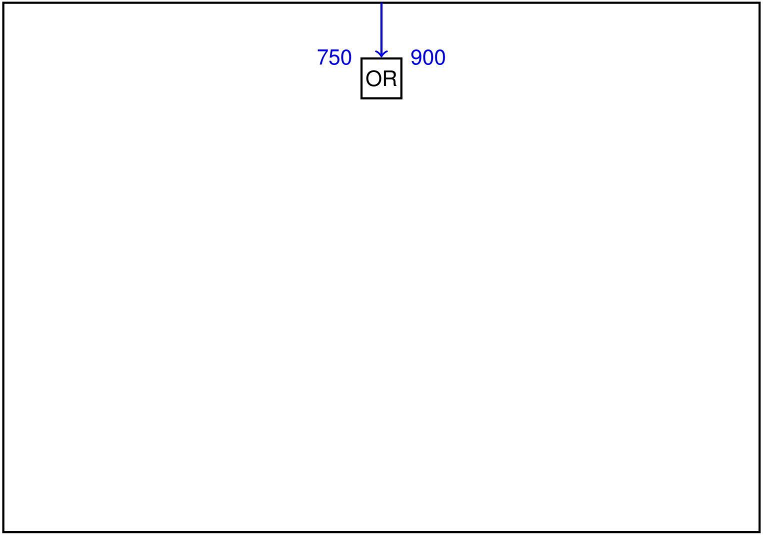

PN History

300
302
305
306
308
311
315
317
⋮
742
746
750
752

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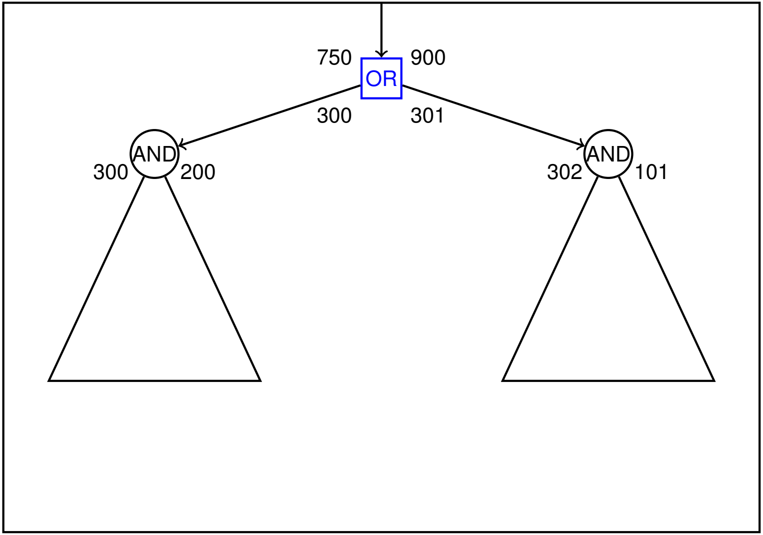

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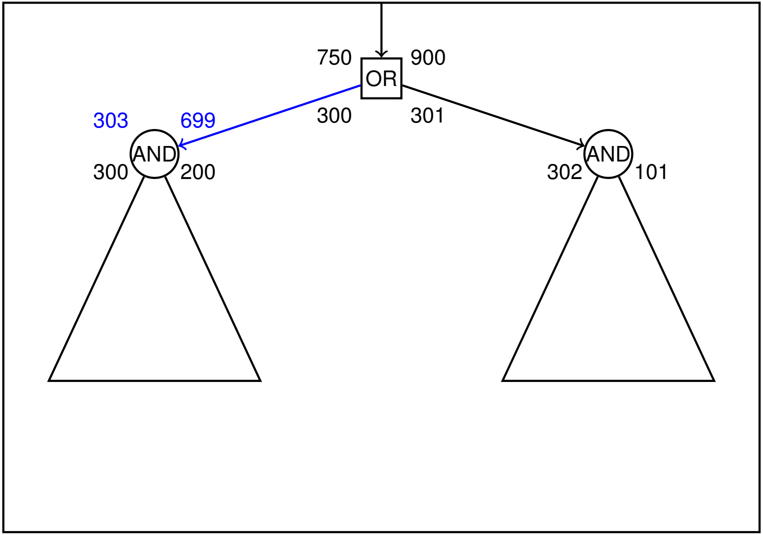

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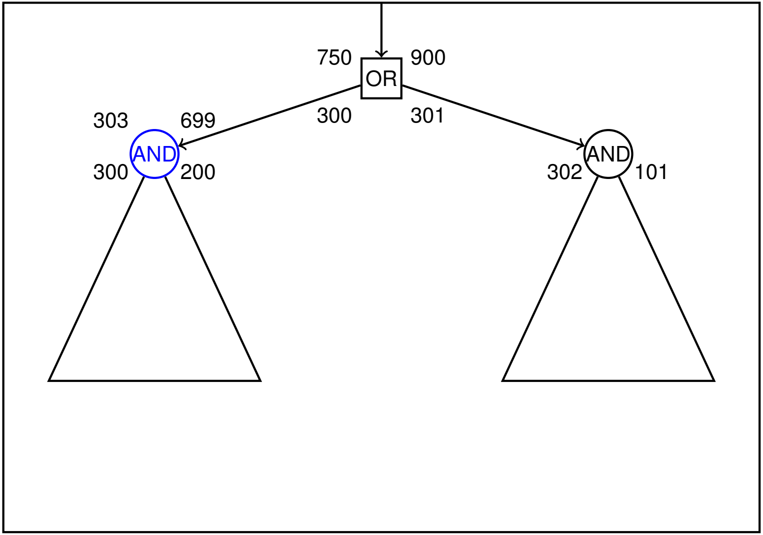

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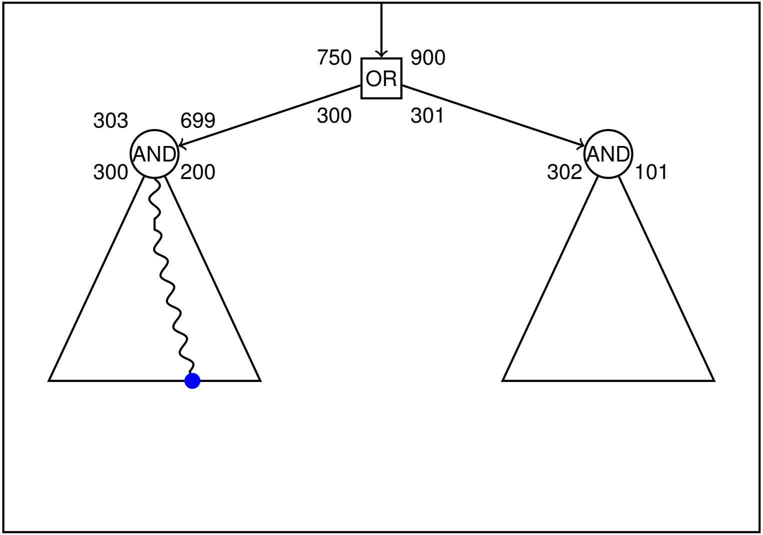

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300, 302, 305, 306, 308, 311, 315, 317, ⋮, 742, 746, 750, 752

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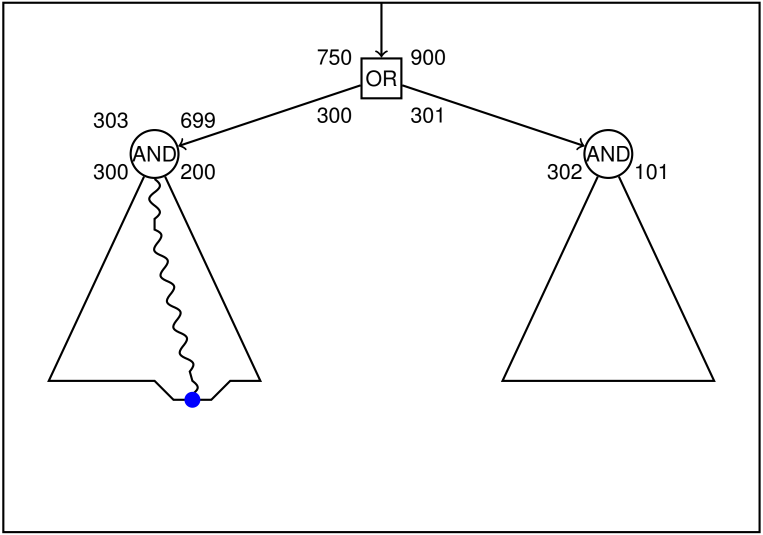

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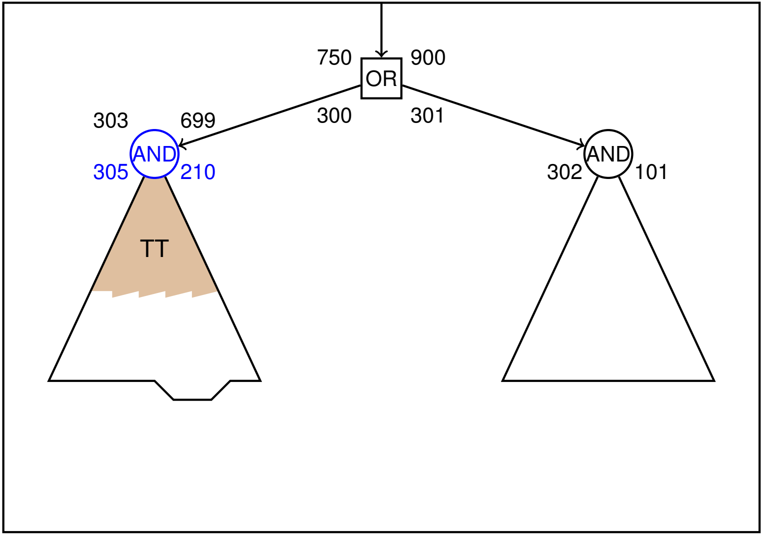

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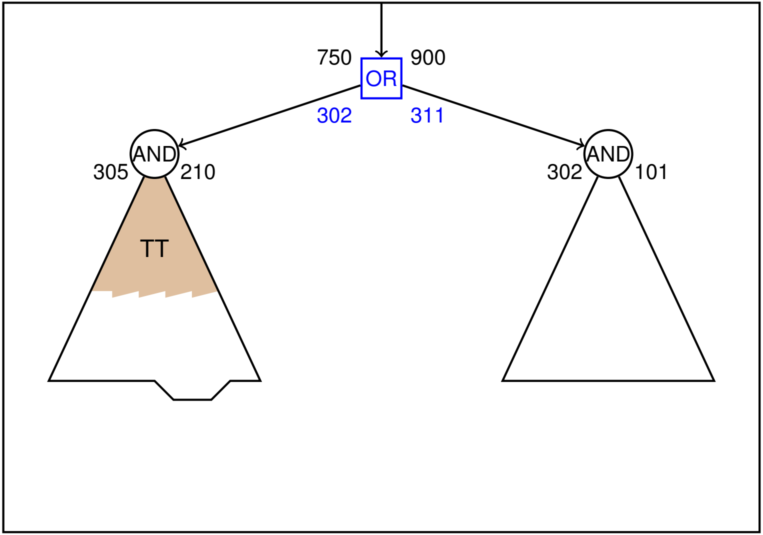

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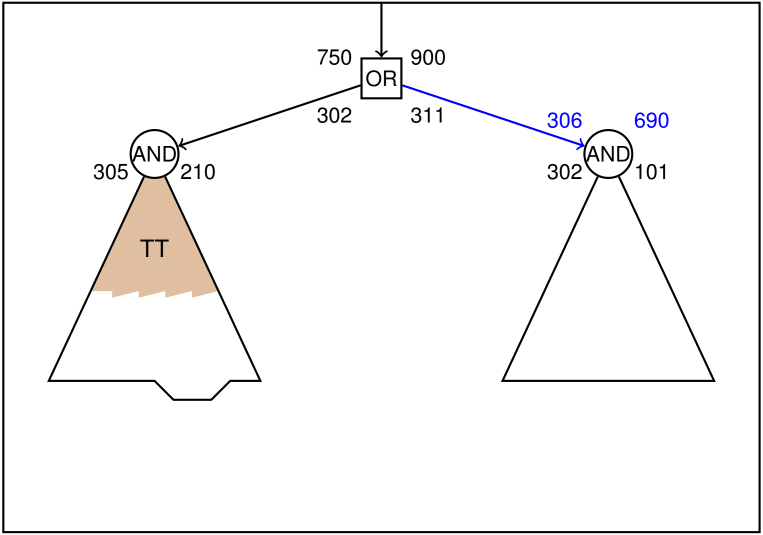

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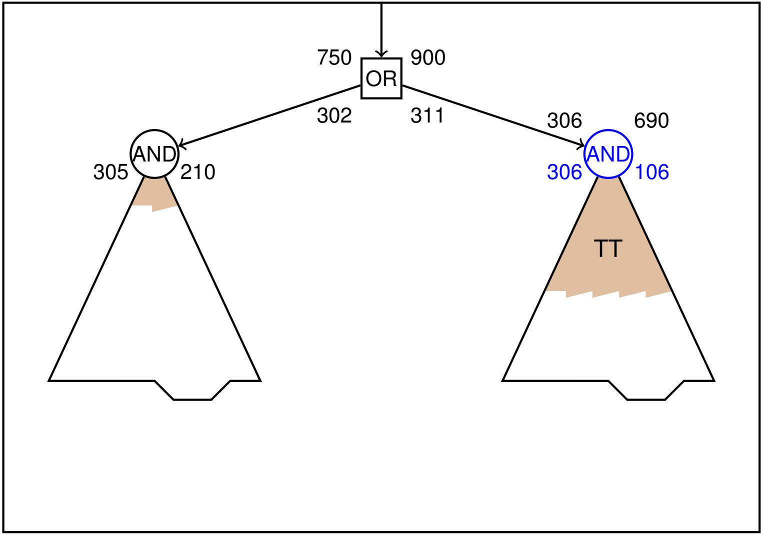

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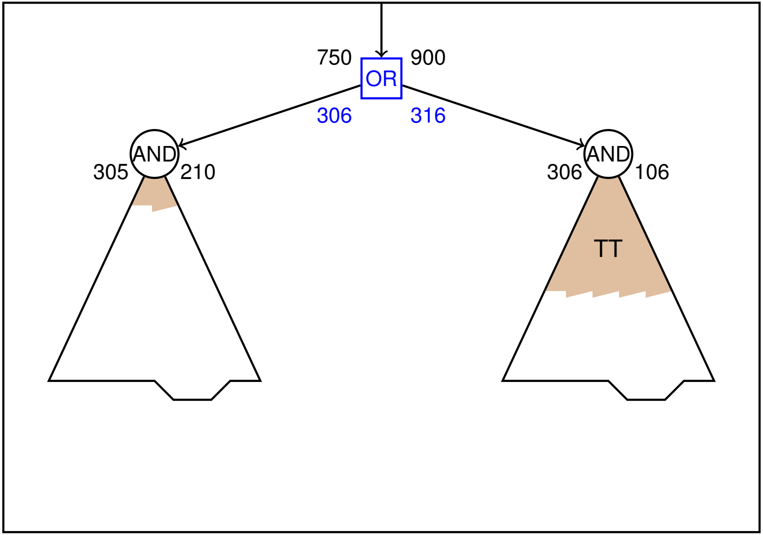

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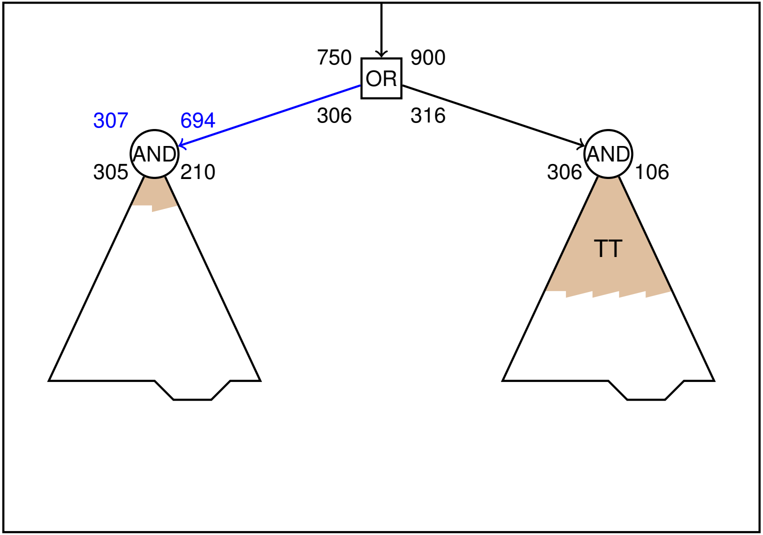

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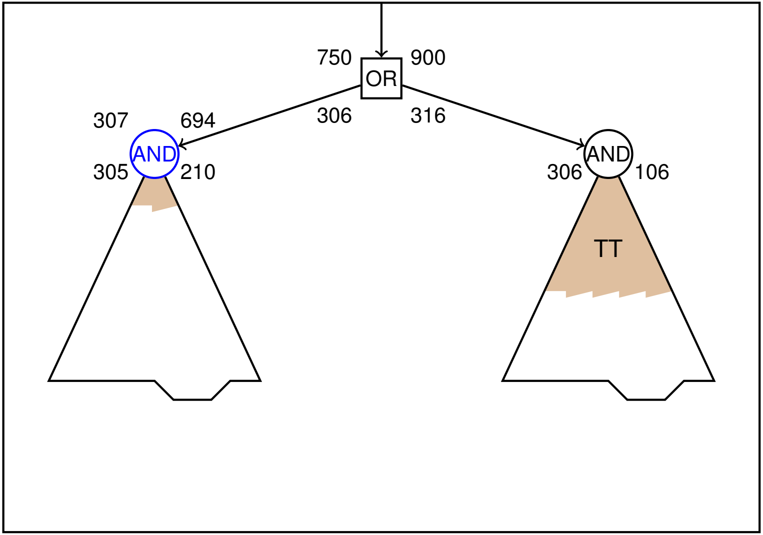

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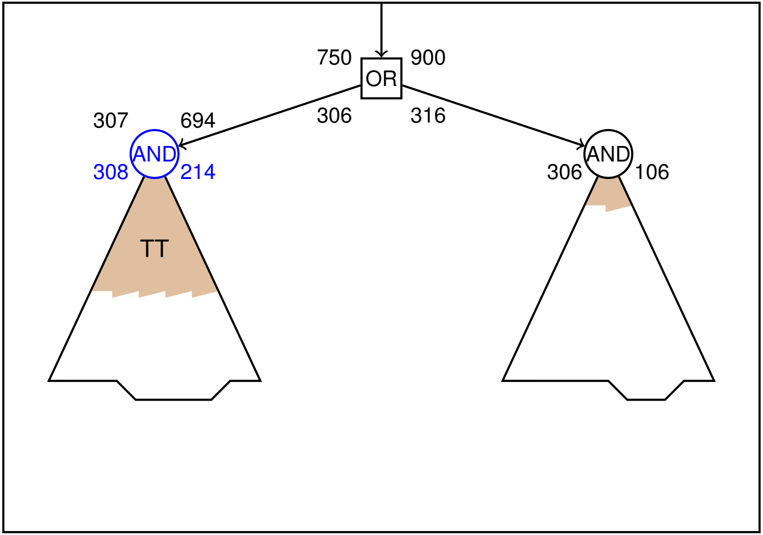

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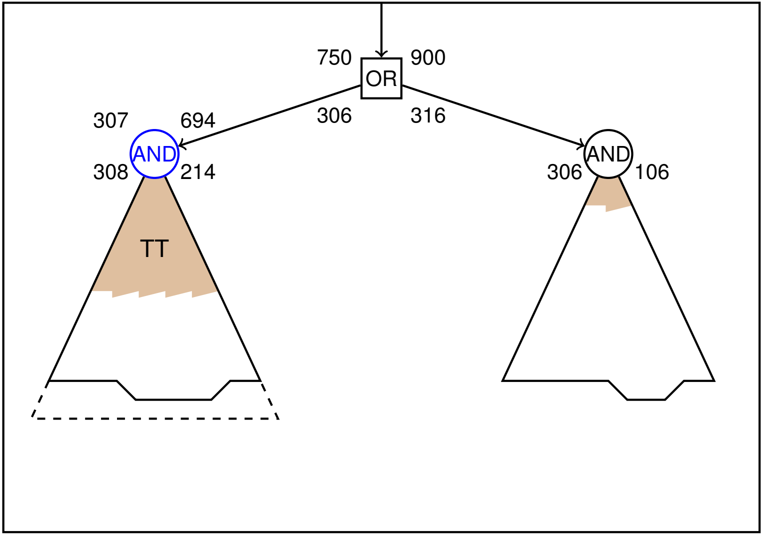

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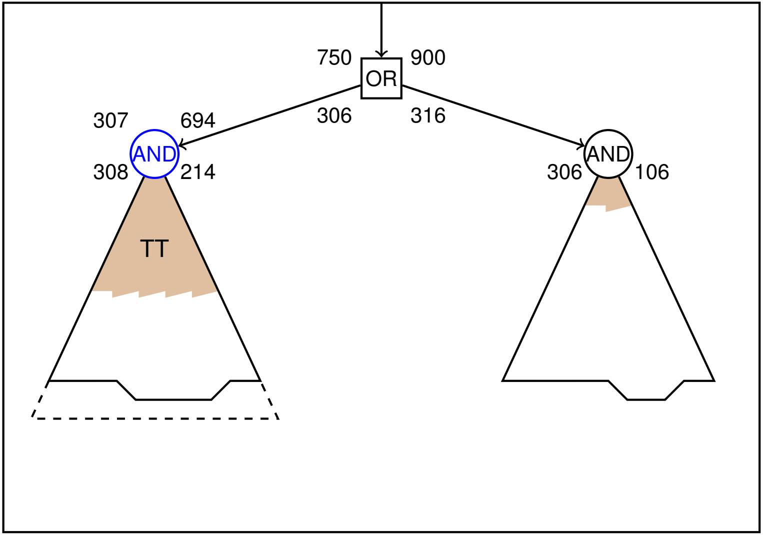

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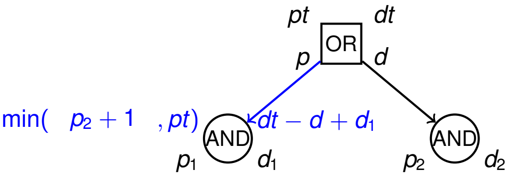

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Advantages

- Reduced number of recursive calls and transposition table refills.
- Less tree traversion.

Disadvantages

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- For bigger ε the algorithm may spent too much time in inessential part of a tree.

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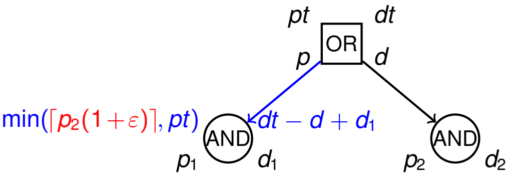

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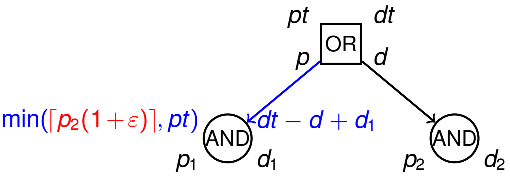

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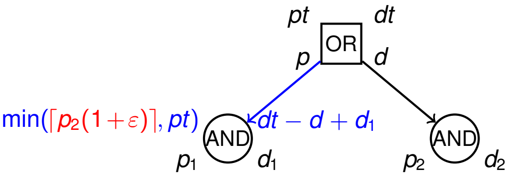

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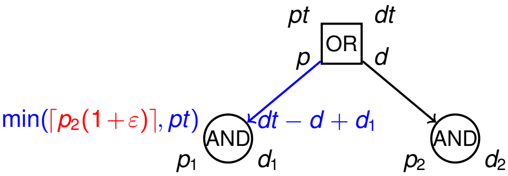

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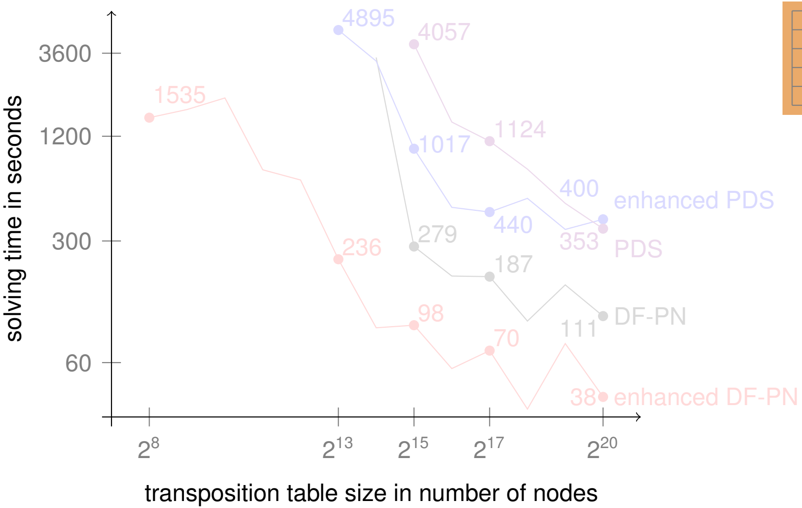
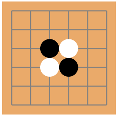
Atari Go: The Size of a Transposition Table





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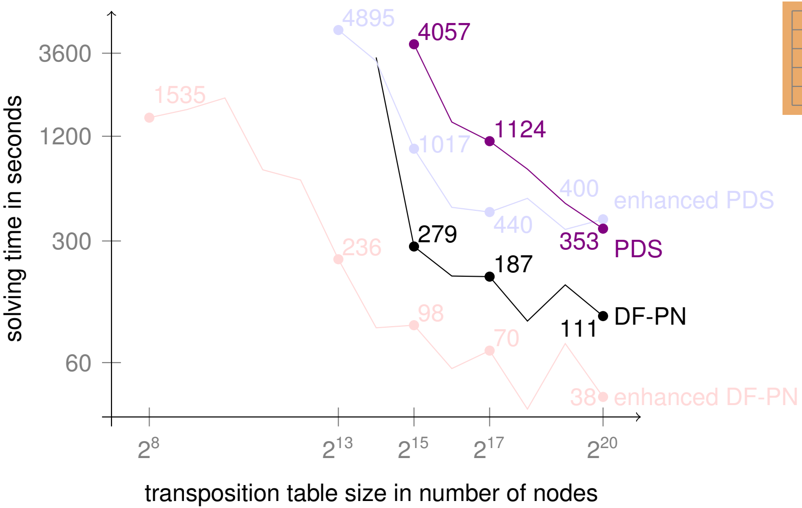

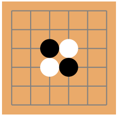

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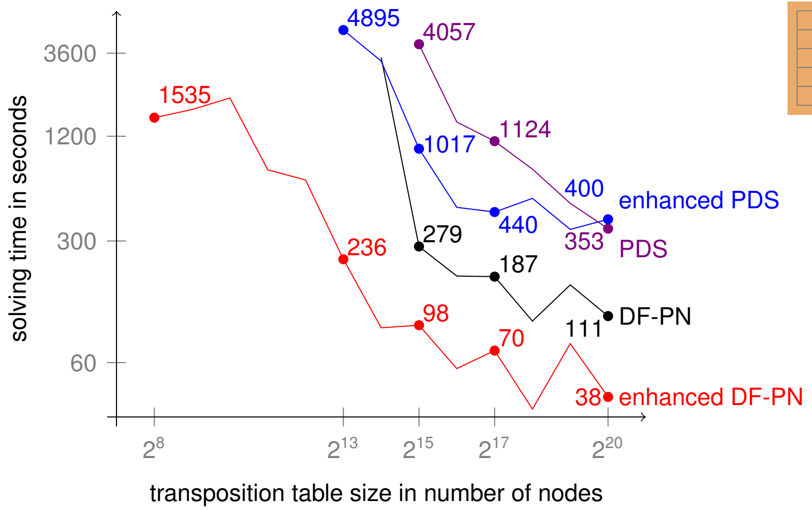
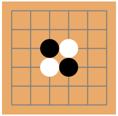
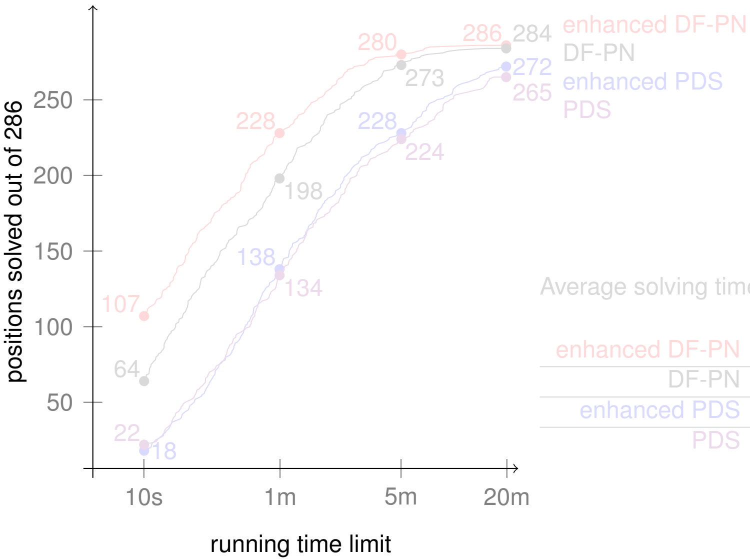
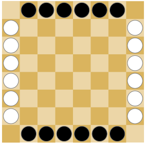




LOA: Efficiency of Solving Hard Problems





Average solving times in seconds

enhanced DF-PN	45
DF-PN	80
enhanced PDS	241
PDS	328

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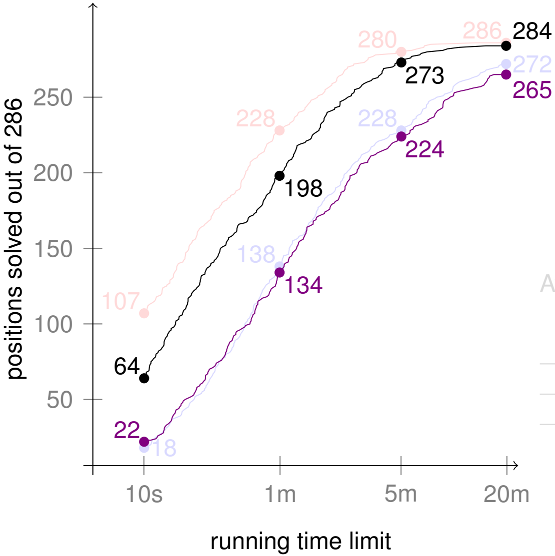

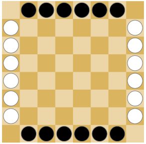

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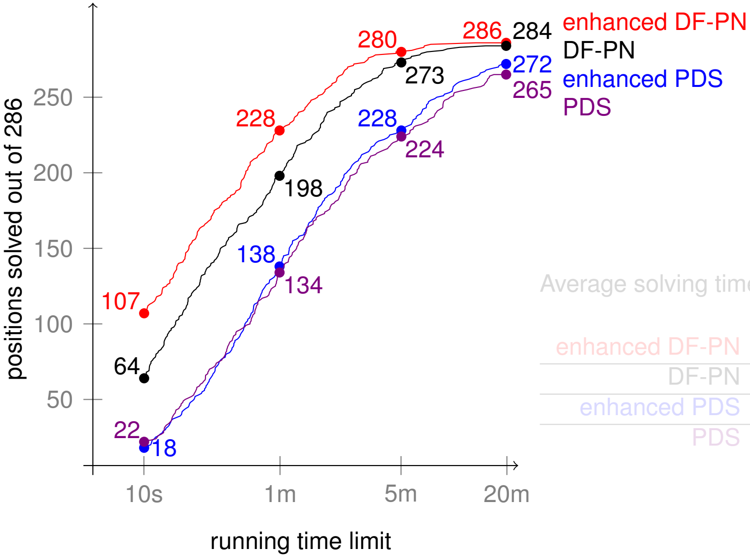

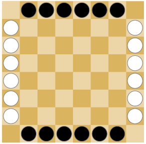

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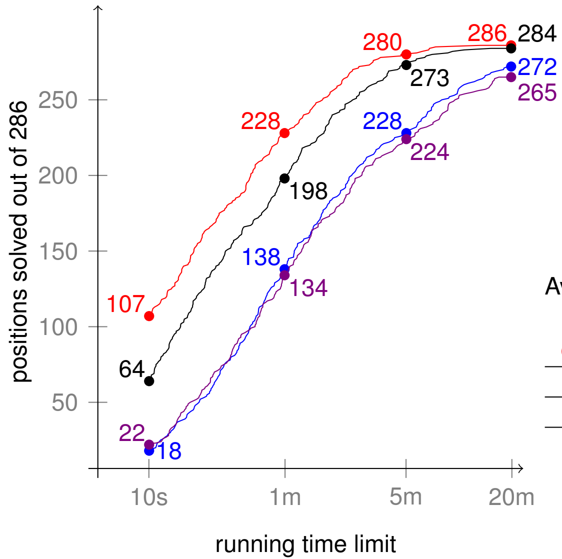

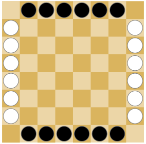

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Summary

- We have pointed out the problems in DF-PN.
- We have introduced $1 + \varepsilon$ trick to enhance DF-PN.
- Atari Go experiment has shown that enhanced methods outperform their plain variants in low memory conditions.
- Experiment on LOA has shown that the trick is also valuable for solving hard problems.

Thank You

Questions?