Predicting the Size of Depth-First Branch and Bound Search Trees

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Introduction

The Problem

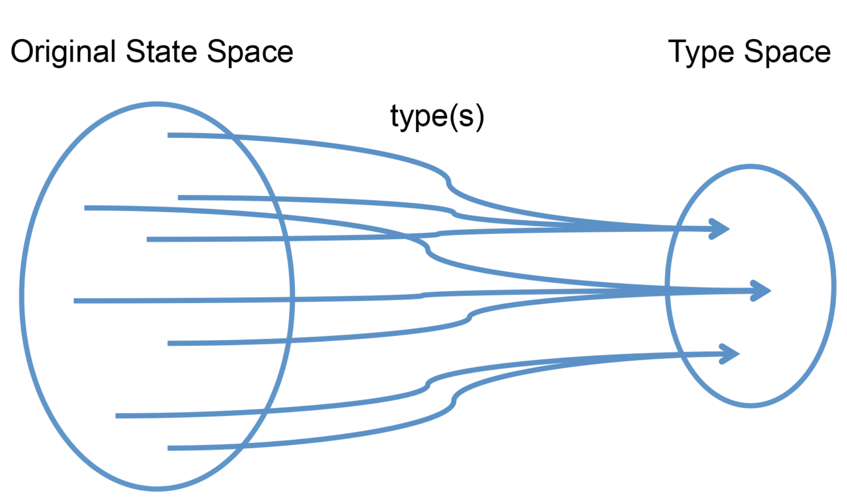
- Given:
  - a start state, and
  - a heuristic function,
- efficiently predict the number of nodes Depth-First Branch and Bound (DFBnB) expands.

Motivation

- know how long a given search will take.
- divide the workload in a parallel computing setting.
- compare different search strategies.

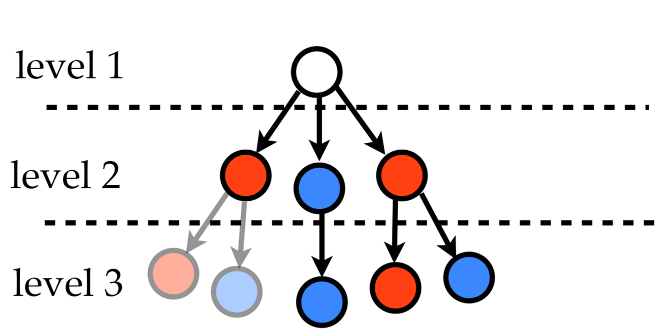
Stratified Sampling by Chen (1989)

Type Systems



Stratified Sampling Assumption

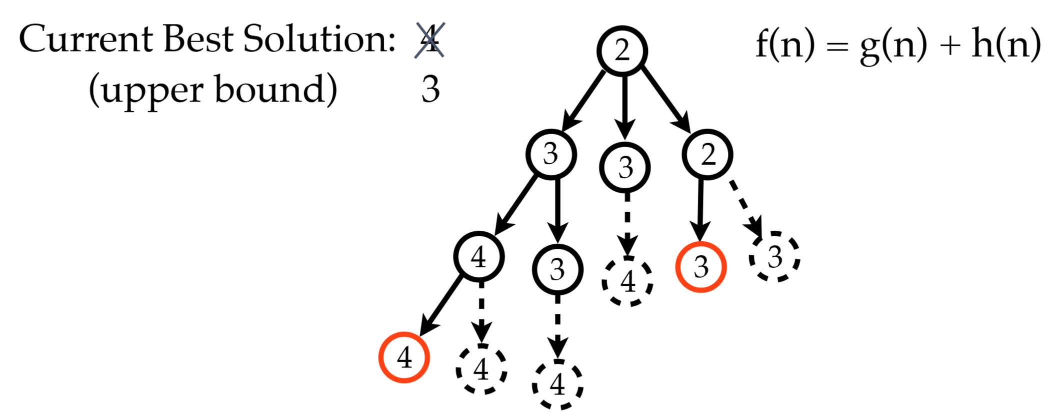
- Nodes of the same type root subtrees of the same size.



Prediction: 9 nodes Expanded

DFBnB Prediction

DFBnB



Chen's Method for DFBnB Prediction

- SS is NOT directly applicable.
  - DFBnB searches in a depth-first manner.
  - DFBnB updates the upper bound as search goes.
  - SS is not aware of the upper bound updates.
- SS produces lousy predictions.

Two-Step Stratified Sampling

TSS Assumption

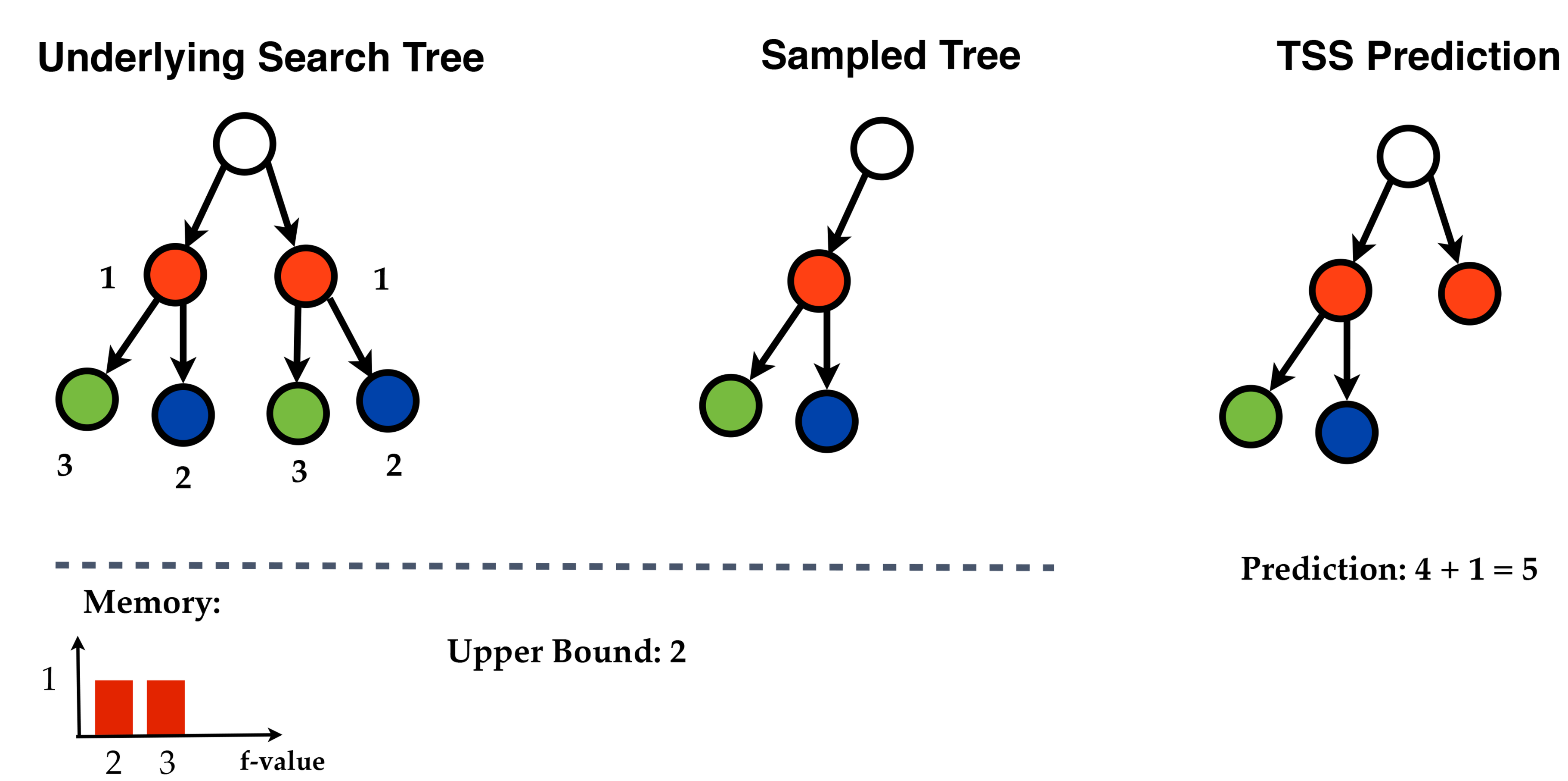
- Nodes of the same type root isomorphic subtrees.

The Algorithm

- We equip SS with a system for approximating the bound updates:
  - First, we run SS to get a subtree of the problem's underlying search tree.
  - Second, we emulate DFBnB in the subtree SS sampled.

Heuristic-Based Type Systems

- **a** and **b** have the same type (Zahavi et al. 2010).



Theoretical Result

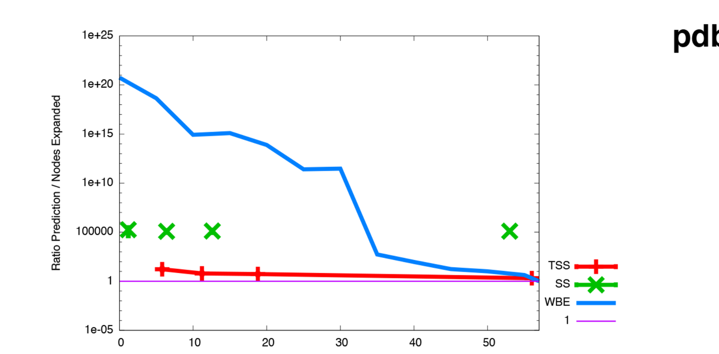
- In the limit, as the number of probes goes to infinity, TSS is guaranteed to produce perfect predictions.

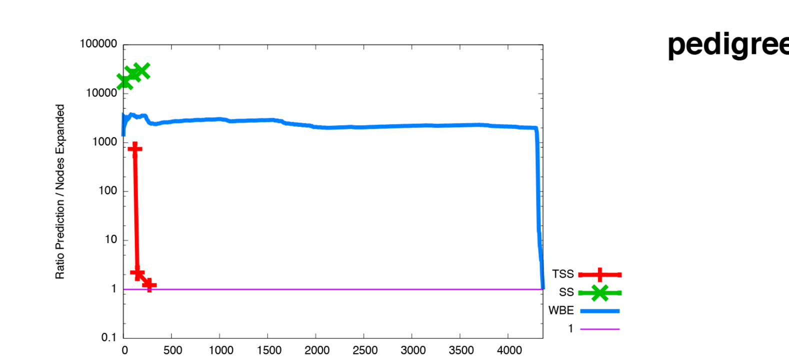
Empirical Results

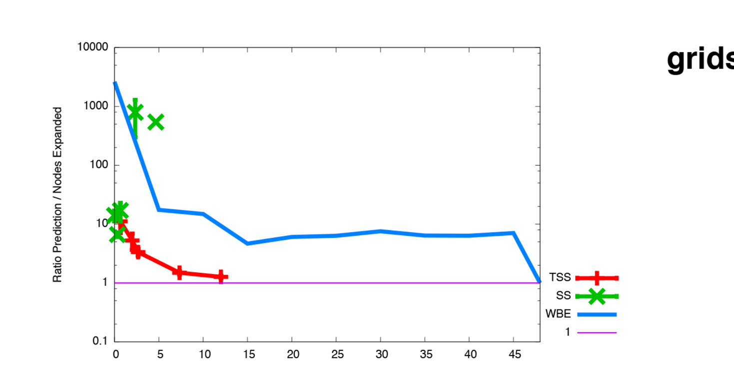
Problem Domains

- Optimization problems over Probabilistic Graphical Models.
  - Protein Side-Chain Prediction (pdb).
  - Computing Haplotypes in Genetic Analysis (pedigree).
  - Randomly Generated Grid Networks (grids).

Some Results







Conclusions

TSS was the only method able to produce good predictions in a timely fashion.
TSS has the guarantee of producing perfect predictions in the limit.
Memory limits the applicability of TSS.

References

Chen, P.-C. 1992. Heuristic sampling: A method for predicting the performance of tree searching programs. SIAM Journal on Computing 21:295–315.