

UG Framework to Parallelize MIP, MINLP, and ExactIP Solvers

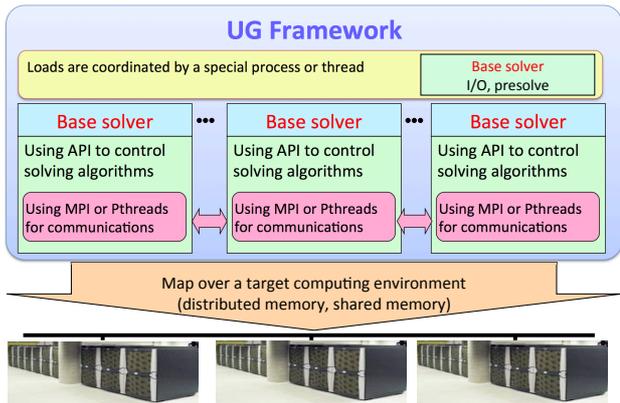
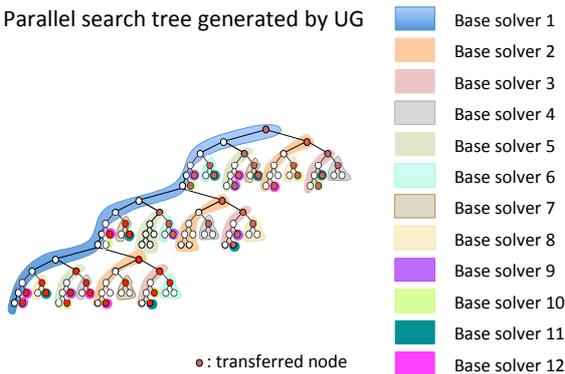
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Ubiquity Generator (UG) Framework

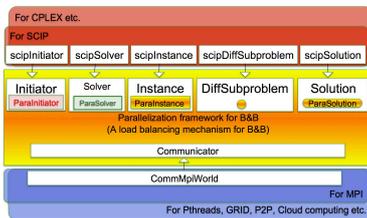
A generic framework to parallelize branch-and-bound based solvers (e.g., MIP, MINLP, ExactIP) in a distributed or shared memory computing environment.

- ▷ Exploits powerful performance of state-of-the-art “base solvers”, such as SCIP, CPLEX, etc.,
- ▷ without the need for base solver parallelization.

Parallel search tree generated by UG



Abstraction of base solvers and communication libraries



Small and simple interfaces between

- ▷ UG framework and base solver
- ▷ UG framework and communication library

A parallel solver instantiated by UG framework is named

`ug[Base Solver, Communication library]`

Current projects

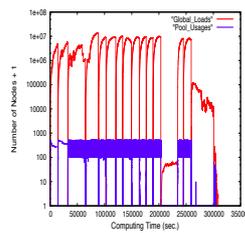
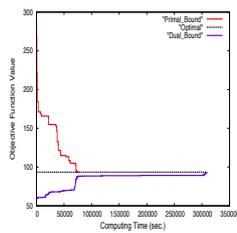
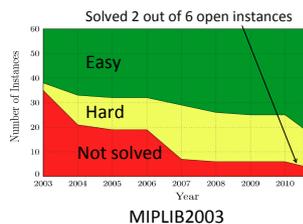
- ▷ ParaSCIP: `ug[SCIP, MPI]`
 - Uses CIP solver SCIP
 - Used to investigate a large scale parallelization
 - Runs on up to 7,168 cores at supercomputer HLRN II
- ▷ FiberSCIP: `ug[SCIP, Pthreads]`
 - Uses CIP solver SCIP
 - Enables parallelization on single desktop computers
- ▷ ParaCPLEX: `ug[CPLEX, MPI]`
 - Uses MIP solver CPLEX

Current results of ParaSCIP (ug[SCIP, MPI])

The following open instances from MIPLIB2003 were solved to optimality the first time:

- ▷ ds – 656 constraints, 67,732 binary variables
 - [Run 1] solved in ~86 hours (restarted from checkpoint 16 times) using up to 2,048 cores
 - [Run 2] solved by a single job with 4,096 cores in ~76 hours
- ▷ stp3d – 159,488 constraints, 204,880 binary variables
 - after applying SCIP presolving 9 times, problem was reduced to 88,388 constraints and 123,637 binary variables
 - [Run 1] solved in ~114 hours (restarted from checkpoint 10 times) using up to 2,048 cores
 - [Run 2] proved optimality of solution using a single job with 4,096 cores in ~44 hours
 - [Run 3] proved optimality of solution using a single job with 7,168 cores in ~32 hours

Computed optimal solutions for 50-10v, probportfolio, reblock354, rmatr200-p20, **dg012142**, **dc1c**, **germany50-DBM** from MIPLIB2010.



Evolution of computation for instance ds [Run 1]

Cooperation



New features

- ▷ Can handle both MIPs and MINLPs (Beta version is released as a part of the SCIP Optimization Suite)
- ▷ Deterministic mode for debugging