Lazy clause exchange policy for parallel SAT solvers

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ANR "Investments for the future"
CPU (ANR-10-IDEX-03-02)

Today's Itinerary

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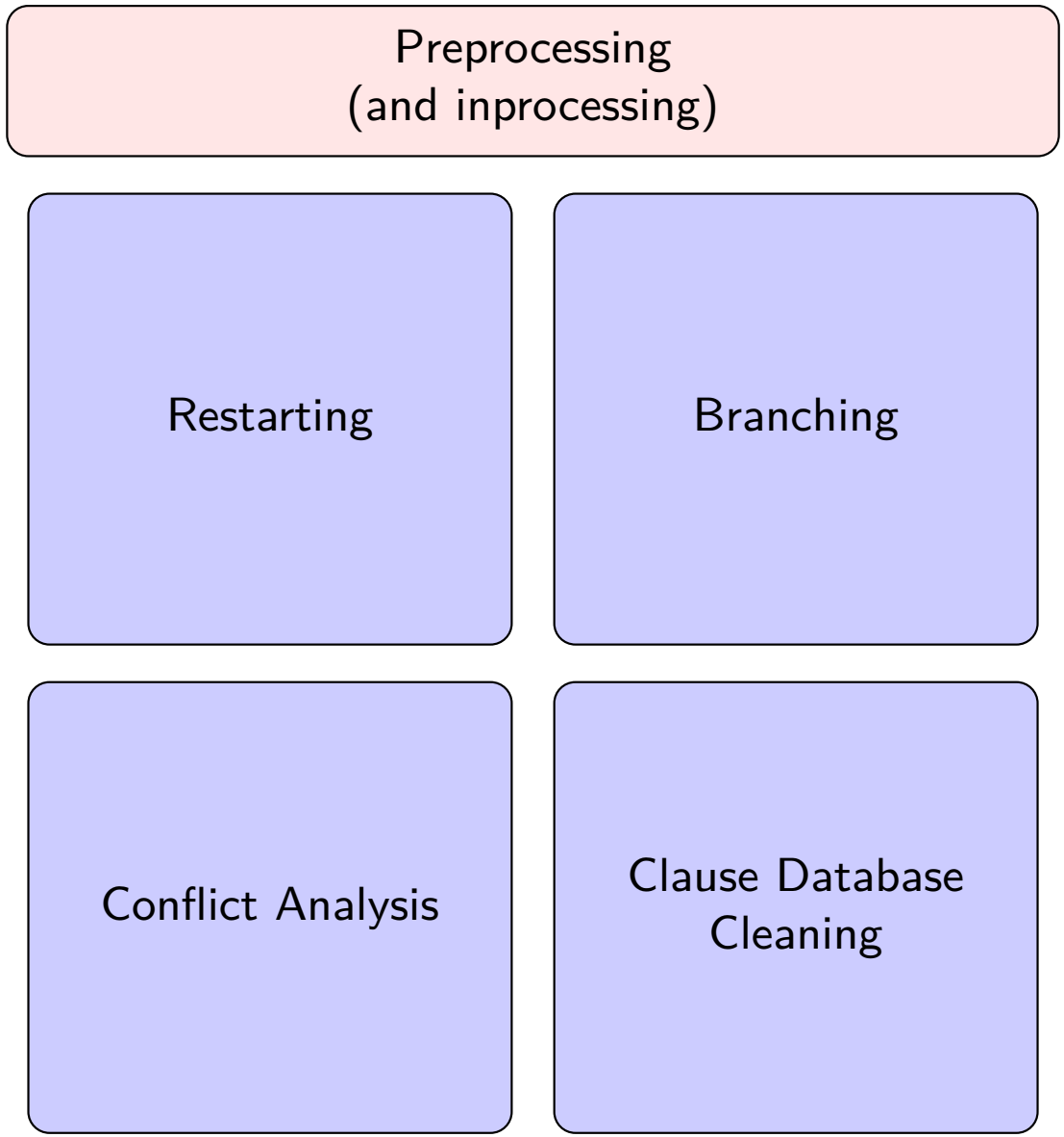
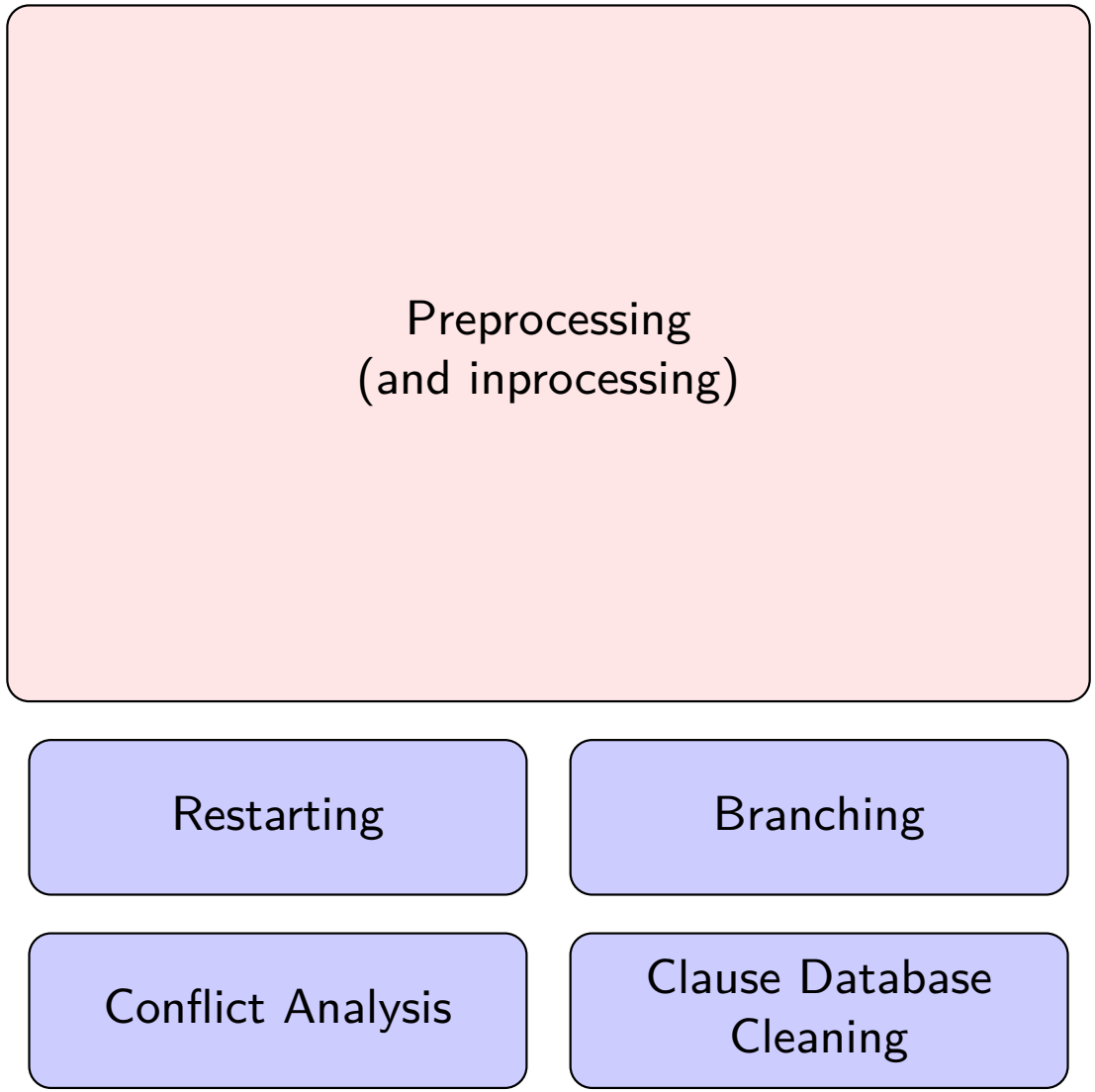
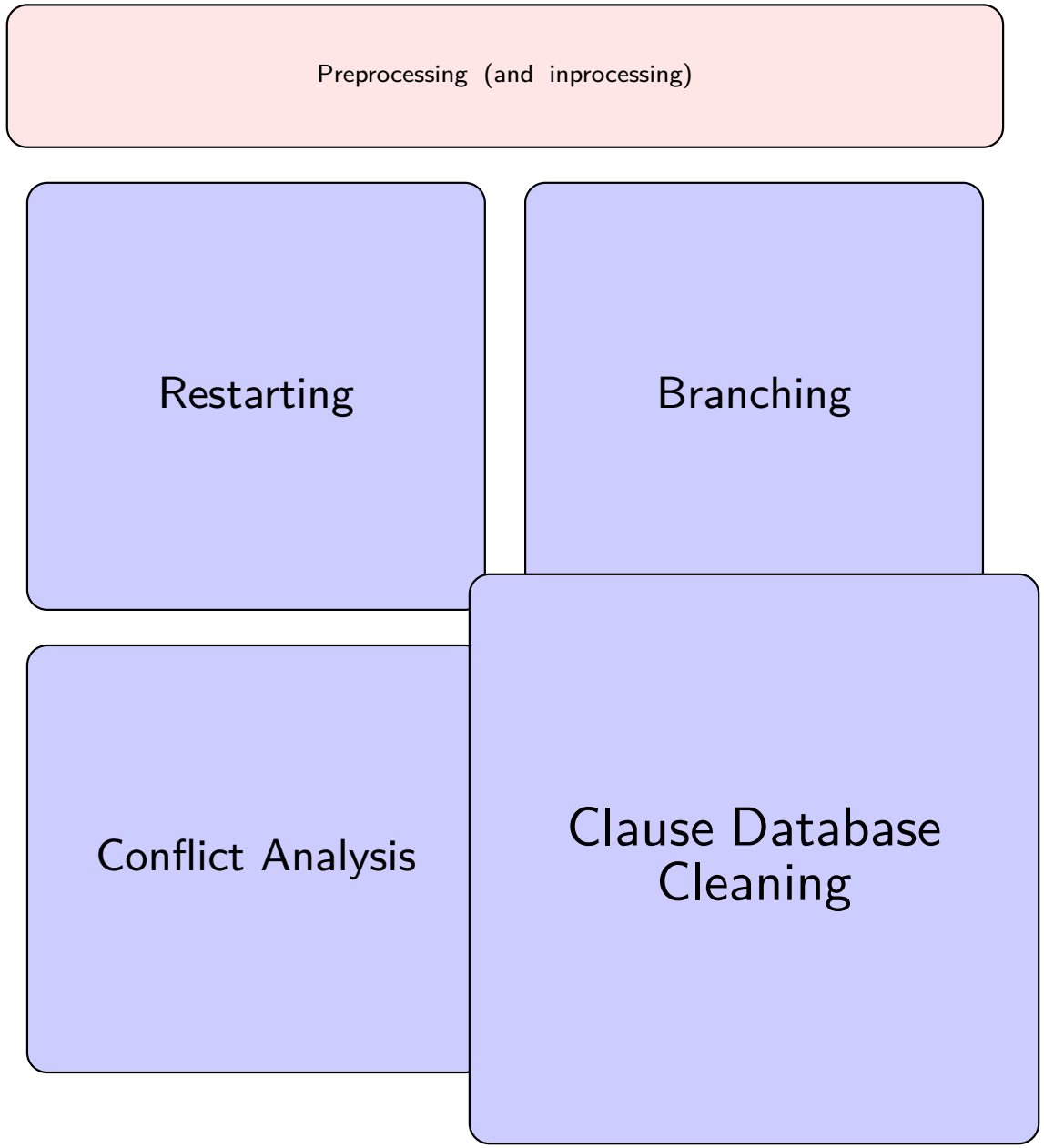
Ingredients of an efficient SAT solver



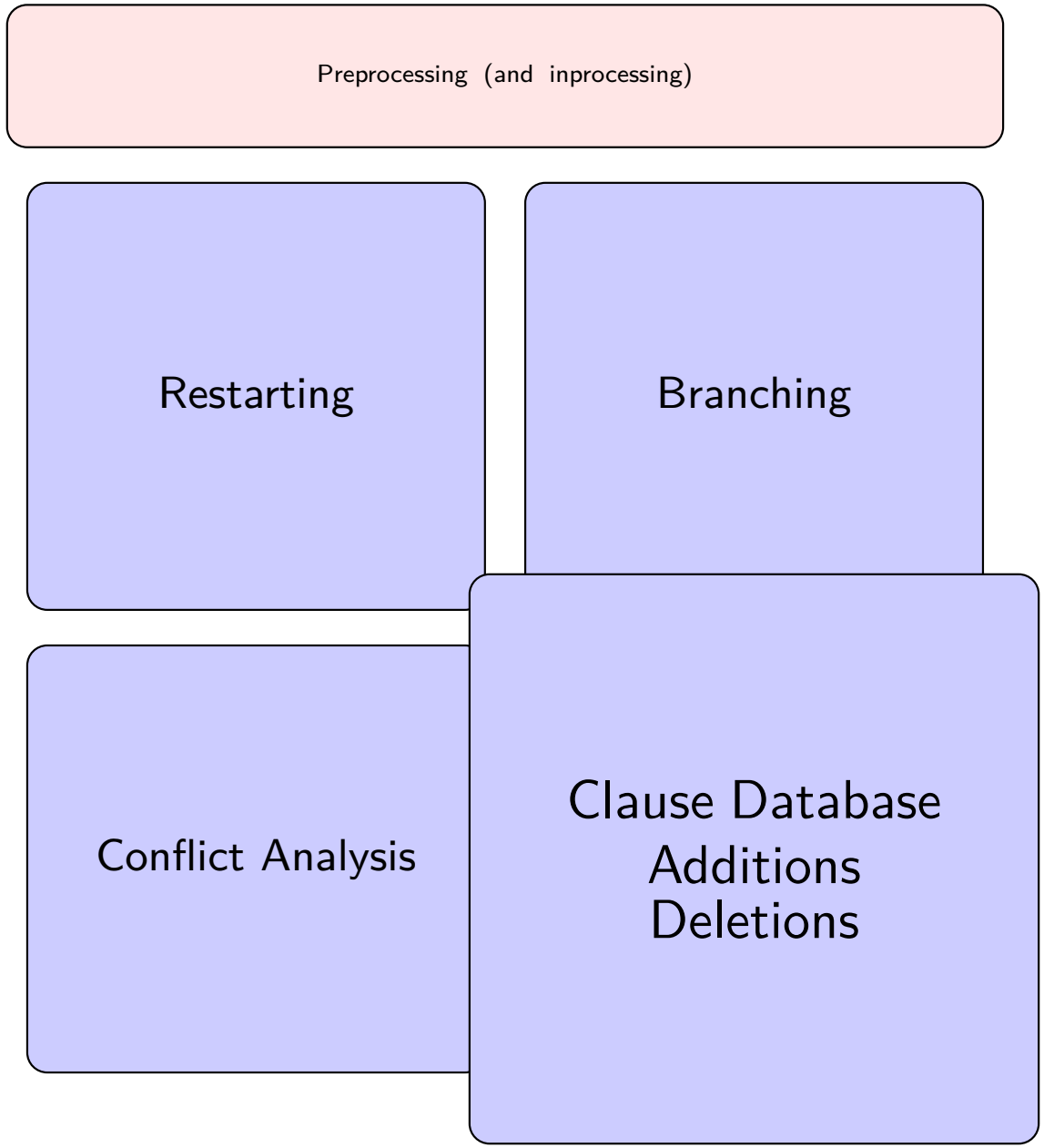
Ingredients of an efficient SAT solver



Ingredients of an efficient SAT solver



Ingredients of an efficient SAT solver



Today's Itinerary

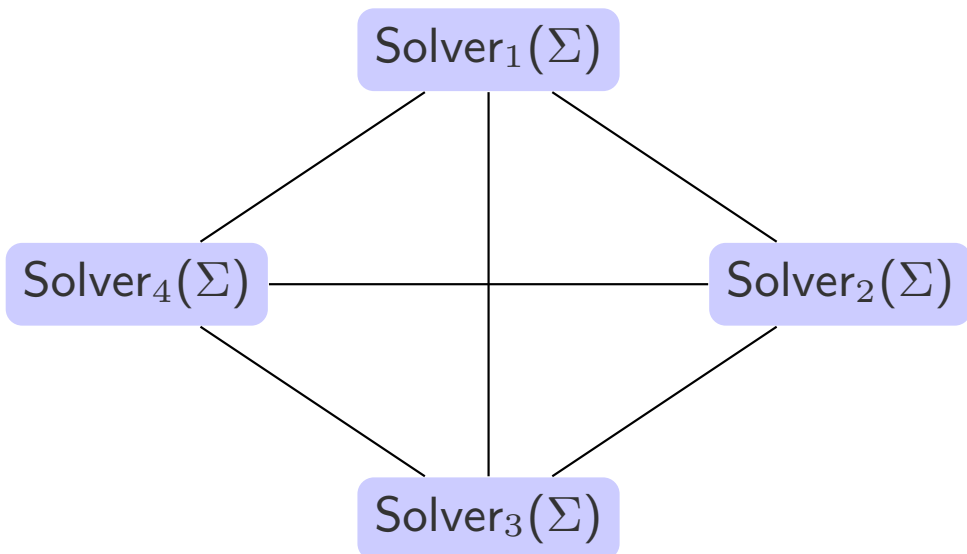
Many Cores

- Multi-core architecture, cloud $\Rightarrow$ design of parallel solvers
- Different strategies
  - Divide and conquer

    ➔ Explicitly splits search w.r.t. assignments
  - Portfolio algorithms
    - Each thread: its own solver and the whole formula

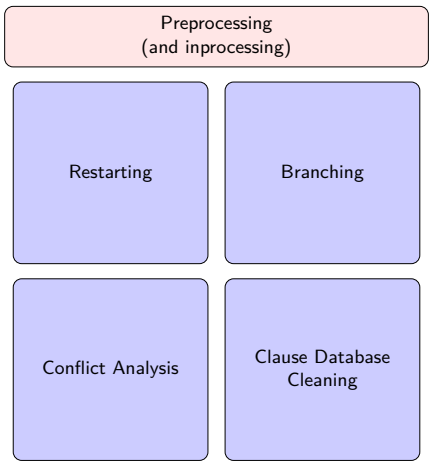
      ➔ Rely on orthogonal searches
  - Parallel solver
    - communication: learnt clauses

      ➔ All threads working on the same proof



Many Cores, Many more problems

Sharing clauses in parallel has many drawbacks



- Imported clauses can be bad (noise, wrong way, . . .)
- Imported clauses can be subsumed / useless
- Imported clauses can dominate learnt clauses
- Each thread has to manage many more clauses
- Many side effects on all core components

Currently: Clauses are sent as soon as they are learnt, plus:

- MANYSAT 1.0: size ≤ 8
- MANYSAT 1.1: dynamically adjust the threshold
- PLINGELING: size ≤ 30 and LBD ≤ 8
- PENELOPE: LBD ≤ 8 (PSM allows more clauses exchanges)

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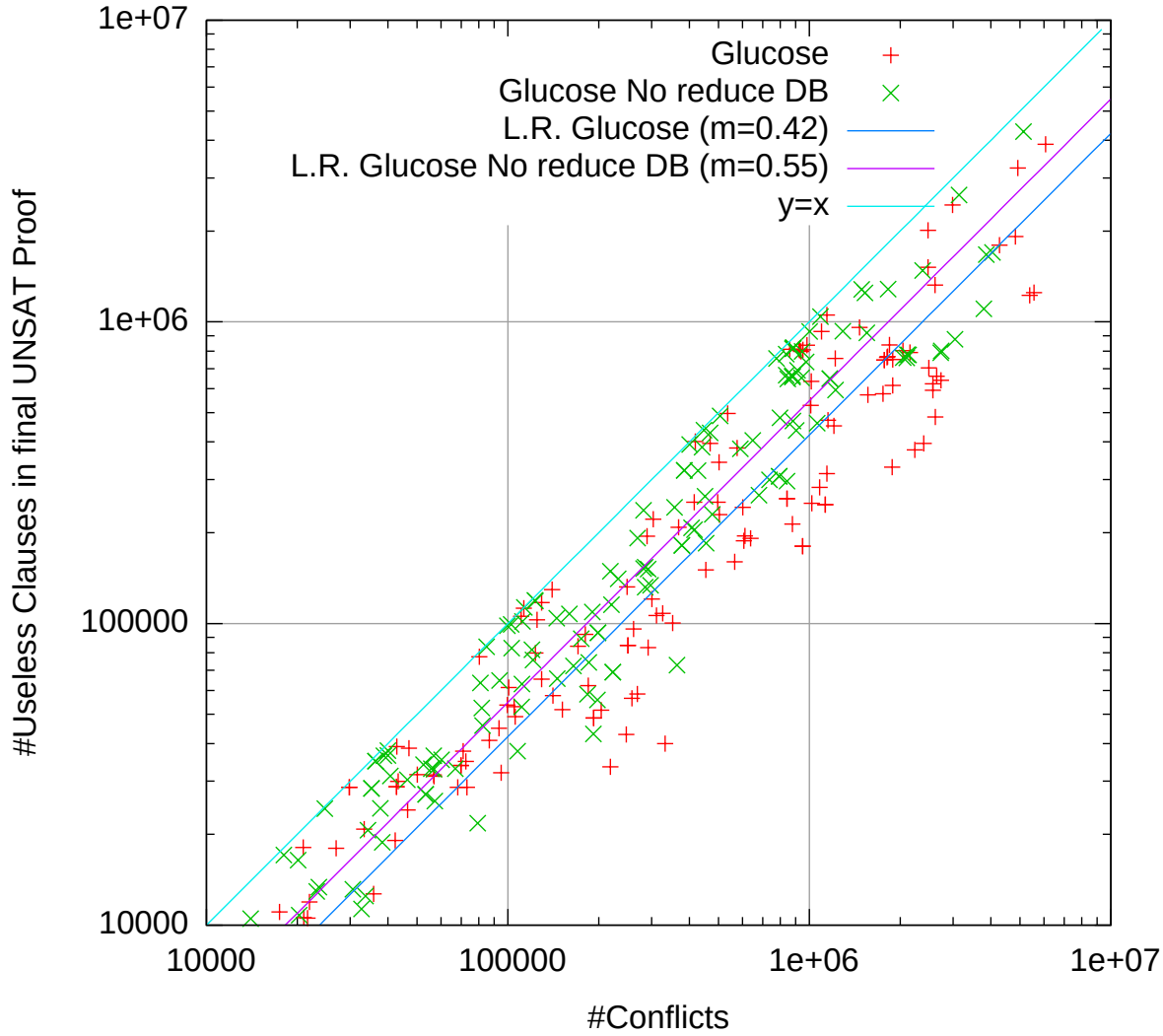
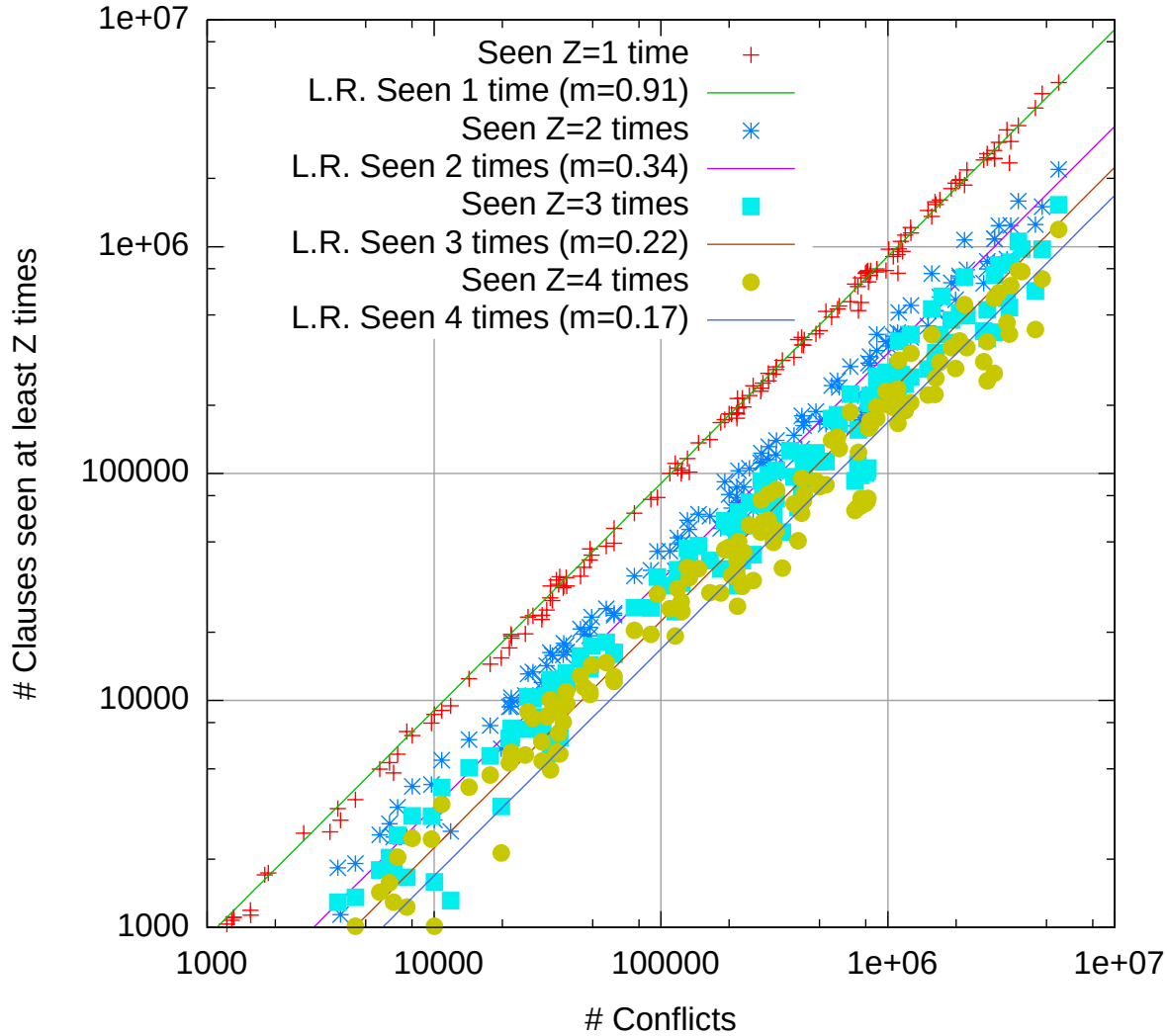
Many *useless clauses* even in single engine solvers



- x-axis : Number of conflicts
- y-axis : Useless clauses in final proof (UNSAT formulas)

How many times clauses are seen in conflicts



- x-axis: Number of conflicts
- y-axis: Number of clauses seen at least Z times

Conclusions from the experiments

A lot of useless clauses even in a single engine!

➔ In parallel, this situation will be even worse!

Why sending a clause that is even not locally interesting?

We will consider clauses seen 2-times (only 34% of learnt clauses)

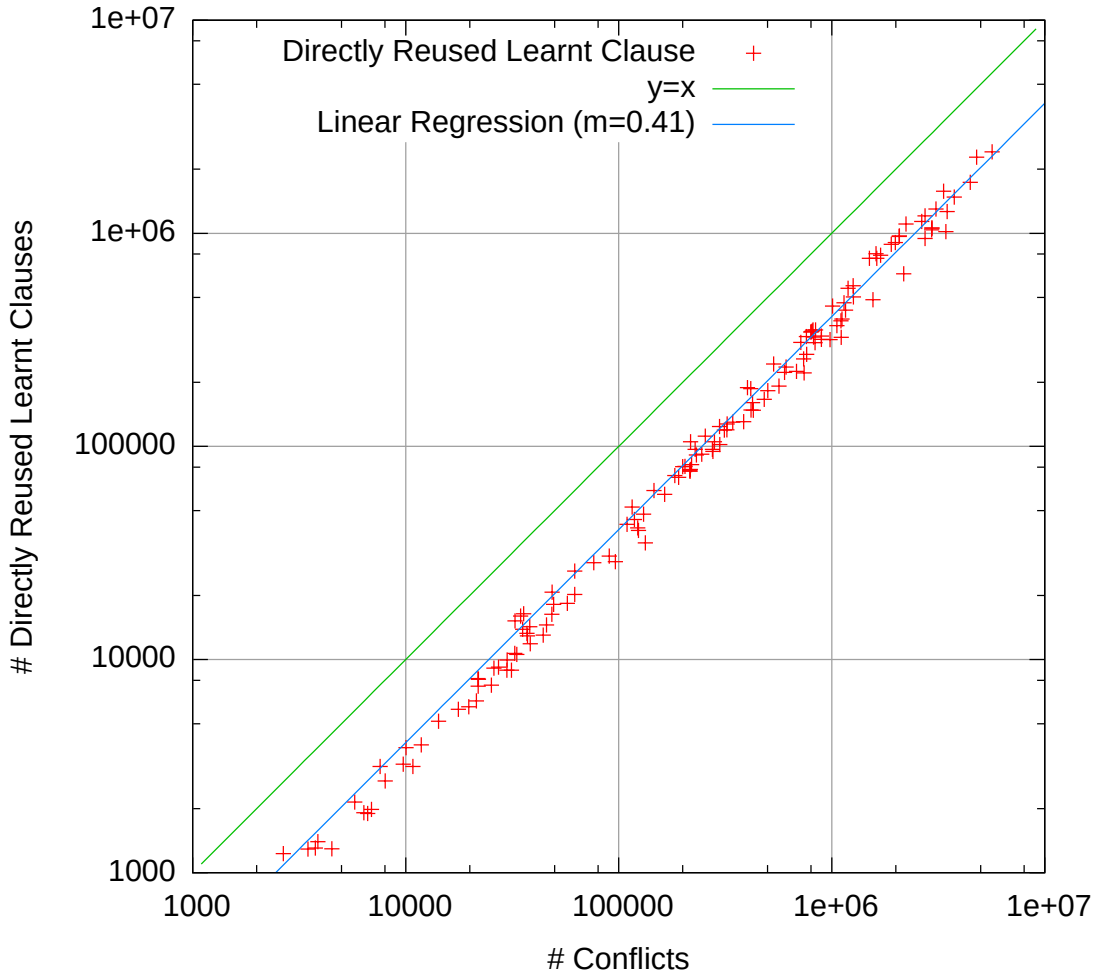
➔ Already filter out the majority of clauses

How to efficiently detect them?

Is there a window of recent clauses to check?

➔ Can we check only recent learnt clauses (and save time)?

Learnt and Directly Reused Clauses



- x-axis: Number of imported clauses (sum over 8 threads)
- y-axis: Number of promoted clauses (sum over 8 threads)

91% of clauses seen at least 1 time. Only 41% are immediately seen.

Lazy Exportation of Clauses

Clauses are sent during conflict analysis

We only export clauses when seen 2 times in conflict analysis and:

- Clauses with LBD $\leq$ median(LBD) and size $\leq$ average(SIZE)
  - Limits updated at each clause database cleaning

Unary clauses and very glue clauses are immediately sent

Lazy because we wait to have a good chance of local interest before considering sending it

Lazy Importation of Clauses

Problem of clauses importations:

- can destroy the current search effort
- clauses can be redundant
- many clauses to manage (performance impact)

How to be sure an imported clause is interesting before considering it?

Idea: put it in probation

- Imported clauses are put in a 1-Watched scheme
- Will be promoted to a 2-Watched scheme only if found empty

Other Advantages

- Less efforts for propagations
- Can be seen as a dynamic Freezing/Reactivating strategy
- Clauses are imported with a local (and correct) LBD value

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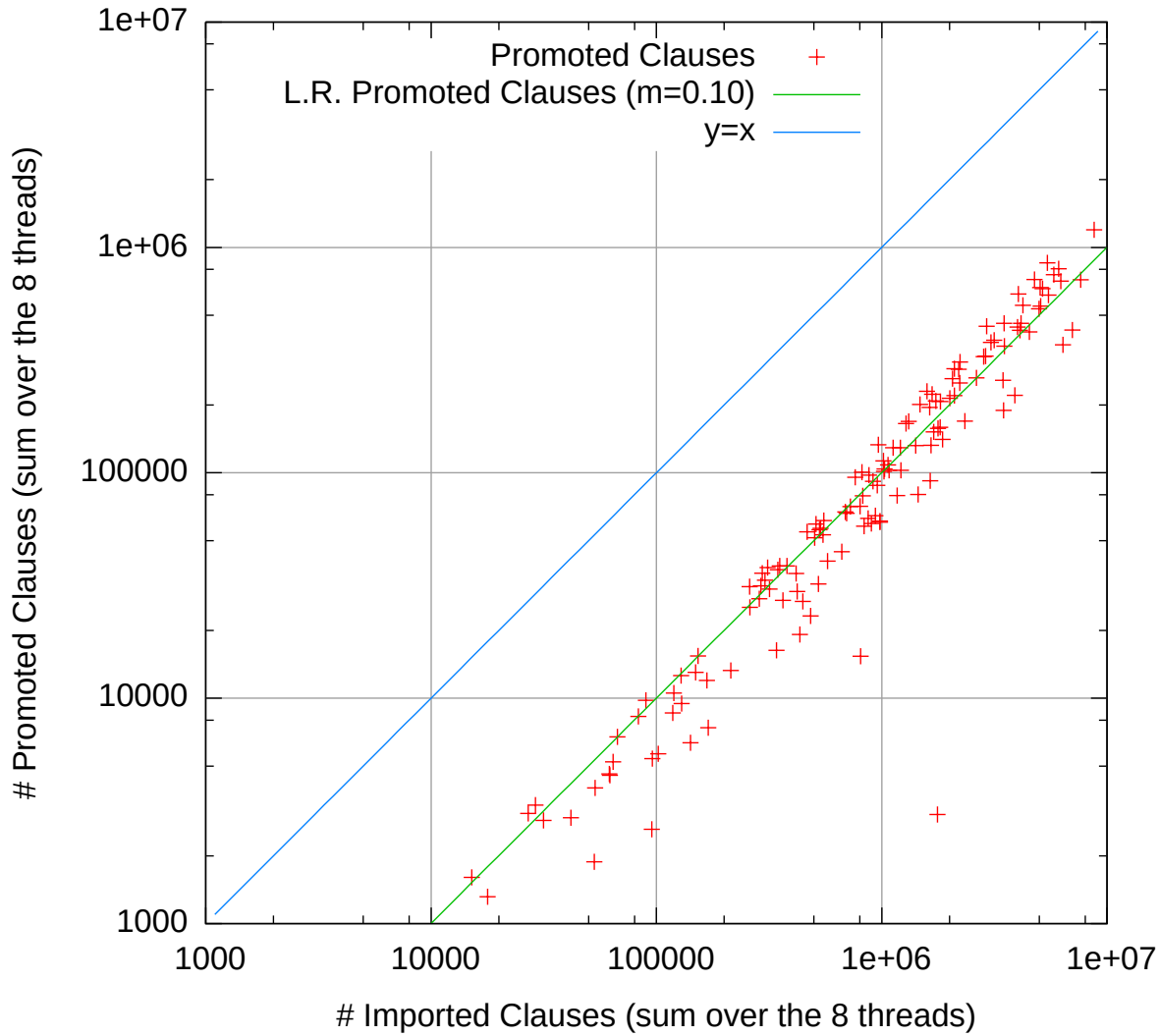
How many promotions?



- x-axis: Number of imported clauses (sum over 8 threads)
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Implementation details

Solvers have many restarts

➔ Import clauses at decision level 0 only

Imported clauses (1-Watched) database have its own deletion strategy

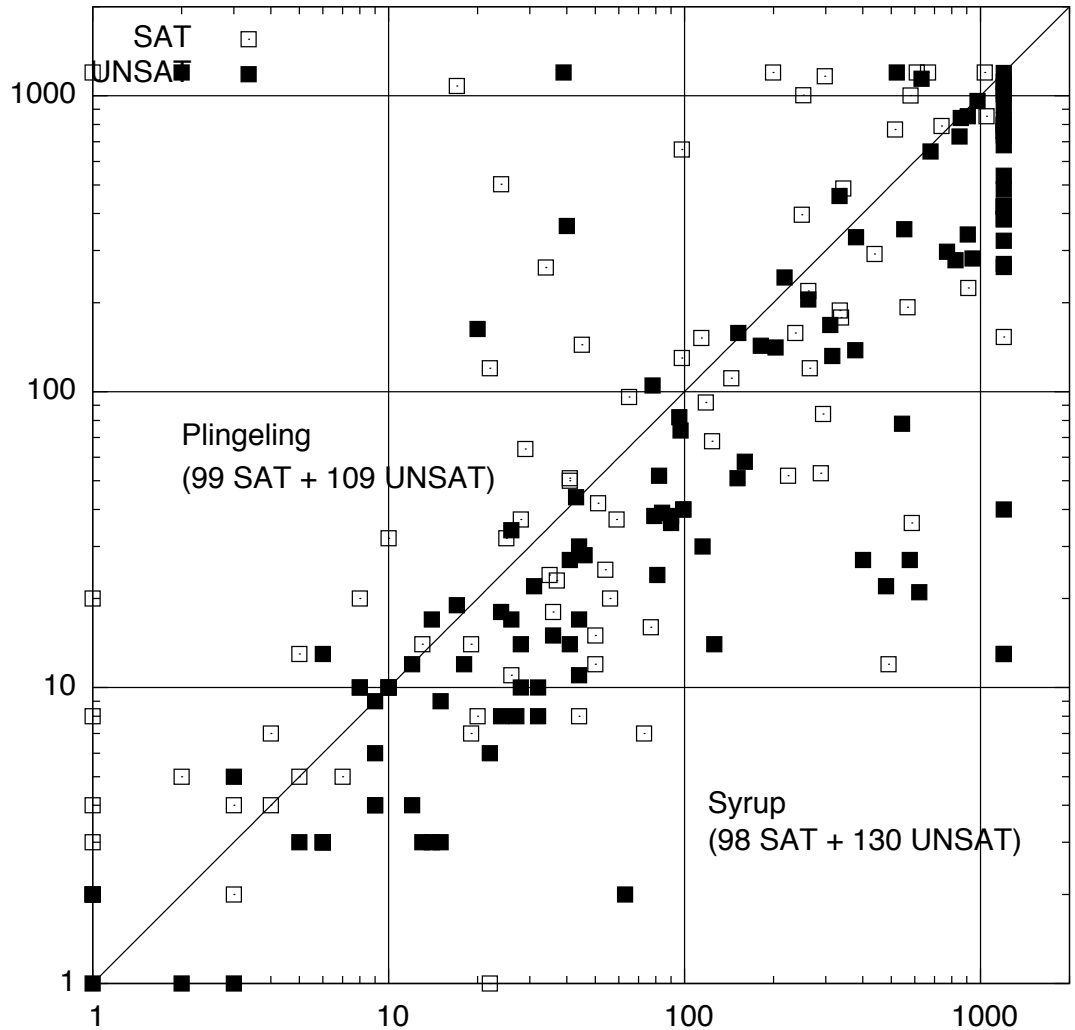
➔ Limits the impact of importation on the solver

(Gory) Details of Glucose-Syrup in the contest:

- One solver is created, then cloned
- Number of solvers adjusted to fit into 40% of allowed memory
- When approaching the max memory allowed, switch to *Panic Mode*: Almost Constant Memory consumption mode
- No tuning of cores strategies. Only the "French's Flair".

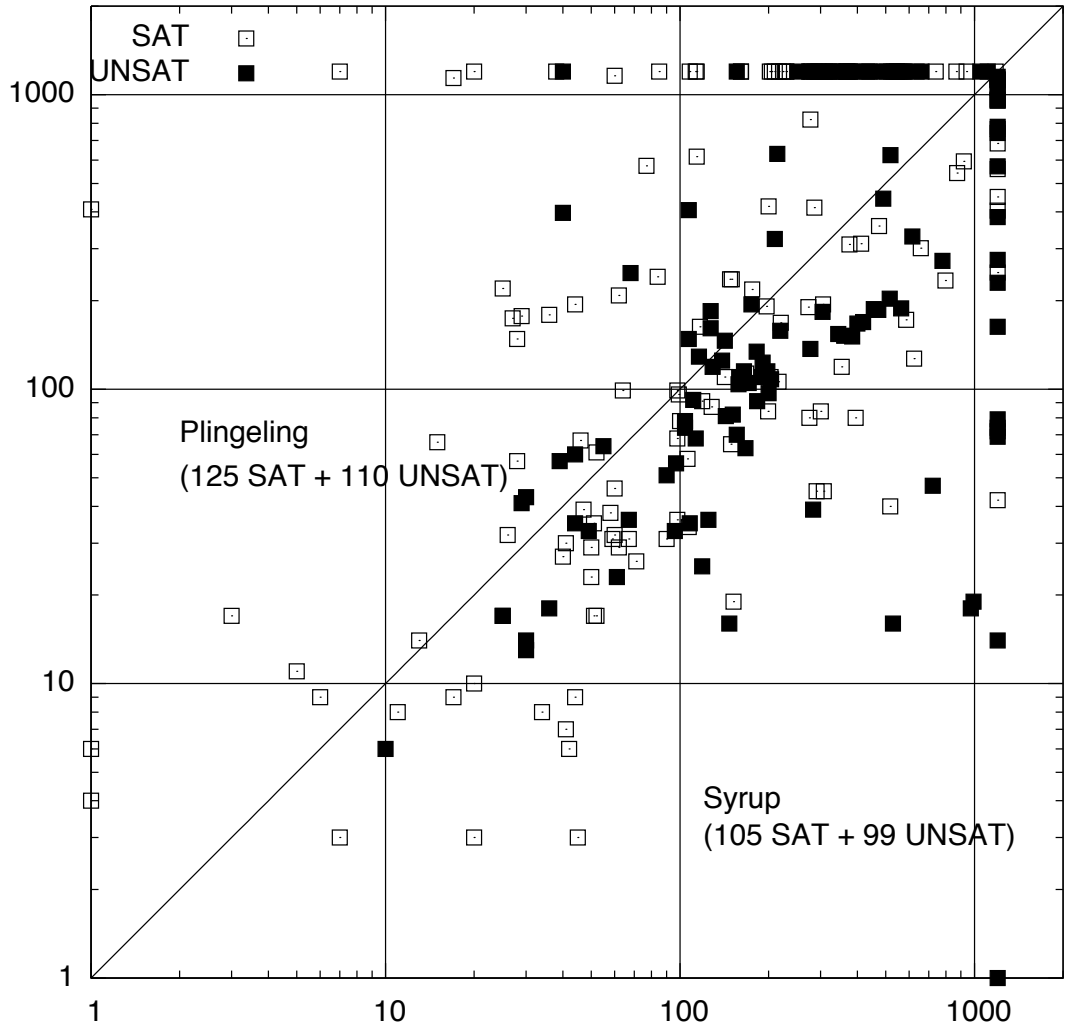
➔ Idea: as few parameters changes as possible

Syrup versus Plingeling on SAT11 benchmarks



- Syrup: 228 instances solved - 98 SAT / 130 UNSAT !!
- Plingeling: 208 instances solved - 99 SAT / 109 UNSAT

Syrup versus Plingeling on SAT13 benchmarks



- Syrup : 204 instances solved - 105 SAT / 99 UNSAT
- Plingeling : 235 instances solved - 125 SAT / 110 UNSAT !!

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Conclusion

A simple, efficient, more semantic way to exchange clauses between cores

Parallel Glucose seems very efficient on non crypto problems (like Glucose)

Special thanks to:

- Marijn Heule
  - For helping us debugging the unstable competition version
- Daniel le Berre
  - For fruitful discussions at the Banff Workshop

Please wait to download a stable-cleaned-improved version of glucose syrup