A Propagation Rate based Splitting Heuristic for Divide-and-Conquer Solvers

Saeed Nejati, Zack Newsham, Joseph Scott, Jimmy Liang, Catherine Gebotys, Pascal Poupart and Vijay Ganesh

University of Waterloo

September 1st
SAT 2017

Introduction

- Parallel SAT solvers (Availability of computing nodes)
- Portfolio, Divide-and-Conquer
- Divide-and-Conquer: Split the formula into several sub-formulas and solve them using CDCL solvers in parallel, and share information while solving

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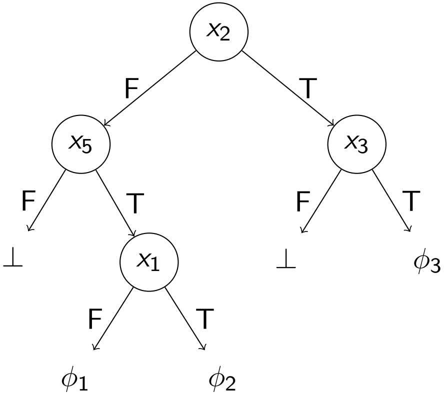
- How to "Divide" so the "Conquer"s become easier?

Search Space Partitioning

- $\phi_1 = \phi \wedge \neg x_2 \wedge x_5 \wedge \neg x_1$
- $\phi_2 = \phi \wedge \neg x_2 \wedge x_5 \wedge x_1$
- $\phi_3 = \phi \wedge x_2 \wedge x_3$



AMPHAROS - Baseline

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- Adaptive load balancing of solvers over cubes

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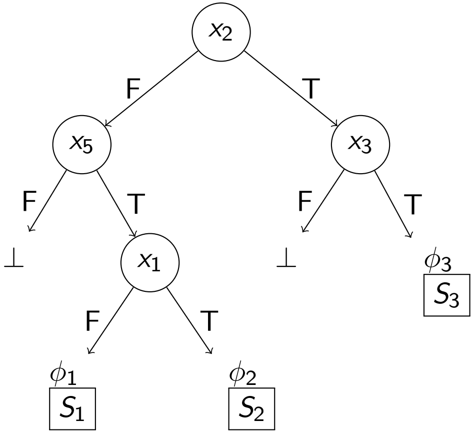

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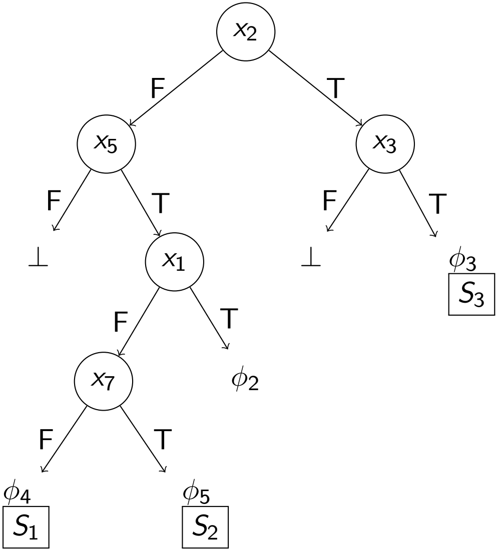

What's added?

- Propagation rate-based splitting heuristic
- Worker Diversification

Backend Solver

- Fairly modular, easy to modify
- Included: Minisat, Glucose
- Added: **MapleSAT**
- Small improvement over existing workers

Splitting Heuristic

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- Propagation rate
  - For each variable: (# of propagations / # of decisions)
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- A dynamic metric
- Computed during solving of each cube
- Minimal computation overhead
- Smaller sub-formulas are expected after splitting

Worker Diversification

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- The best configuration in our experiments:
  - Luby + Geometric + MABR (Multi-Armed Bandit Restart)

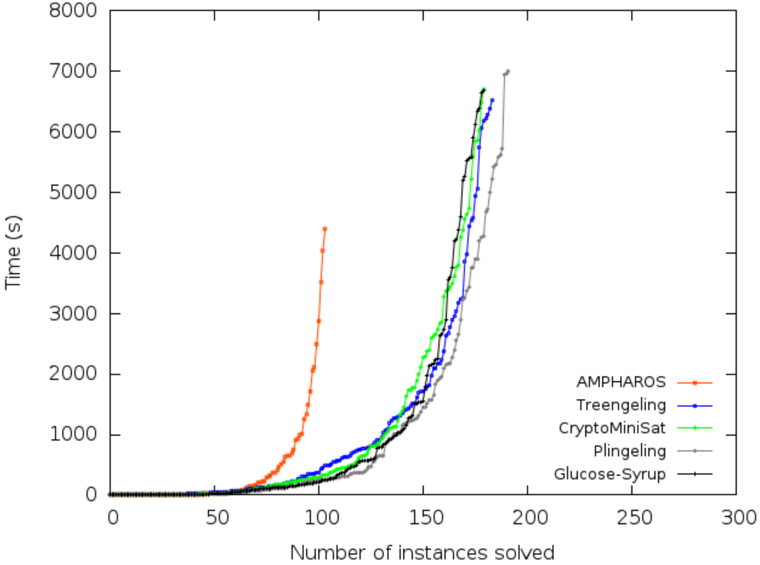
Results

Experimental Setup

- Machines:
  - 8 core Intel Xeon CPUs @ 2.53 GHz
  - 16GB RAM
- Benchmarks:
  - SAT 2016 Application
    - 300 instances
    - 2-hour timeout
  - Cryptographic Hash functions
    - Preimage of 21, 22, 23 rounds of SHA-1
    - 48-hour timeout

Resutls

SAT 2016 Application Benchmark



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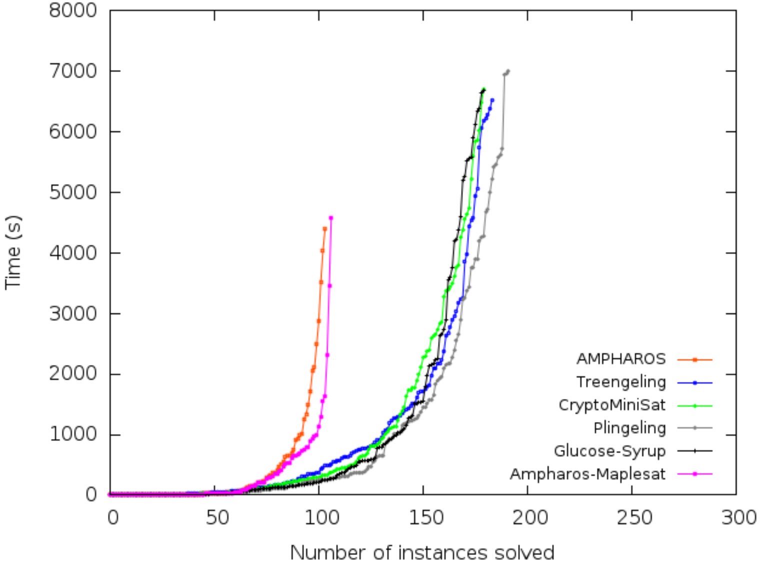

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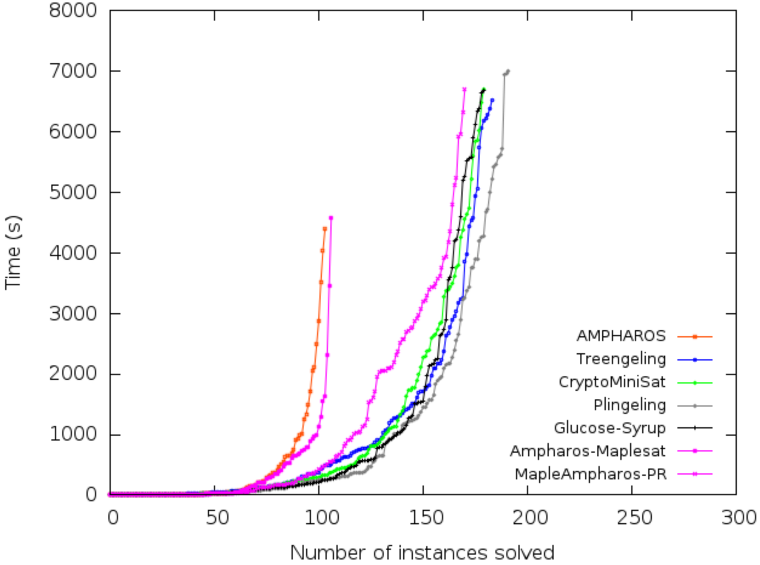

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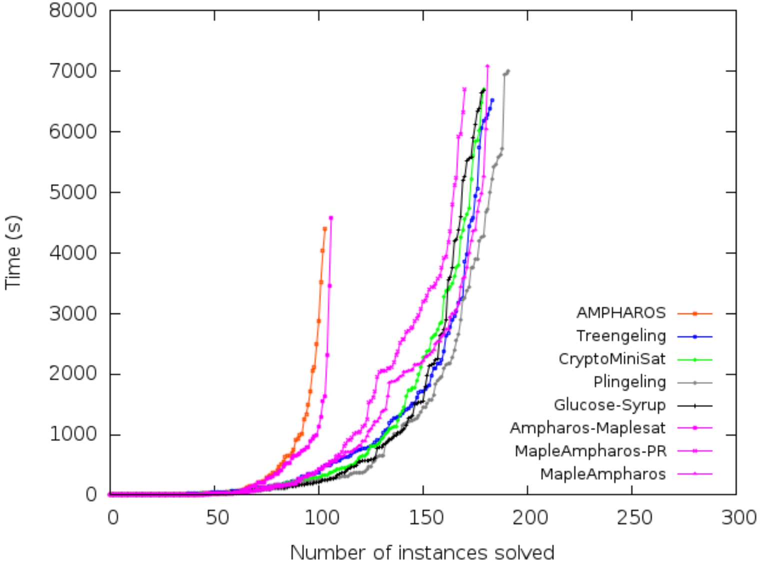

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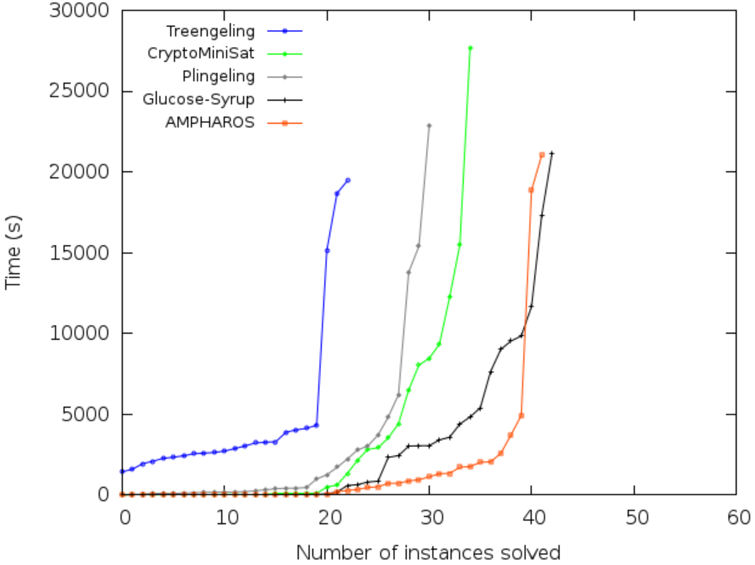
SHA-1 preimage Benchmark



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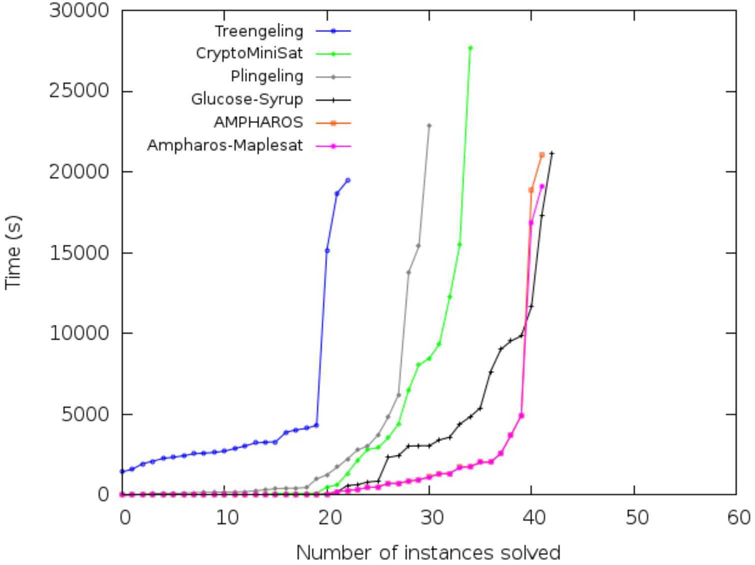

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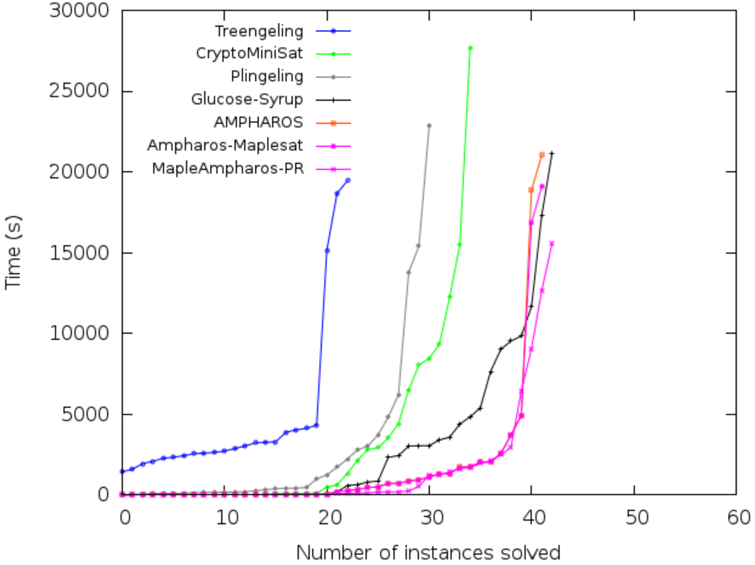

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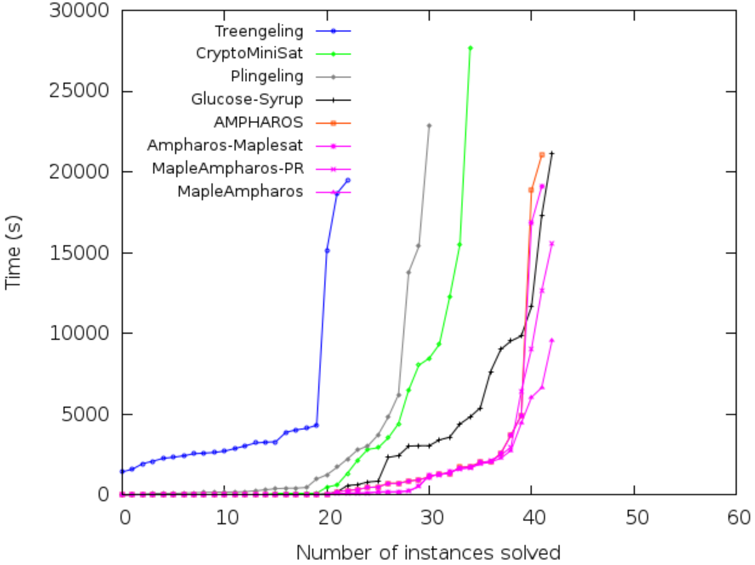

Conclusion

- An improved version of AMPHAROS competitive to top parallel solvers
- Important role of Splitting heuristic
- Dynamic vs Static metrics (Cheaper guess / Heavier, more accurate!)
- Still not as successful as portfolio solvers, but getting closer!

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- More adaptive diversification and splitting

Thank you

Questions?