CryptoMiniSat — A Rough Guide

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SECURITY RESEARCH LABS

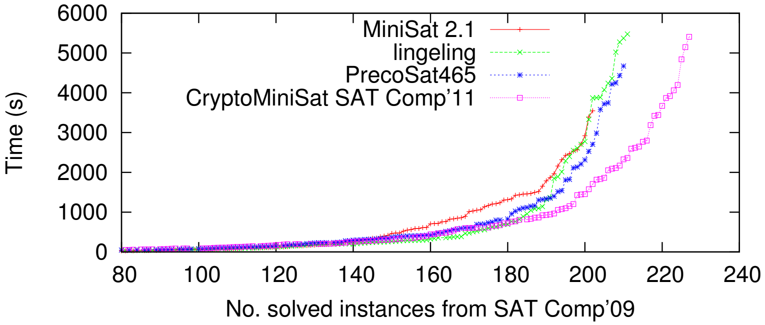
Story line

1. Vision
2. Architecture
3. Future work

Outline

Goals of CryptoMiniSat

- SAT solver that excels at cryptography
- General purpose: won SAT Race'10



- Collaborative: GPL, mailing list, regular releases

Ideas vs. code

Ideas first

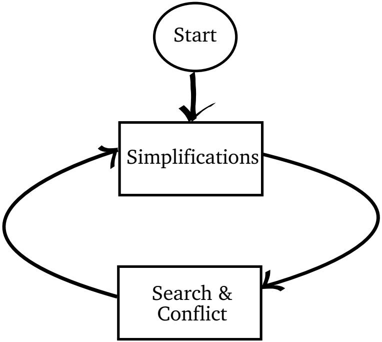
- Concentrate on stuff that matters: ideas
- Code is there to express them clearly, *not* most efficiently
- The cleaner the code, the easier we can add new ideas

Code second

- An overall 5% speedup of code wins $\approx$ 1 problem from SAT'09
- A new idea wins $\approx 2 - 3$ problems from SAT'09 set
- Speeding up code is useful when there are no other ideas

Expand-contract loop

- Expand: Generate new learnt clauses, and clean them when needed
- Contract: Apply subs., strength., var-elim, failed lit, etc.
- Iterate until we solve the problem: no “pre-processing”



The search-conflict duality

Conflicts

- SAT solvers are glorified resolution engines!
- Vars: used to compact the proof
- Conflict clauses: nodes of the conflict tree

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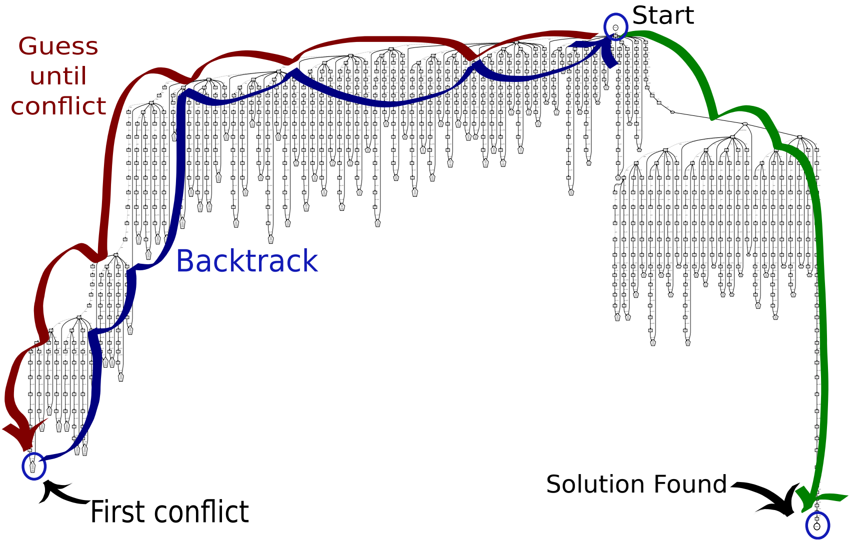
Search

- SAT solvers are glorified search engines!
- Vars: store partially computed values
- Conflict clauses: universally applicable search tree compactors (early confl&extra prop)

Example Search Tree



Outline

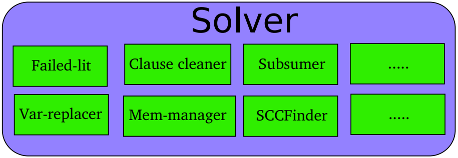
Overall architecture

Classes, communication

- A class for each major element
- Use object composition
- CNF should be the *only* connecting layer

Each class

- Self-contained: internalise complexity
- Build indexes/datastructures/etc., use them, throw them away
- Problem is meant to change (relatively) rapidly, so above makes sense



Get the most out of computed data

Level 1 propagation

- Failed literal probing
- (inv.) Stalmarck
- Hyper-binary resolution
- (Useless binary clause removal)

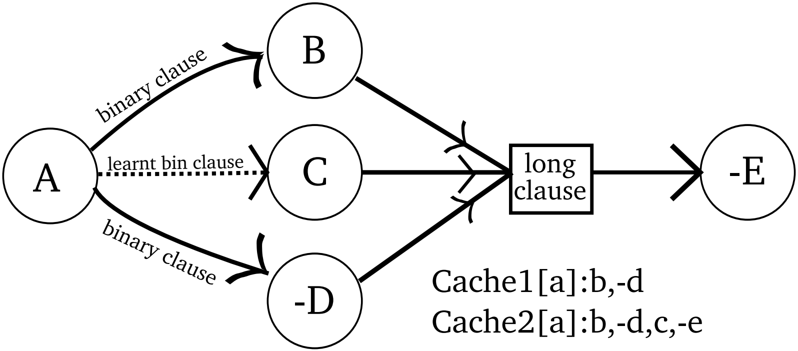
Occurrence lists

- Backward-subsumption
- Strengthening
- Variable elimination

Implication cache

Cache definition

- Enqueue a literal, find what is propagated
- Cache1: Implied by non-learnt binary clauses
- Cache2: Implied by any clause



Cache1[a]:b,-d
Cache2[a]:b,-d,c,-e

Implication cache usage

- Conflict clause minimisation
- Fast vivification
- Fast, lazy Stalmarck
- Subsumption w/ non-existent non-learnt binary clauses
- Fast literal dependence calculation
- Extended SCC
- (Share data between threads)

Learnt clauses and restarts

Combinations

- Geom. rest. + clause activities: for packed problems
- Glue-based dyn rest. + glues: for large industrial problems
- (Agility-based dyn rest. + glues: for both, but not perfect)

Choose between static and dynamic

- Variable activity stability decides
- Restart 5 times, 100 conflict each, save top 100 vars
- Calculate how many common vars were present in top 100
- Many the same: search tree is static. Otherwise: it's dynamic

Dynamic vs. Static

Dynamic

- Problem will be attacked from many different angles
- Activity of a clause diminishes when search tree is rebuilt
- But its usefulness for this part of tree still stands
- So use glues – they don't change

Static

- The search tree will remain approximately the same
- So the clause should remain active even after restart(s)
- Activity is therefore a good measure, forget glues

Misc ideas

- Randomise *everything*: var-pick, var-polar, failed-lit, etc.
- Burst search: VSISD is nice, but may miss something
- Propagate binary clauses first vs. strengthening with cache
- Unelimination through recursive adding of removed clauses

Outline

Future work

- CryptoMiniSat is being actively developed
- New multi-threading ideas are experimented on
- Cleaner architecture is a major goal

Thank you for your time

Any questions?