Cooperation control in Parallel SAT Solving

N. Lazaar, Y. Hamadi, S. Jabbour, M. Sebag

Parallel SAT Solving

Decentralized resolution

- Each core: conflict-directed clause learning
- Cooperation: each core sends the learned clauses to other cores
- Why? additional clauses help pruning the search space.

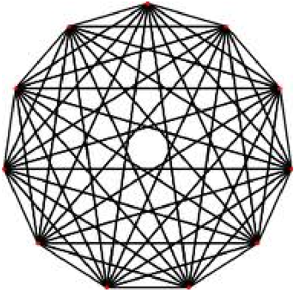
Previous work

Hamadi et al. 09

- Controlling the length of the shared clauses
  (TCP/IP congestion avoidance, additive increase multiplicative decrease)

Limitations

Does not scale up when the number of cores increases.



Position of the problem

- Dynamically control the topology of the network
- This paper: density ρ is fixed

BESS
Bandit Ensemble for parallel SAT Solving

Core tasks

- Design the reward
- Adjust the decision schedule   wrt internal SAT schedule

BESS structure

- Each receiver core
- selects n emitter cores $n = 1/2$ # cores

Designing the reward of an emitter core

Reward(emitter): sum of reward(shared clauses)

I. Global clause rewards

- Size-based: clause of length s removes 2^{N-s} instances

$$r(c) = -\log 1 - 2^{-s}$$

- Literal-block distance
  each literal (decision level) produces unit propagations
  LBD: difference between highest and lowest decision levels in the clause literals
- Mixtures of the above

FAIL

Designing the reward of an emitter core, 2

II. Receiver-specific clause rewards

- Literals ℓ are associated their activity $a(\ell)$
  $\#$ (their assignment $\rightarrow$ failure)

$$r(c) = \frac{1}{c} \sum_{\ell \in c} sigmoid\left(\frac{a(\ell)}{a_{max}}\right)$$

BESS Algorithm

In each core, independently

- Maintain a reward threshold
- Update the reward of alive emitters relaxation
- Pr (removing emitter) $=$ Pr (emitter reward $<$ threshold)
- Turns (oldest) sleeping emitters into alive ones to achieve n alive emitters at all time.

Experimental setting

Platforms

∗ 8-core Intel Xeon, 16 GB RAM, 2.33GHz

∗ 32-core AMD Opteron Proc. 6136, 64GB RAM, 2.4GHz.

SAT instances SAT-Challenge 2012.

588 SAT+UNSAT instances.

Parameters

∗ CPU time limit = 30mn CPU per core

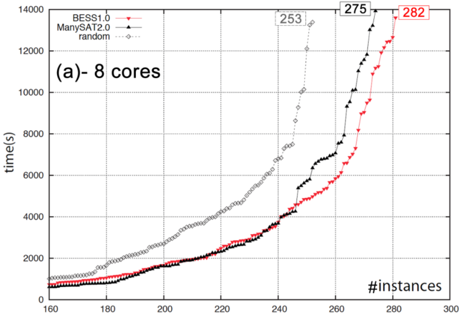
∗ Shared clause limit size: 8

∗ Alive emitters: 1/2 nb of cores.

Baseline

Random selection of alive emitters in each time step.

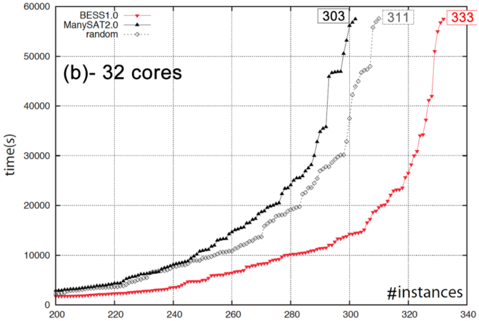
Results on 8 cores



Comments

- Bess slightly improves on ManySAT 2.0 for difficult problems

Results on 32 cores



Comments

- Random improves on ManySAT 2.0 (confirms scalability issue)
- Bess improves on Random and ManySAT 2.0
  solves the first 300 pbs in 20,000 s. versus 50,000 s.

Perspectives

1. Adjust the *number* of emitters for each core
2. Adjust the clause length limit
3. Share information among cores to speed-up cooperation, enforce diversification.