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)

Limitations

Does not scale up when the number of cores increases.

Position of the problem
• Dynamically control the topology of the network
• This work: density $\rho$ is fixed

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 $2^N$ instances:
  \[ r(c) = -\log(1 - 2^{-s}) \]
• Literal-block distance (LBD): each literal (decision level) produces unit propagations - LBD: difference between highest and lowest decision levels in the clause literals
• Mixtures of the above: **FAIL**

II. Receiver-specific clause rewards
• Literals $l$ are associated their activity $a(l)$ # (their assignment $\Rightarrow$ failure)
  \[ r(c) = \frac{1}{c} \sum_{l \in c} \text{sigmoid}(\frac{a(l)}{a_{max}}) \]

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 $n = (1/2 \#\text{cores})$

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 validation

Parameters
• 588 SAT+UNSAT instances.
• CPU time limit = 30mn CPU per core
• Shared clause limit size: 8

8-cores: BESS slightly improves on ManySAT2.0 for difficult problems
32-cores:
• ManySAT2.0 lacks scalability
• BESS: 10% improvement on ManySAT2.0

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.