COMBINING MACHINE LEARNING WITH DEDUCTION FOR SAT SOLVERS

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(Slides courtesy Jia Hui Liang)

Improve the performance and understanding of SAT solvers using machine learning techniques

"The speed and degree of improvements is declining. Now we seem to have faced one of the ceilings that calls for a breakthrough."
-Chanseok Oh

Between SAT and UNSAT: The Fundamental Difference in CDCL SAT (2015)

WHY MACHINE LEARNING?

MB/sec of new data

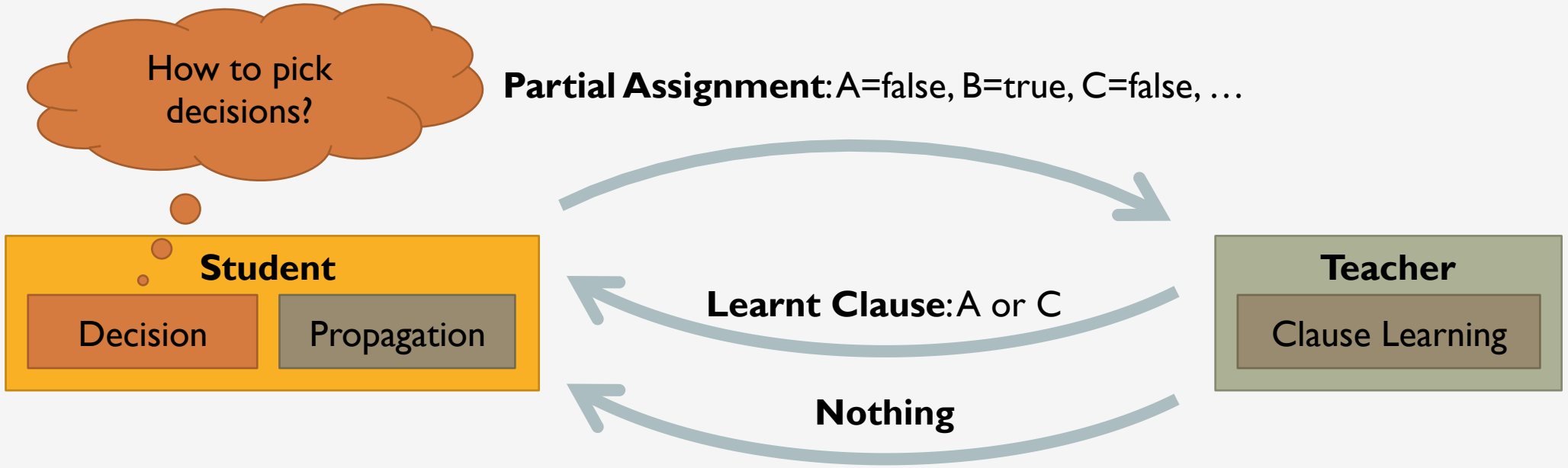
Effective (LRB)

Theory

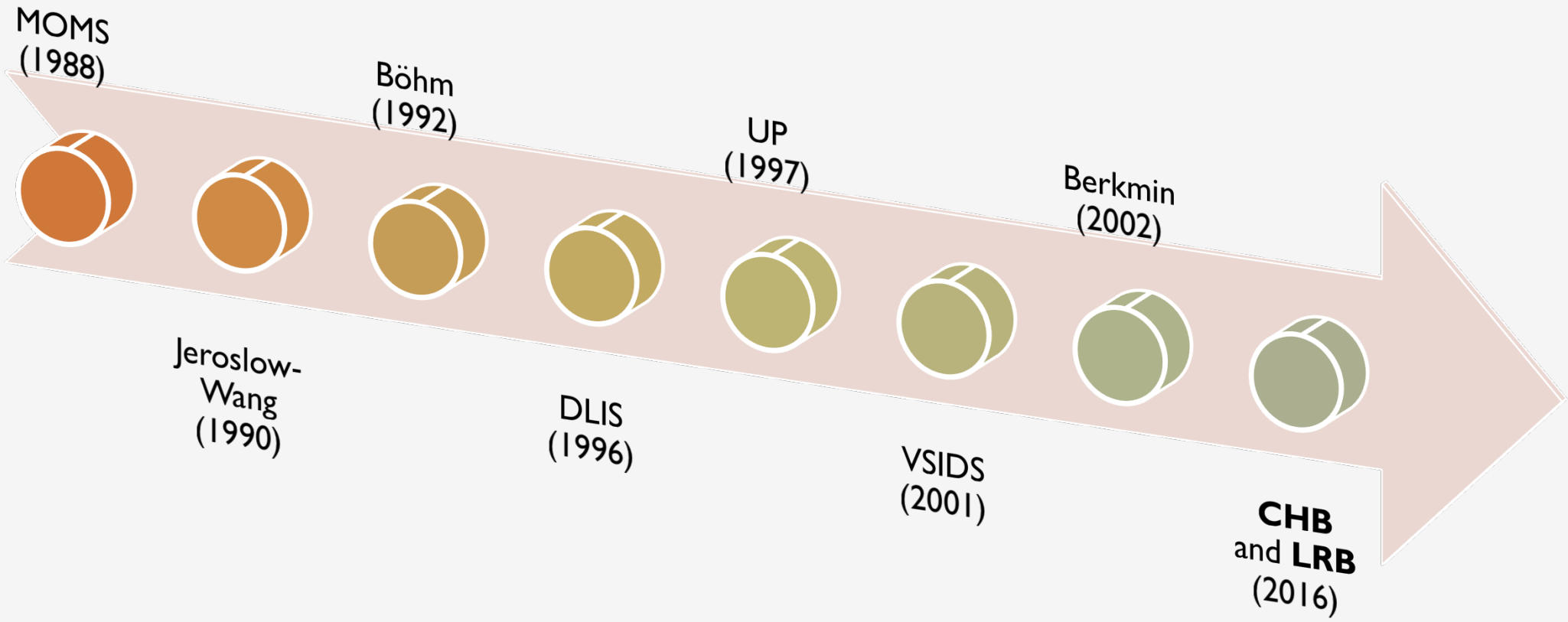
Rich Literature

Unexplored

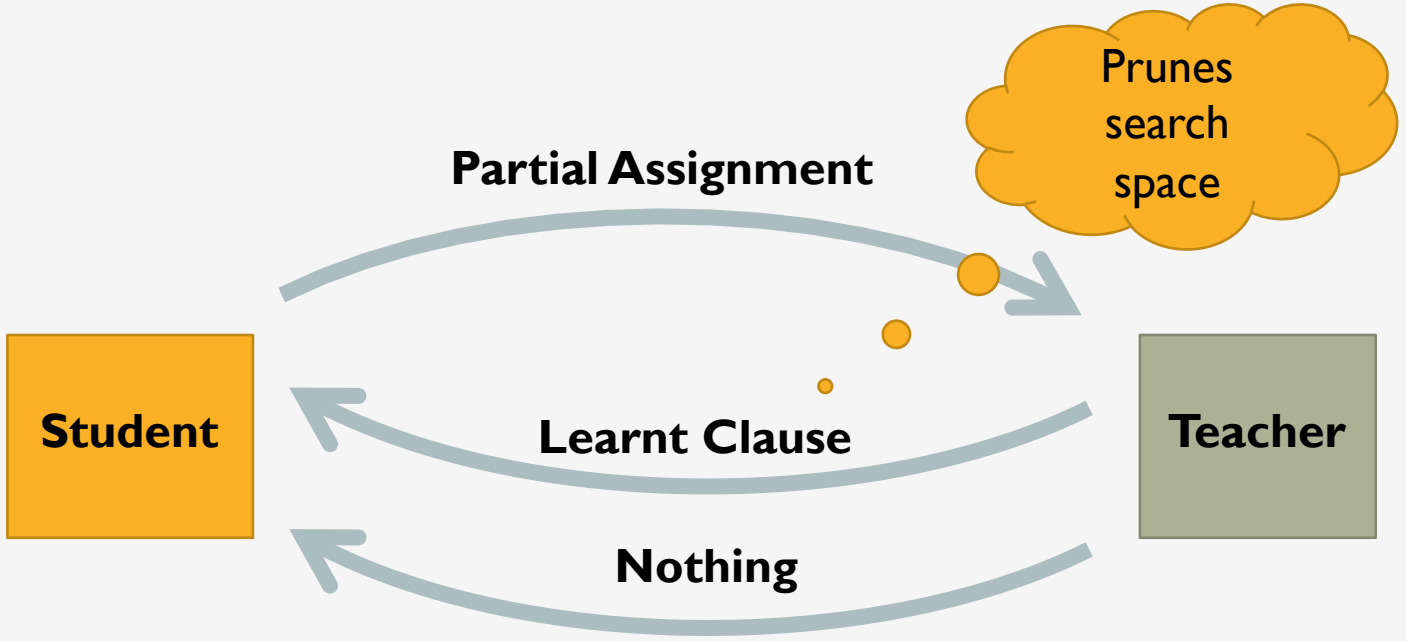
SAT OVERVIEW



HISTORY OF BRANCHING HEURISTICS

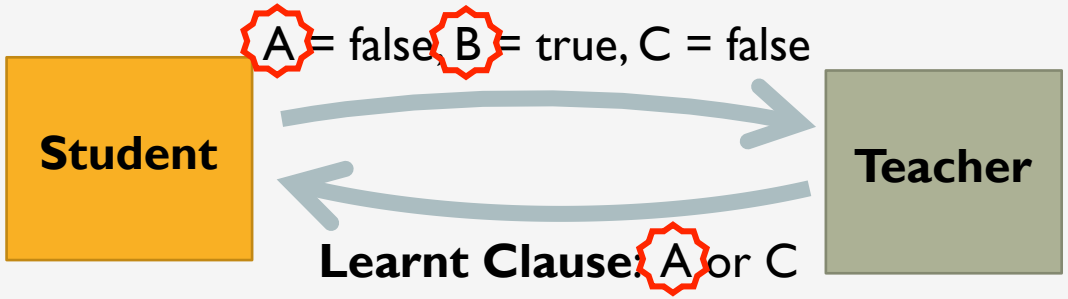


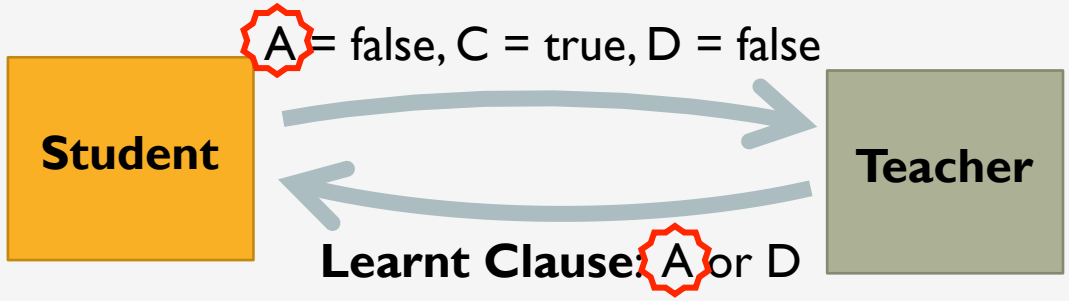
LEARNING RATE OPTIMIZATION

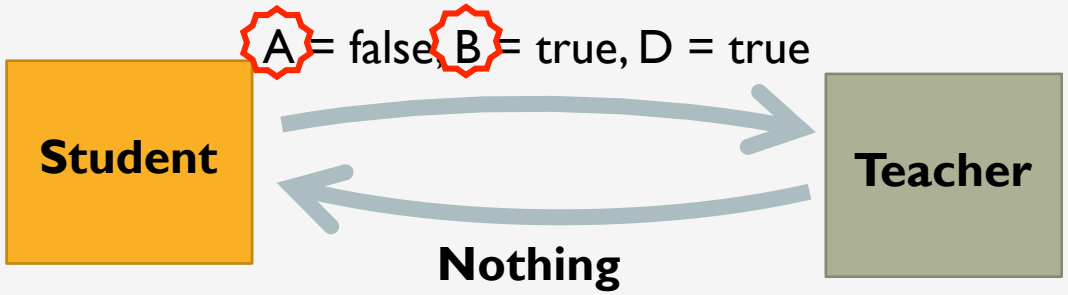


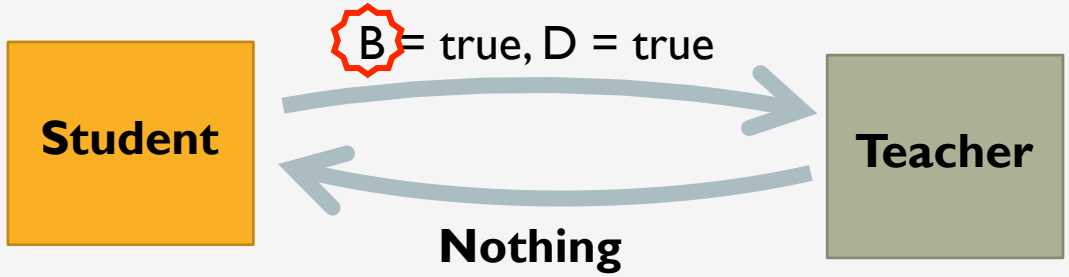
Maximize the probability Teacher responds with Learnt Clause

LEARNING BY TRIAL AND ERROR



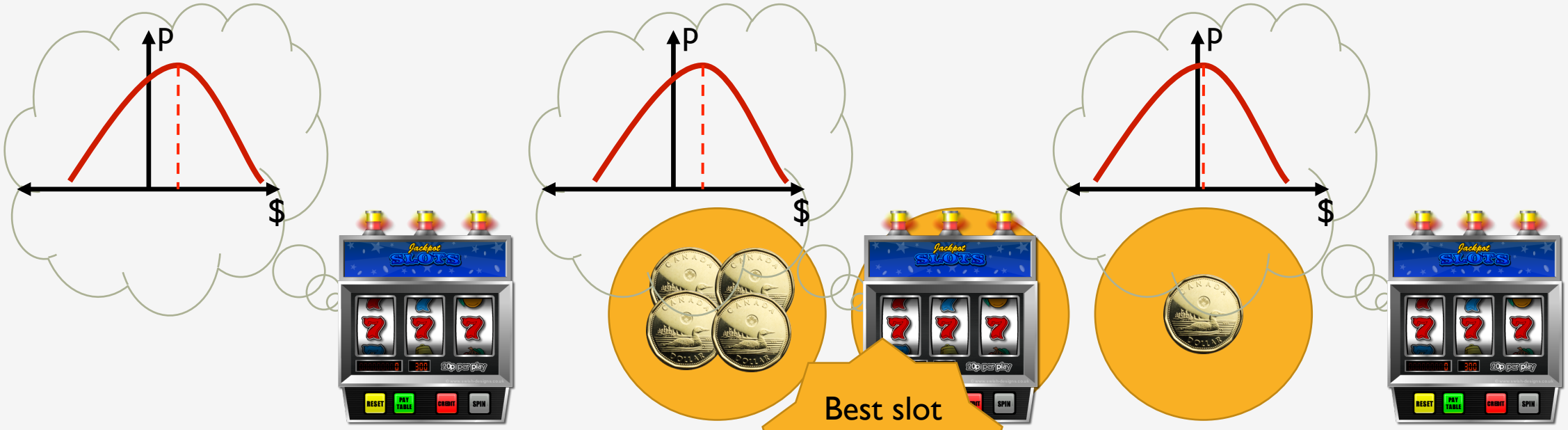






learning_rate(**X**) = ℙ(**X** is in learnt clause | **X** is assigned & in conflict)

MULTI-ARMED BANDIT



sample average = 1/3 × $4 + 1/3 × $3 + 1/3 × $1

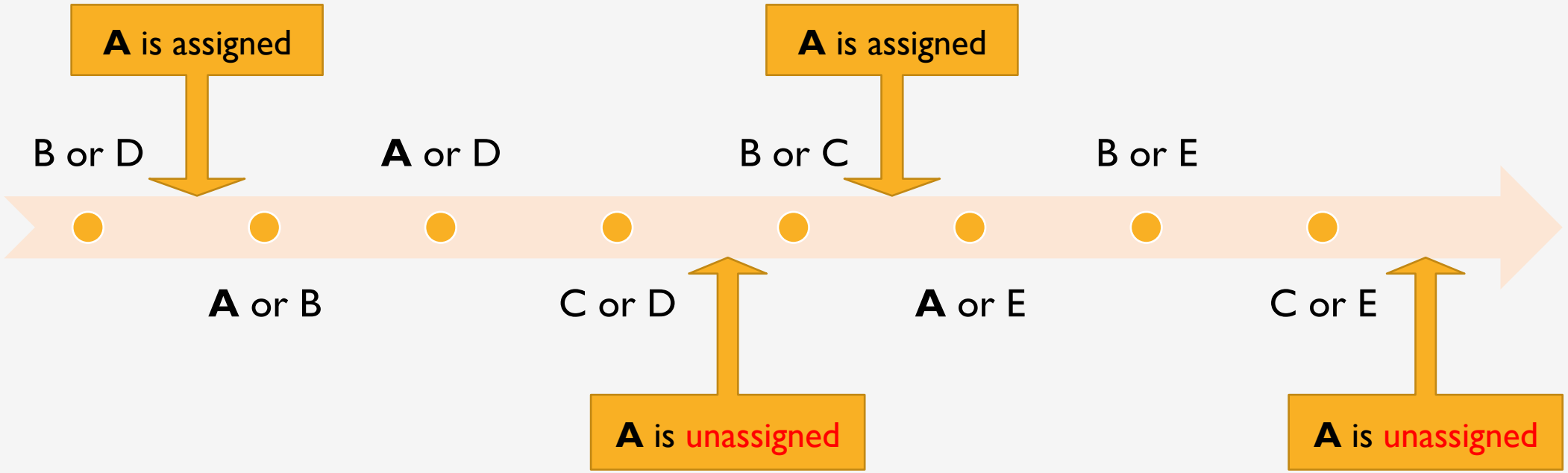
exponential moving average = $(1 - \alpha)^2 \times \$4 + (1 - \alpha) \times \$3 + (1 - \alpha)^0 \times \$1)$

Best slot machine to play (for now)

Less weight

More weight

LRB EXAMPLE



learning_rate(**A**) = 2/3

learning_rate(**A**) = 1/3

exponential moving average = $(1 - \alpha)^1 \times 2/3$ + $(1 - \alpha)^0 \times 1/3$

EXTENSIONS

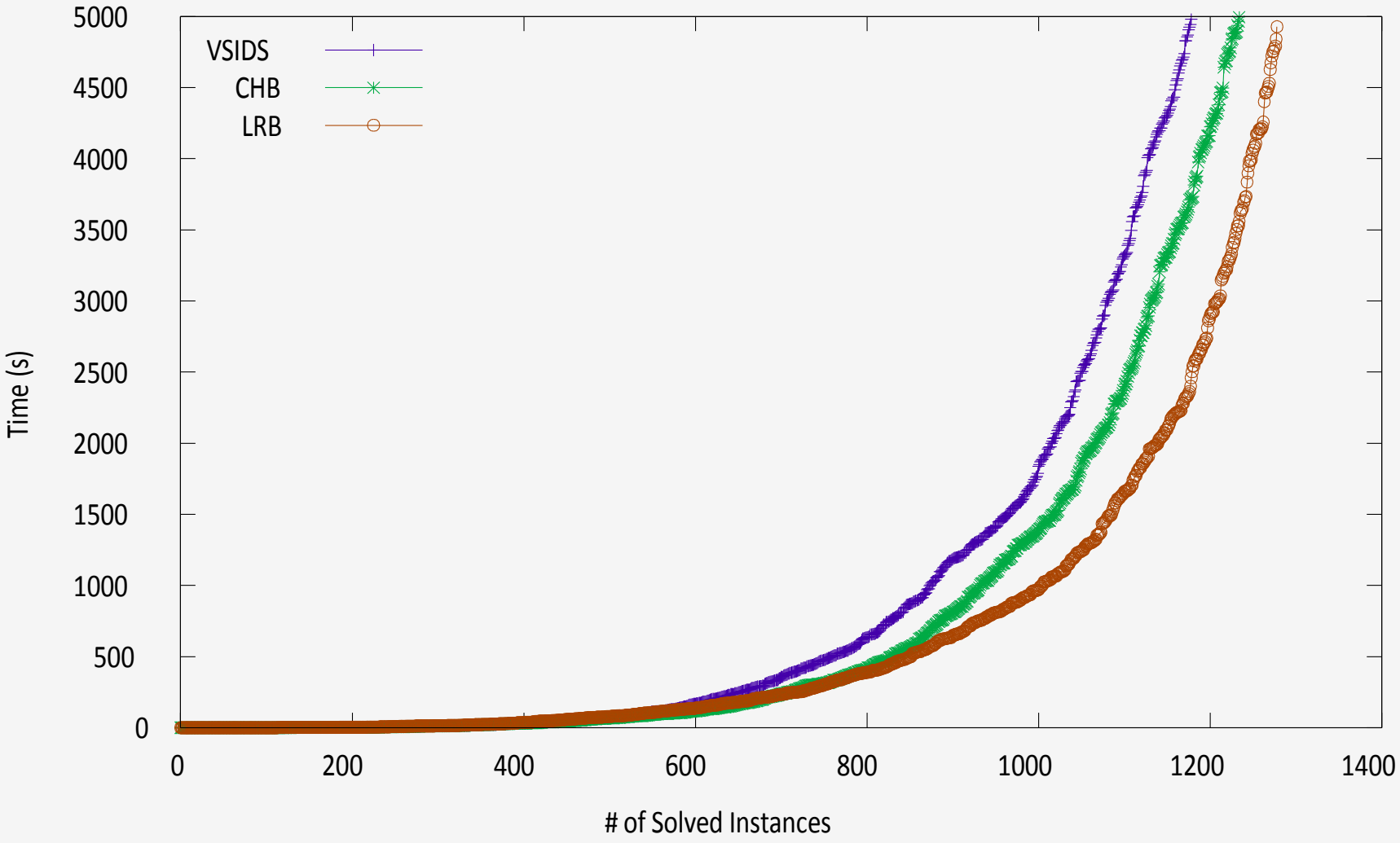
Reason Side Rate

- Prefer variables close in proximity to learnt clause variables.

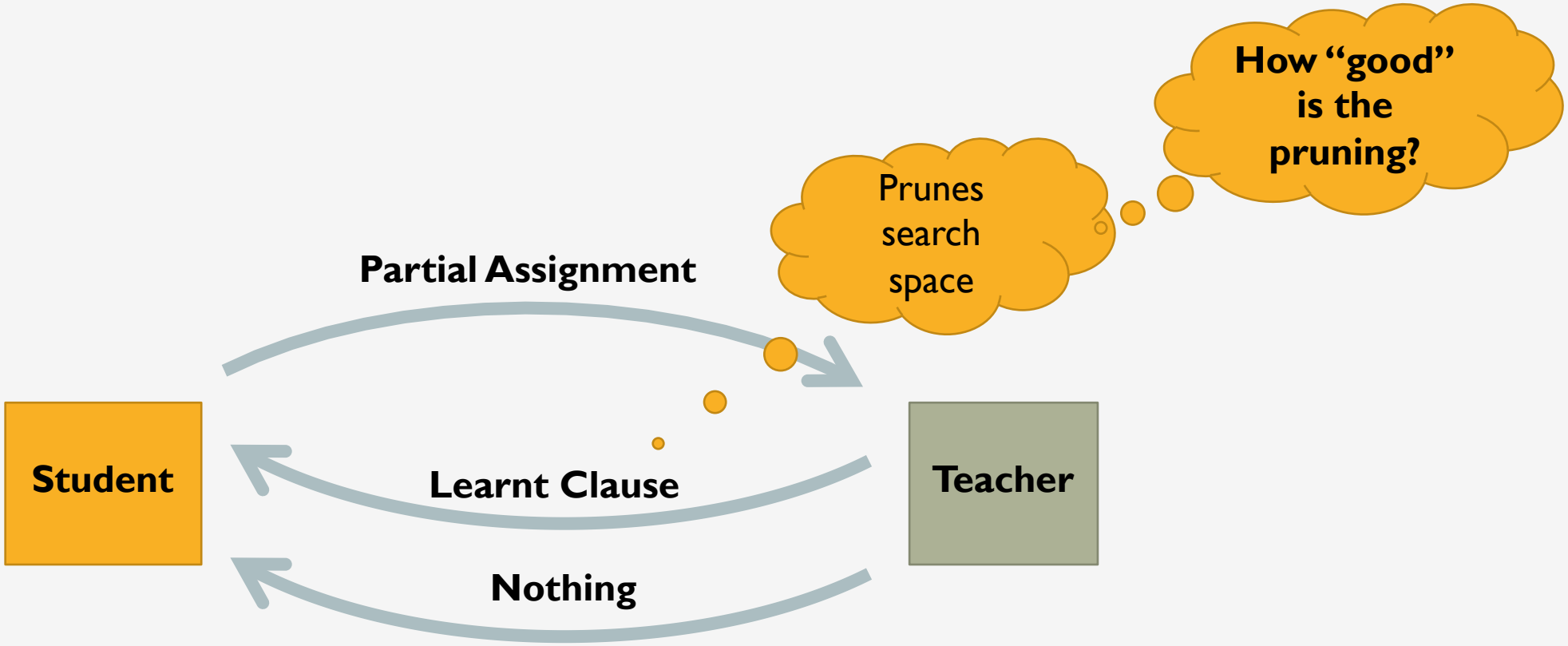
Locality

- Prefer recently assigned variables.

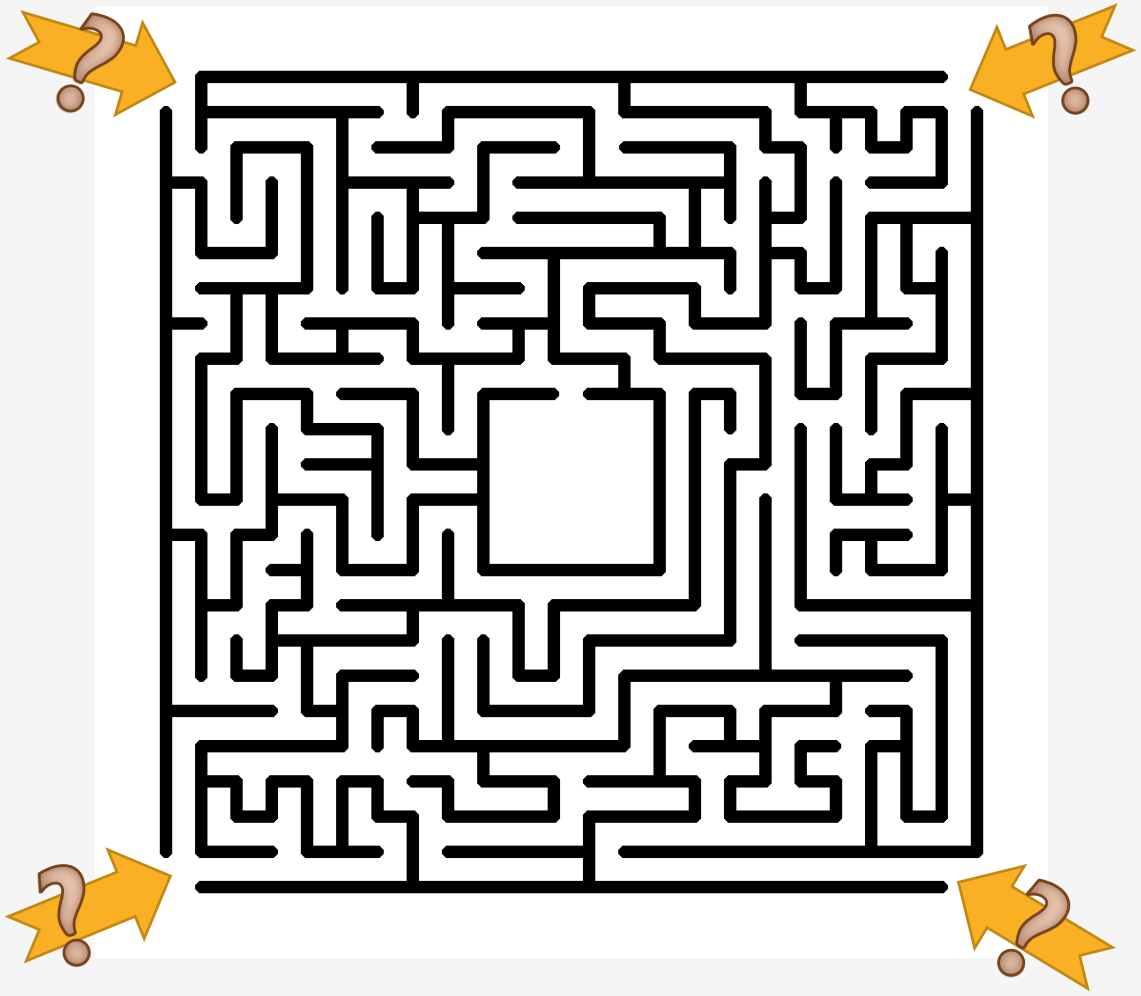
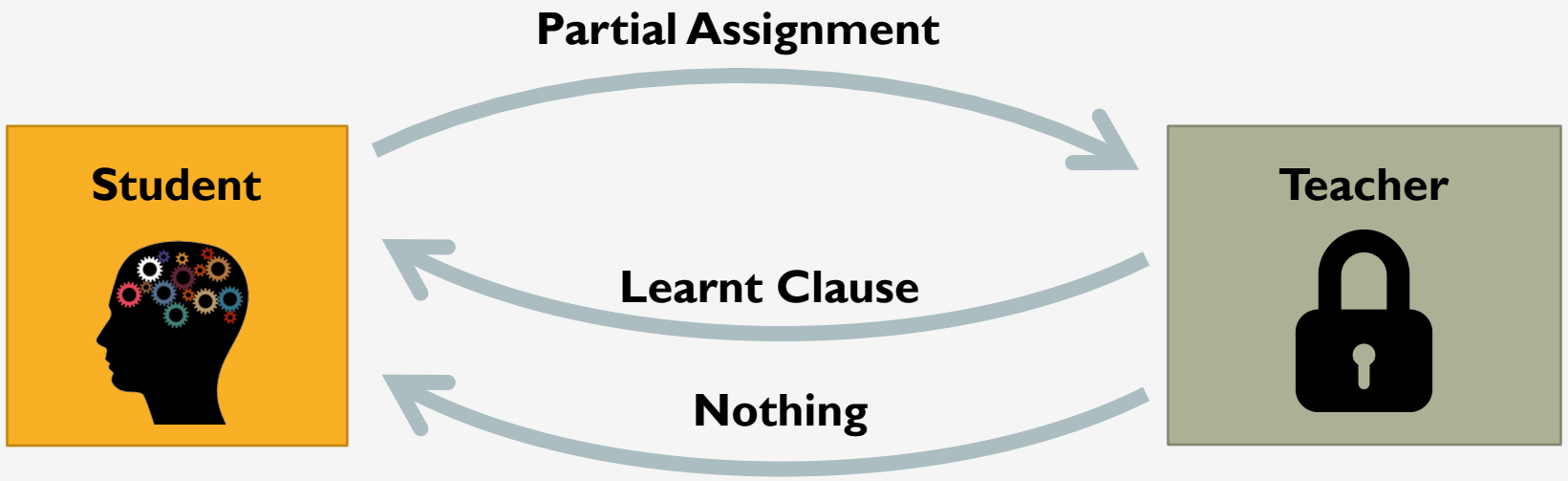
EXPERIMENTAL EVALUATION



FUTURE WORK: QUALITY OF LEARNING OBJECTIVE



FUTURE WORK: VARIABLE RANKING INITIALIZATION



FUTURE WORK: OPTIMIZE CONFLICT ANALYSIS CUT