University of Amsterdam
Knowledge Representation 2017

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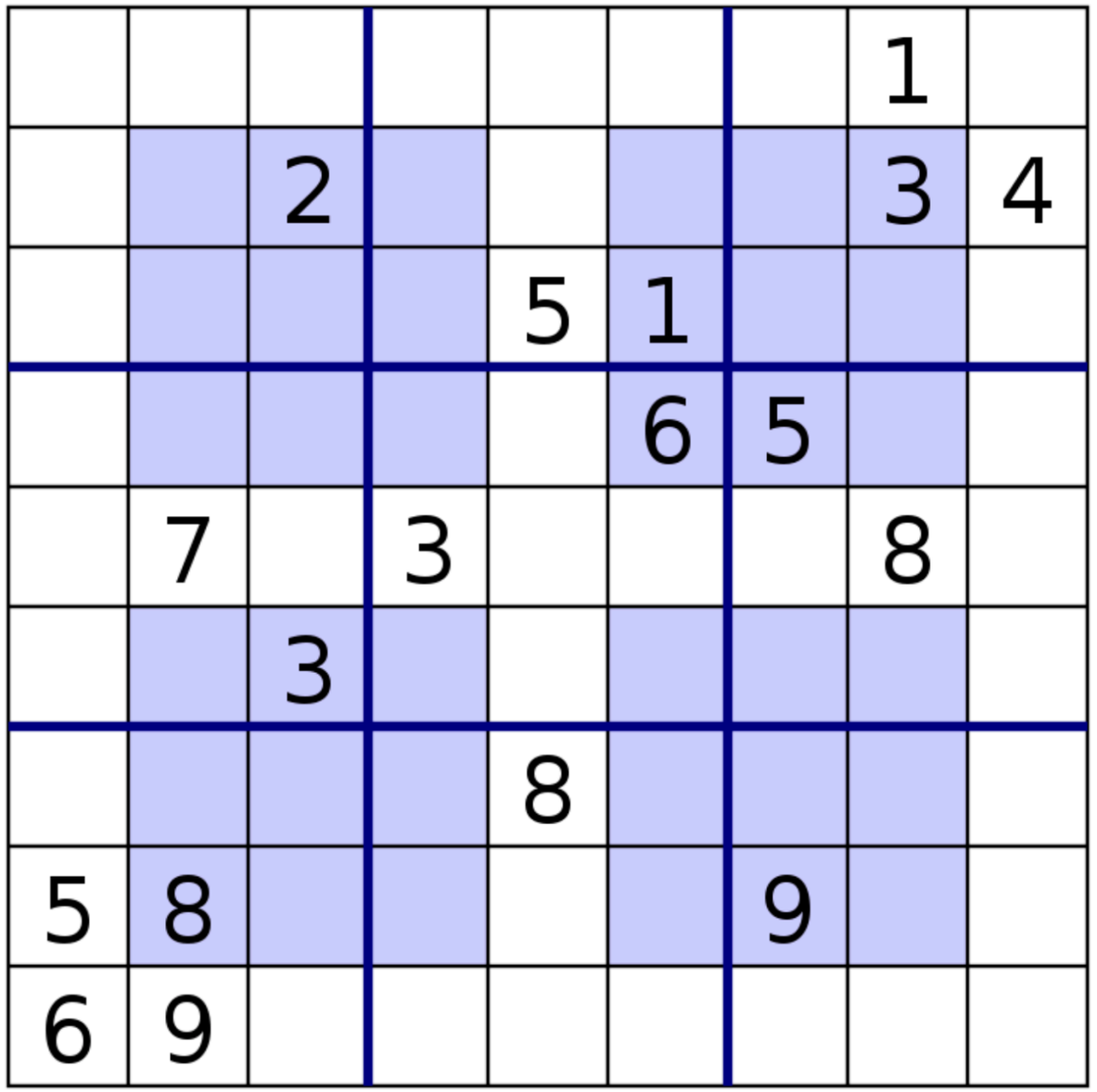
WHEN INTUITION MISFIRES

HYPER SUDOKUS ARE HARDER THAN STANDARD SUDOKUS

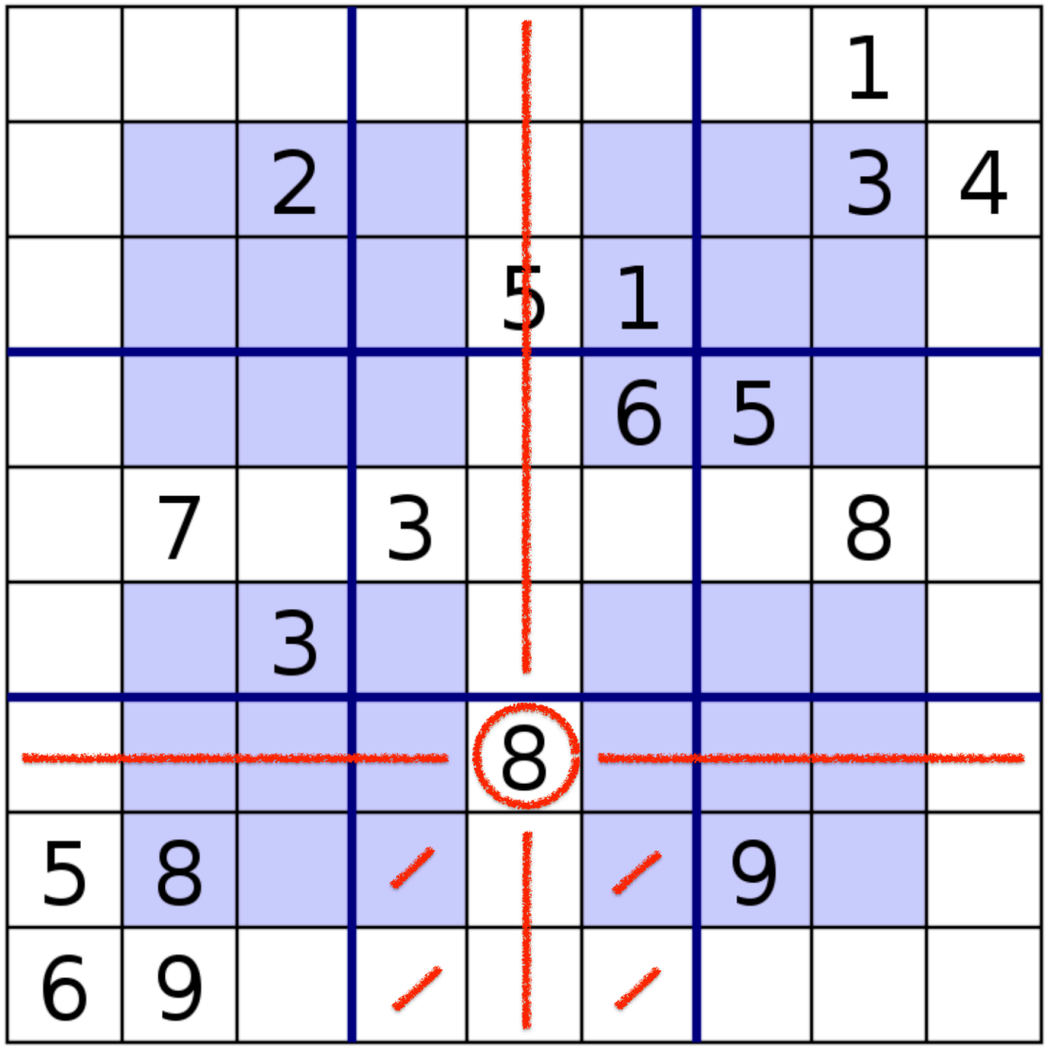
WHAT IS A HYPER SUDOKU?

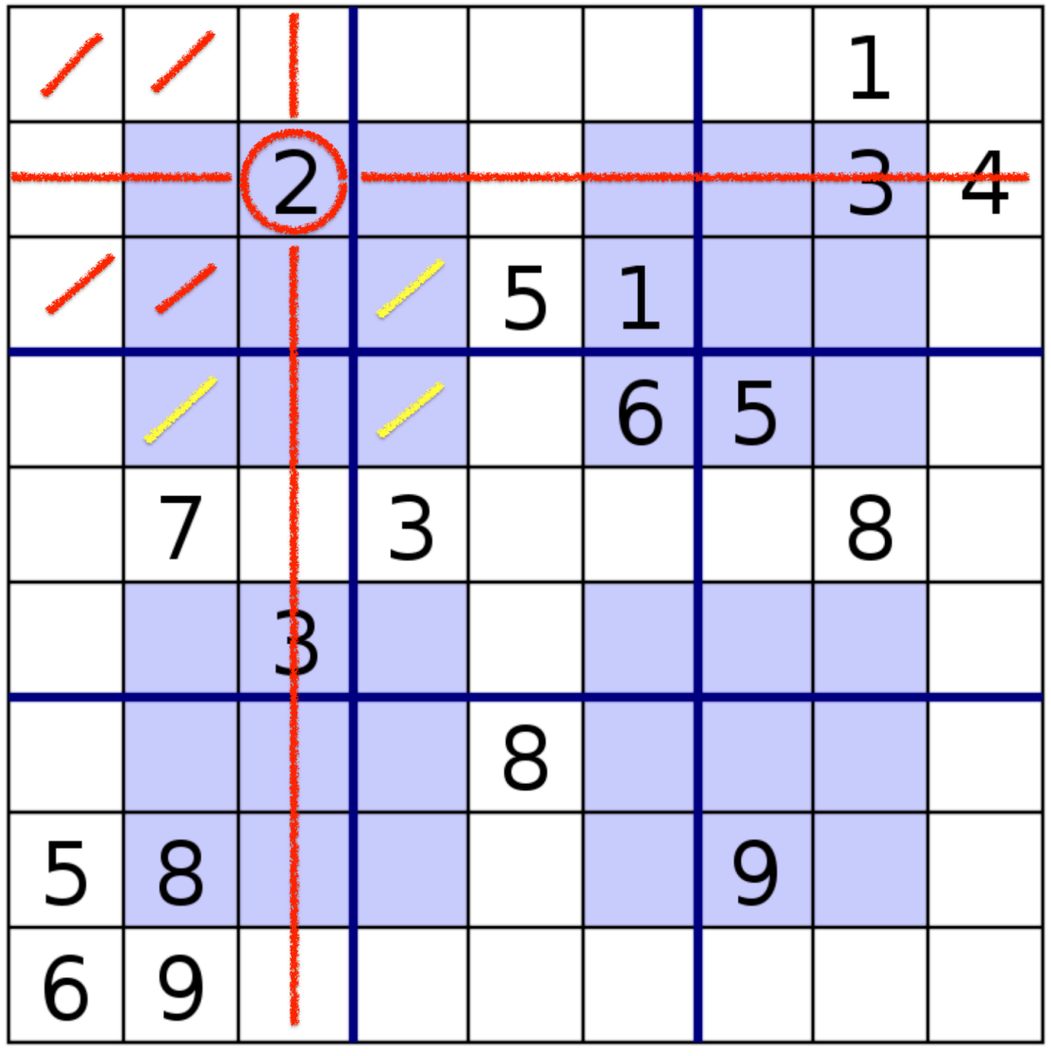
- 4 additional blocks

- in each **hyperblock**,
  each number
  from 1 to 9
  appears exactly once



HYPER SUDOKUS ARE EASIER* THAN STANDARD SUDOKU





* *hardness* with zChaff: number of added **conflict literals** and **conflict clauses**

hardness with WalkSAT: number of **restarts** and **variable flips**

EXPERIMENTAL SETUP

SAT solvers

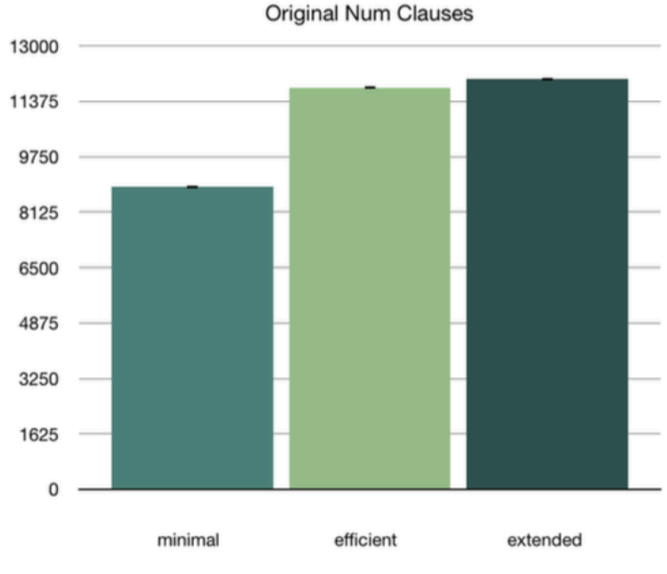
> PicoSAT
> zChaff
> WalkSAT

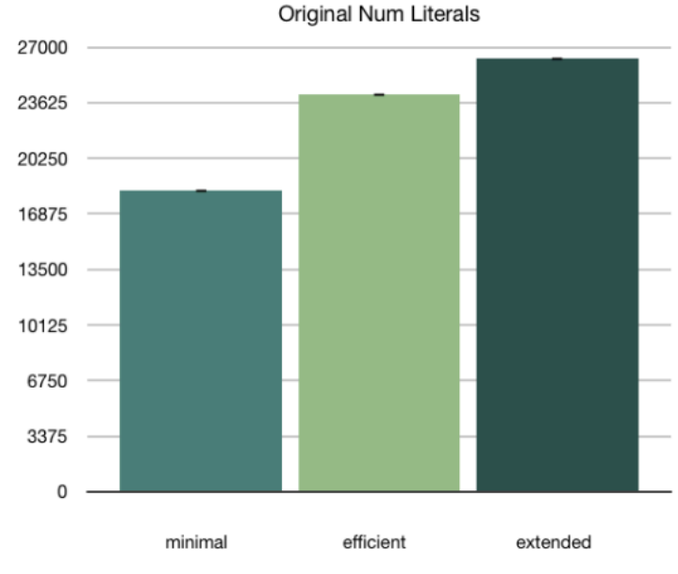
Encodings

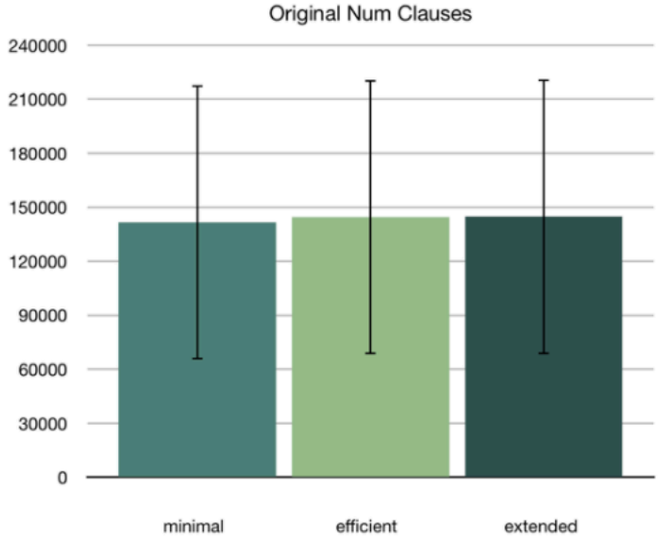
> minimal
> efficient
> extended
+ hyper-constraints

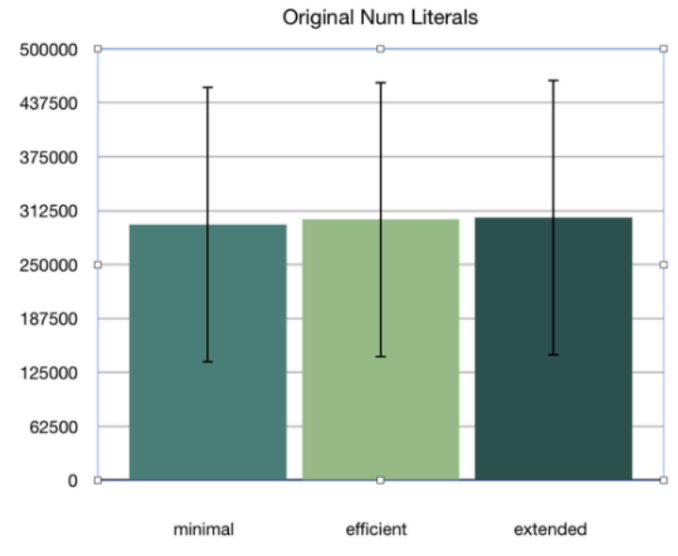
Data sets

kaggle.com/bryanpark/sudoku
sudokucentral.co.uk/hypersudoku.php



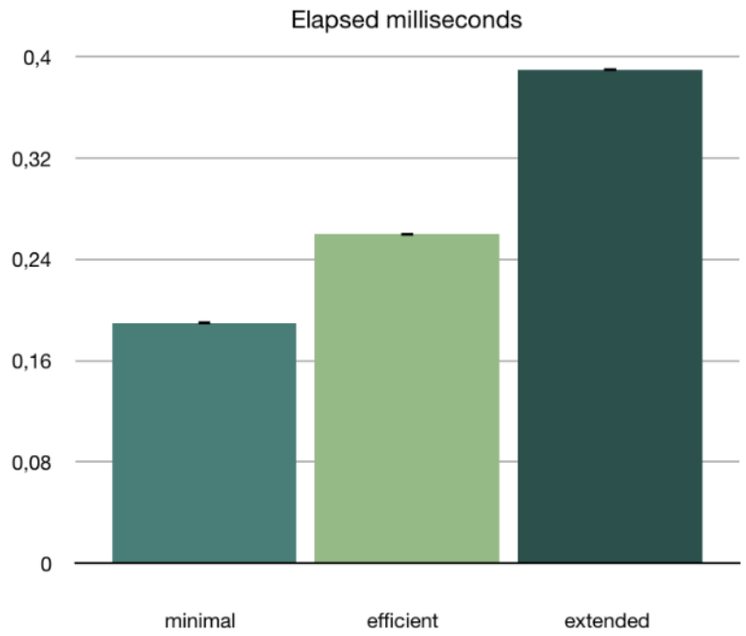


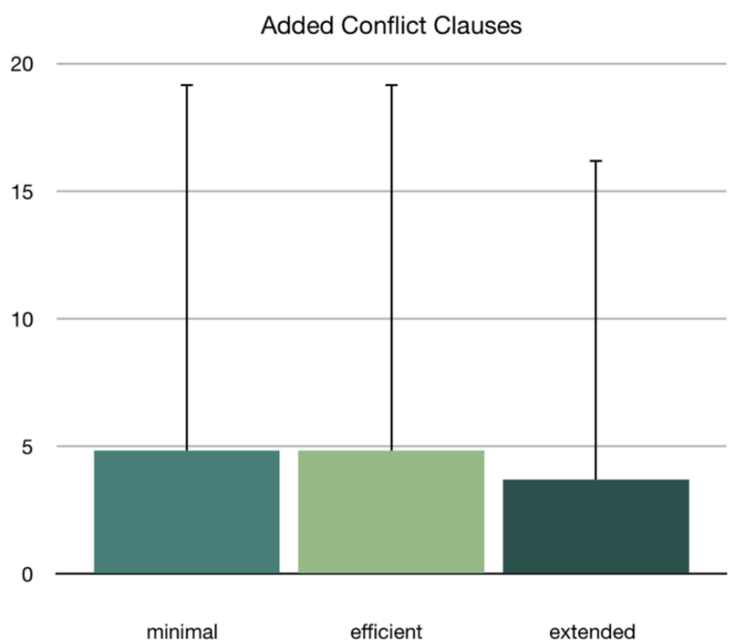


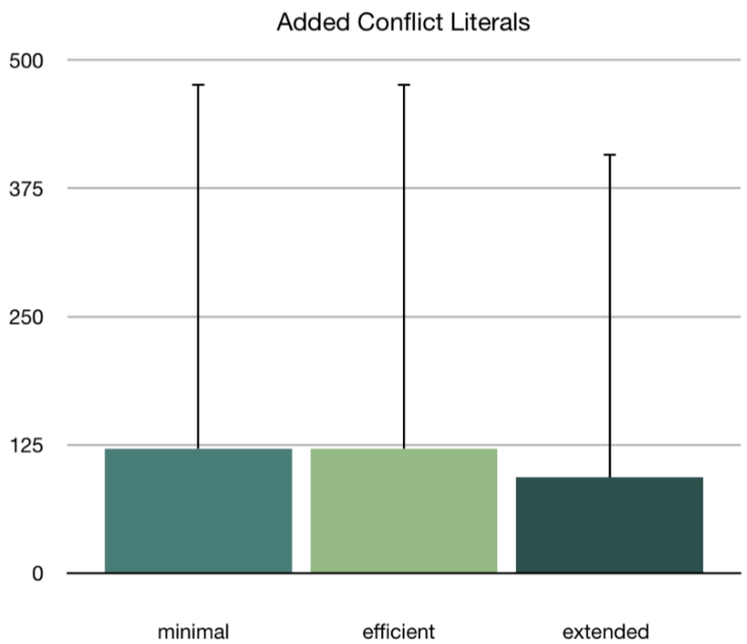


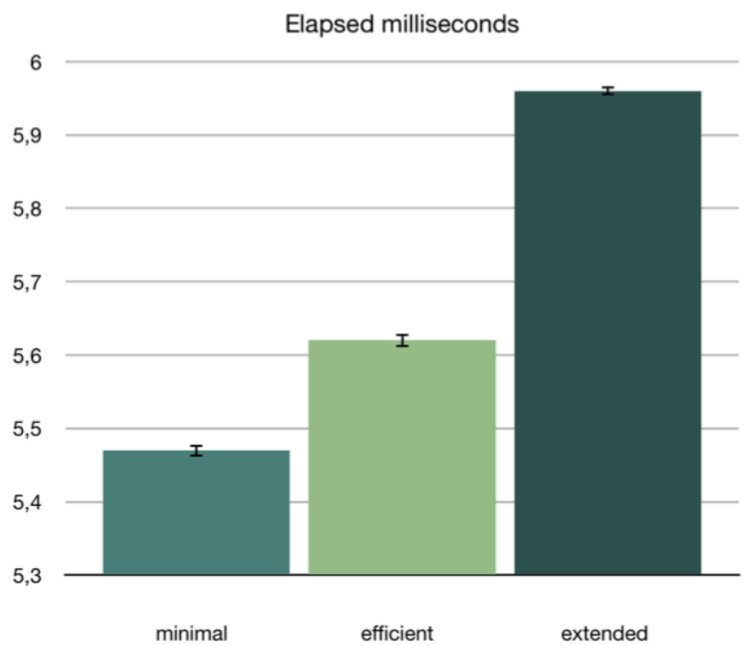
HYPER SUDOKUS REQUIRE CONFLICT CLAUSES AND LITERALS

THE EXTENDED ENCODING YIELDS LESS CONFLICT CLAUSES AND CONFLICT LITERALS

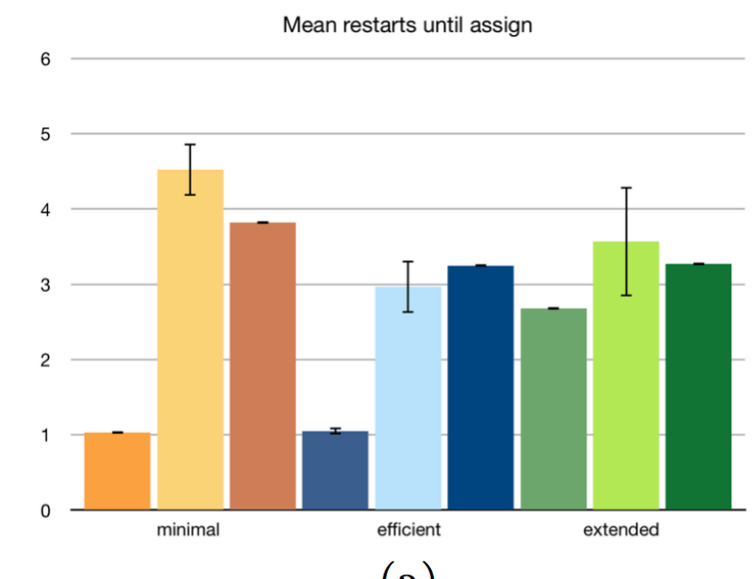




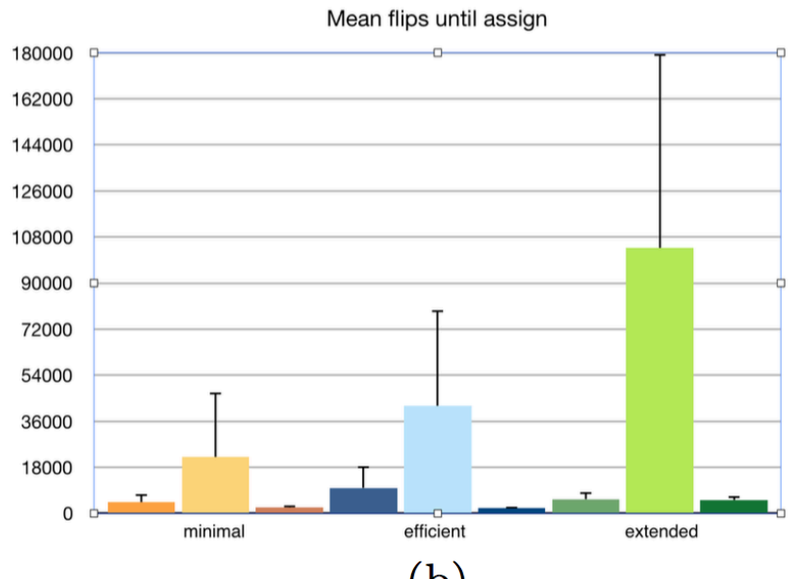




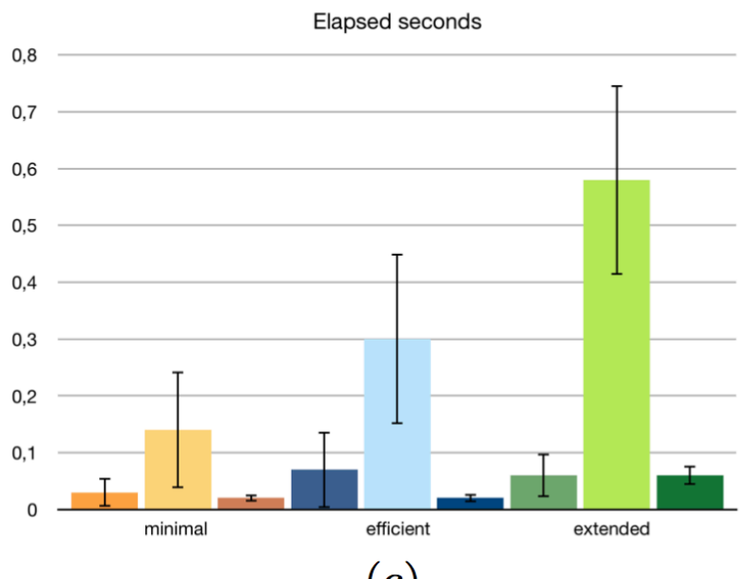
HYPER SUDOKUS REQUIRE MORE VARIABLE FLIPS THAN A STANDARD SUDOKU AND APPROXIMATELY THE SAME NUMBER OF RESTARTS



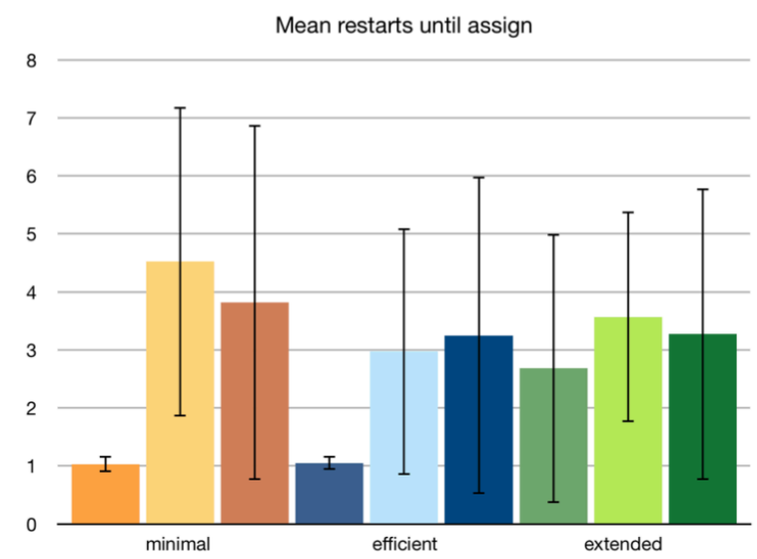
(a)



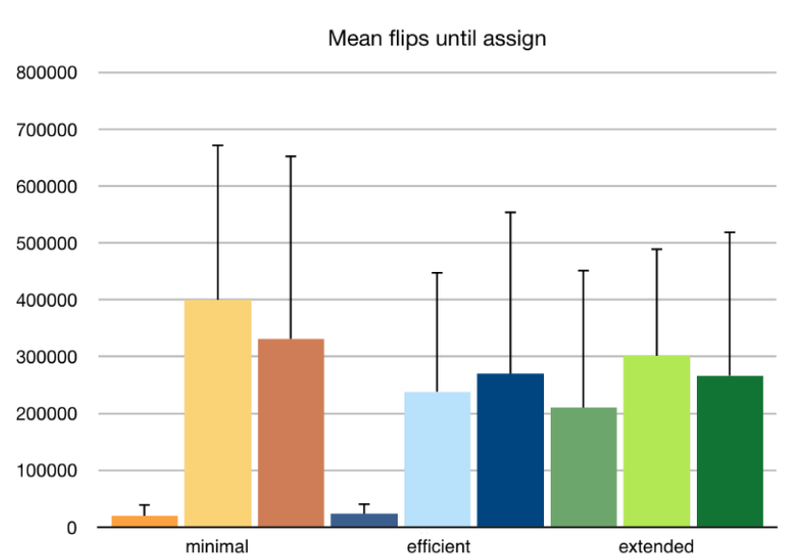
(b)



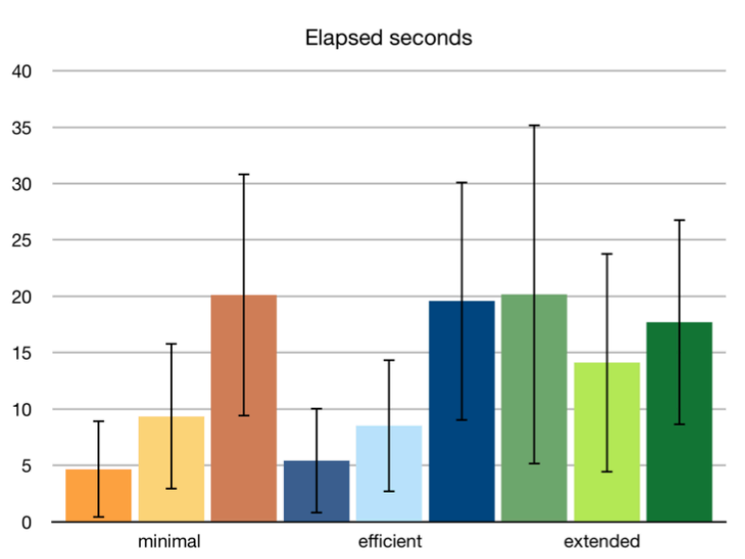
(c)



(d)



(e)



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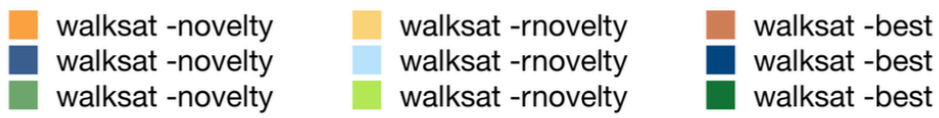

FOR A SAT SOLVER, IT APPEARS TO BE EASIER TO SOLVE A STANDARD SUDOKU THAN A HYPER SUDOKU.

- Intuitively, Hyper Sudokus allow for a more constrained logical reasoning, but the very form of these constraints (additional clauses and literals) negatively affects the performance of the tested SAT solvers.
- For an accessible SAT problem, performance of solvers is inversely proportional to the number of clauses and literals.
- Unless a SAT problem requires a more complex or explicit encoding, it is best to opt for the encoding that minimises the number of clauses and literals.