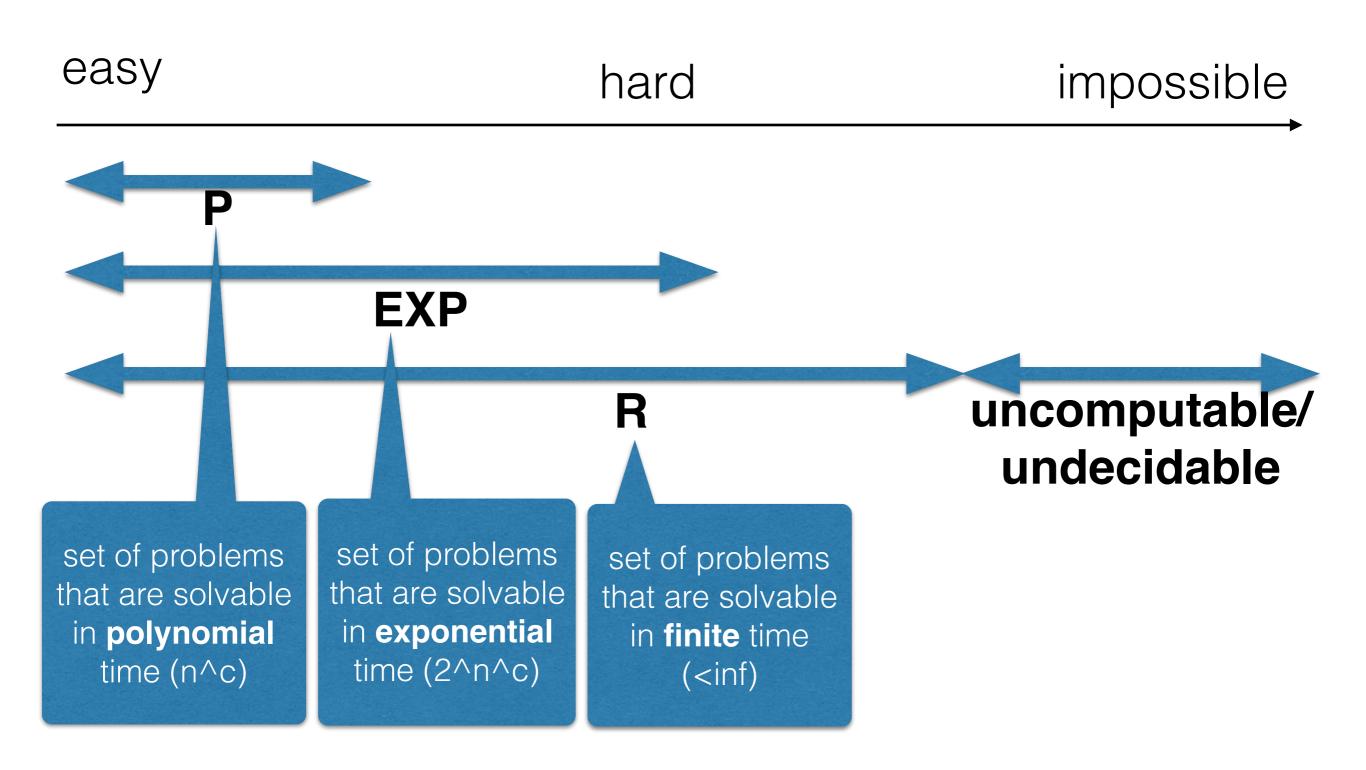
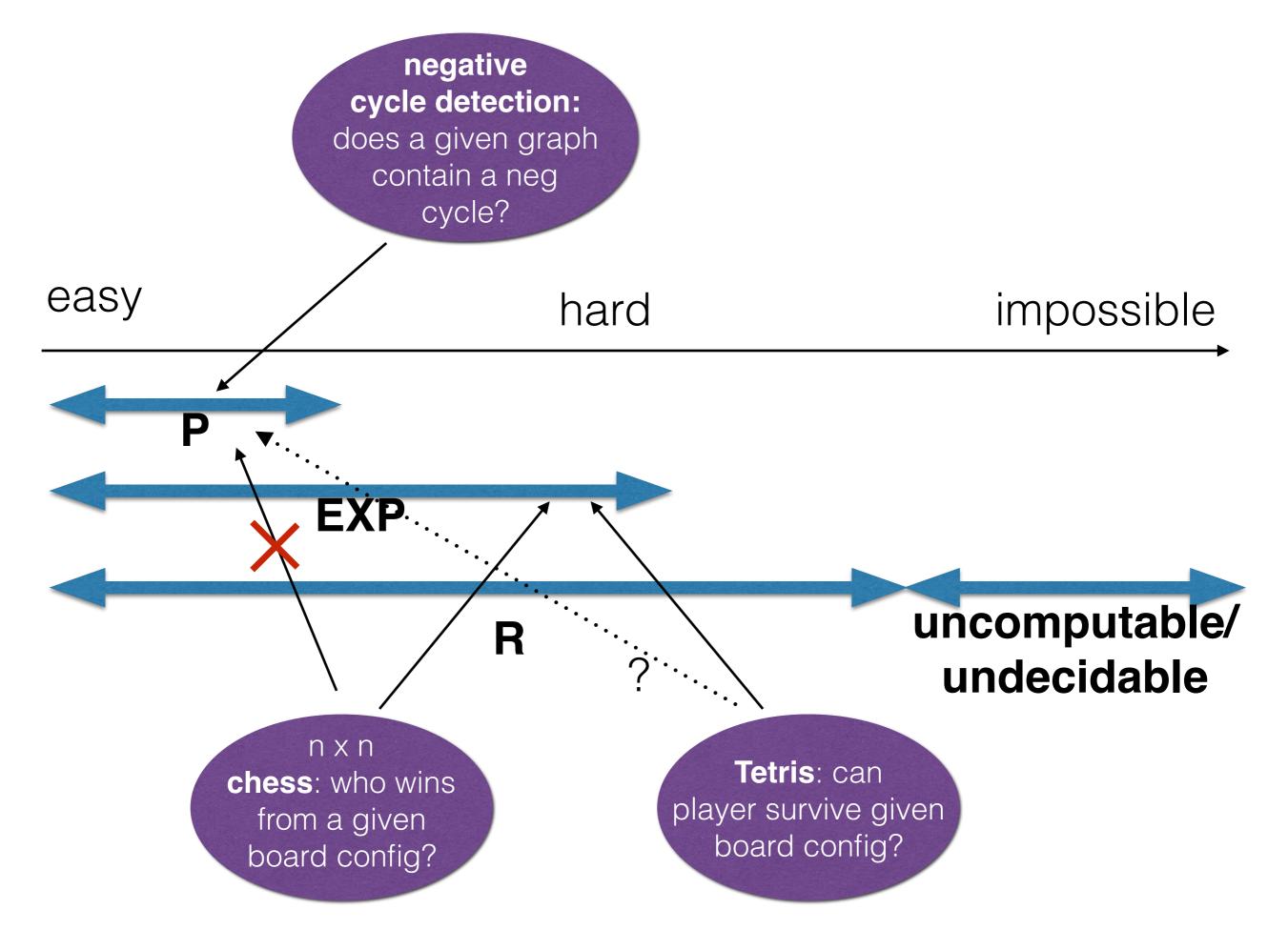
Computational complexity

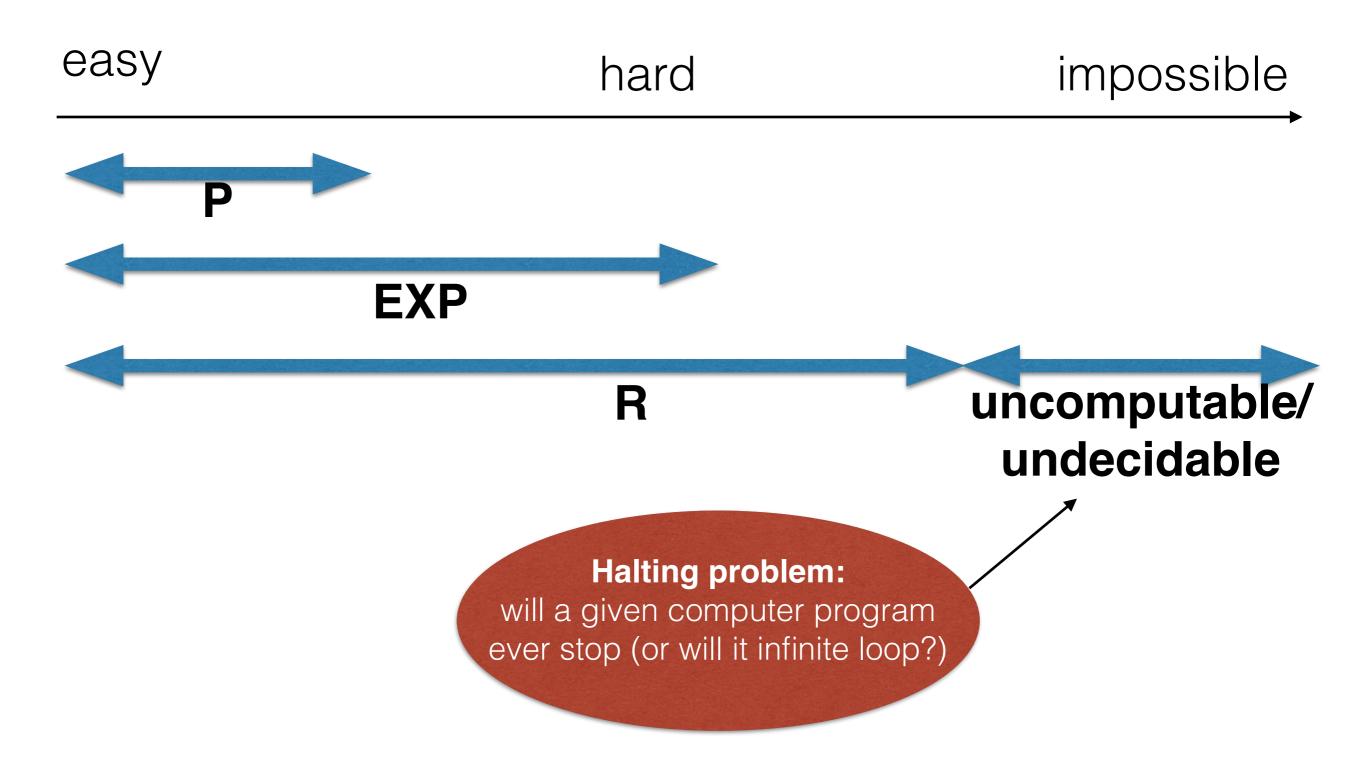
CS 146 - Spring 2017

Which is harder, Tetris or Chess?

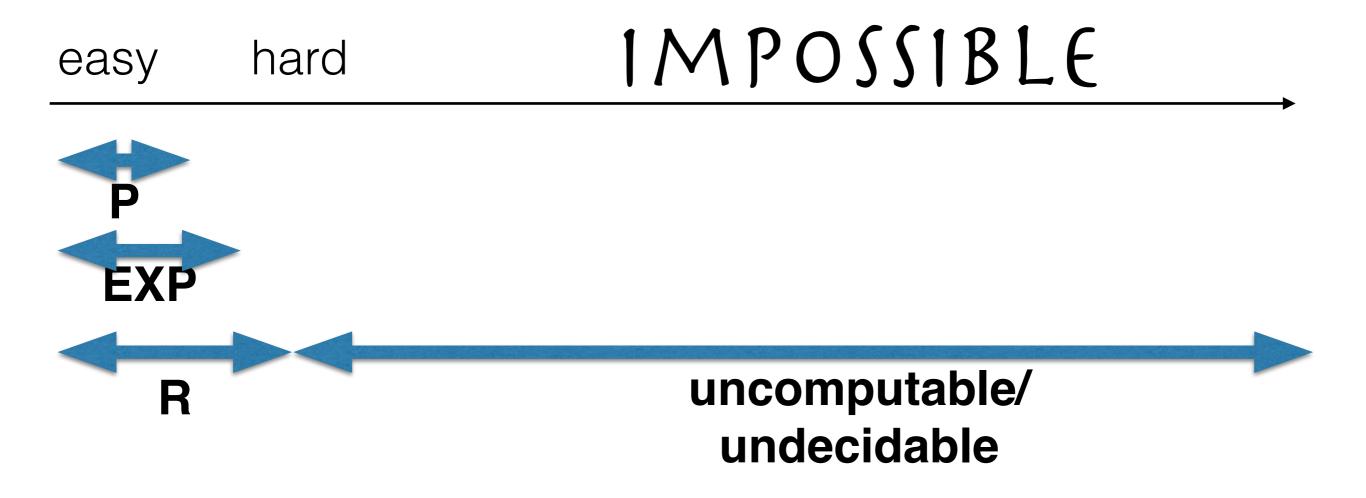




[Breukelaar, Demaine, Hohenberger, Hoogeboom, Koster, Liben-Nowell 2004]



Most decision problems are uncomputable



Proof sketch: ...

Decision problem: YES/NO question

VS

Optimization problem: find the min/max question

negative cycle detection

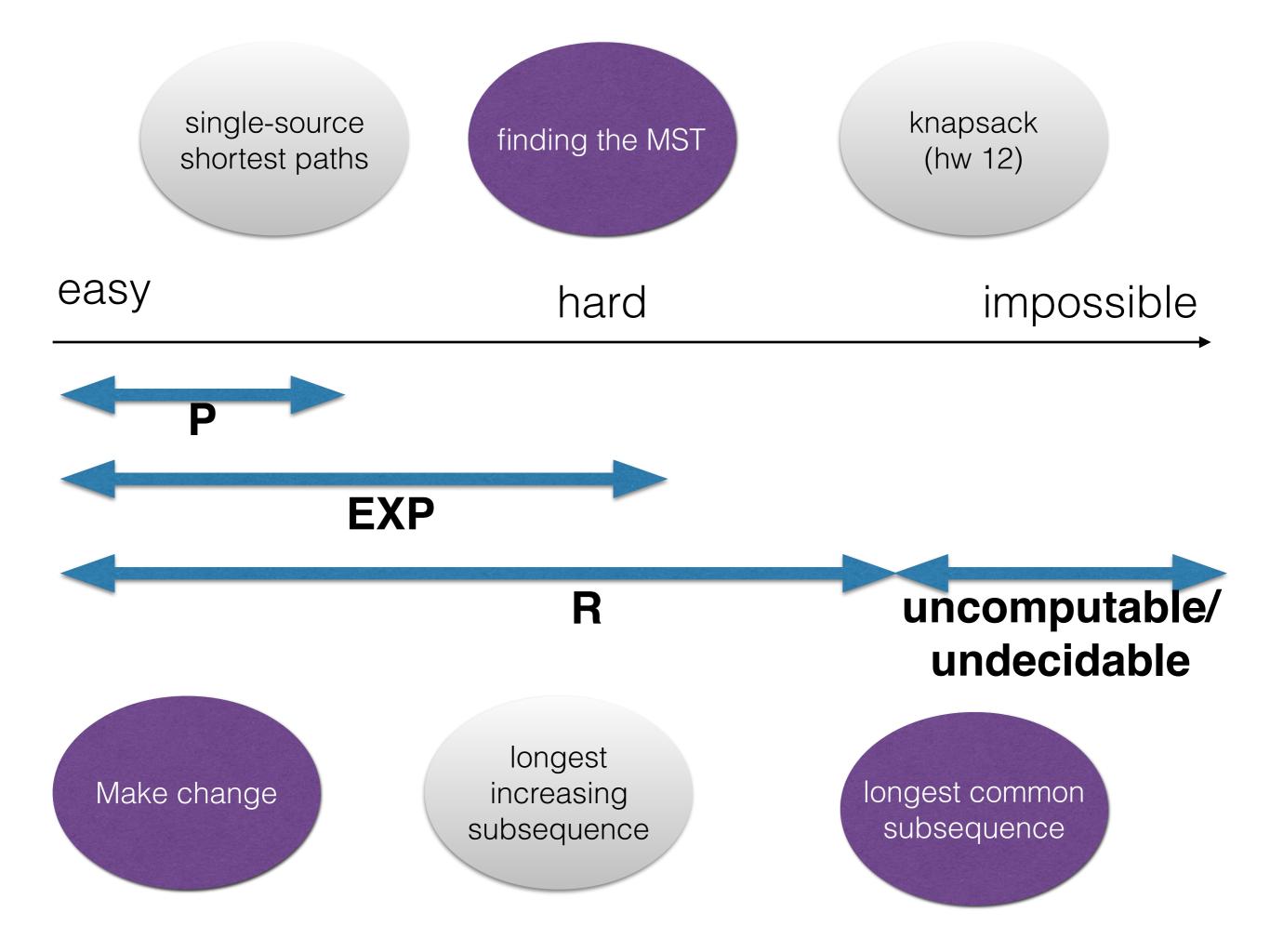
maximum subarray sum

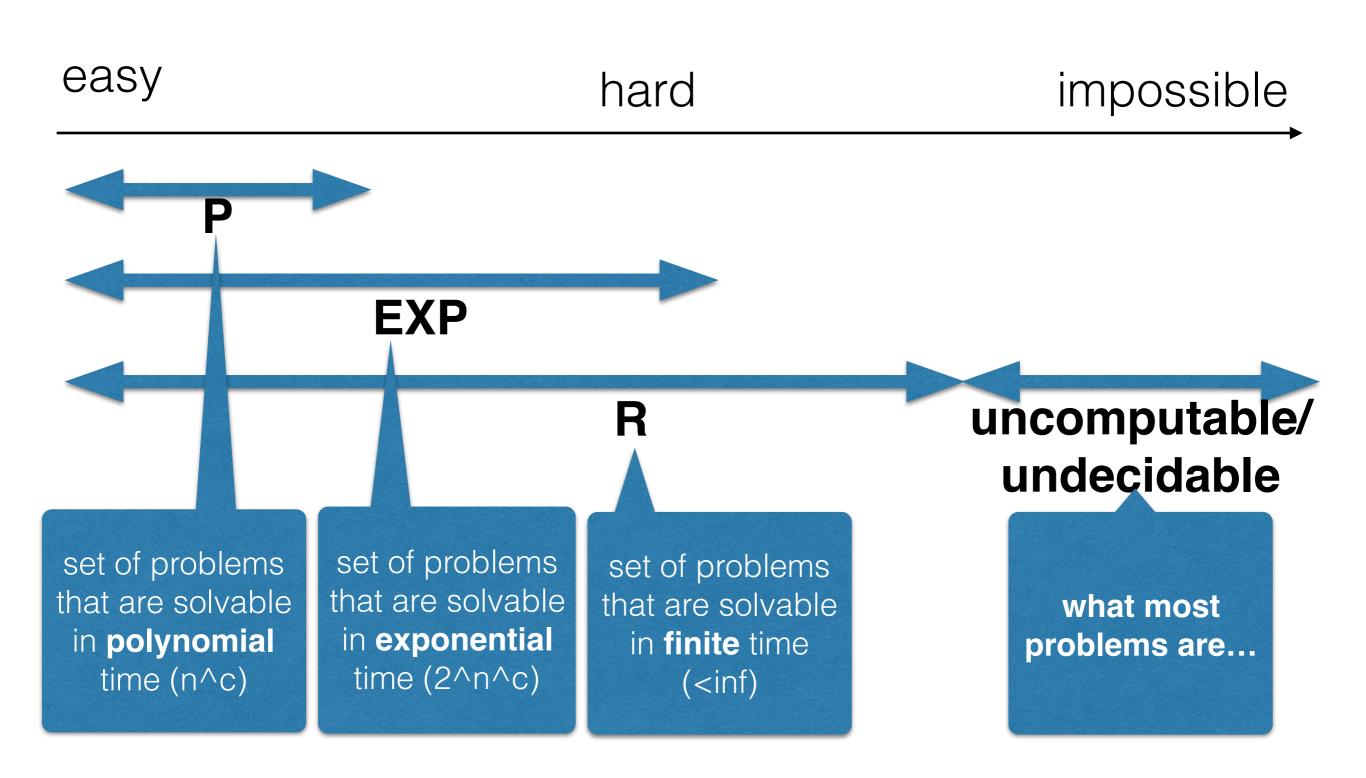
is the minimum change < x coins?

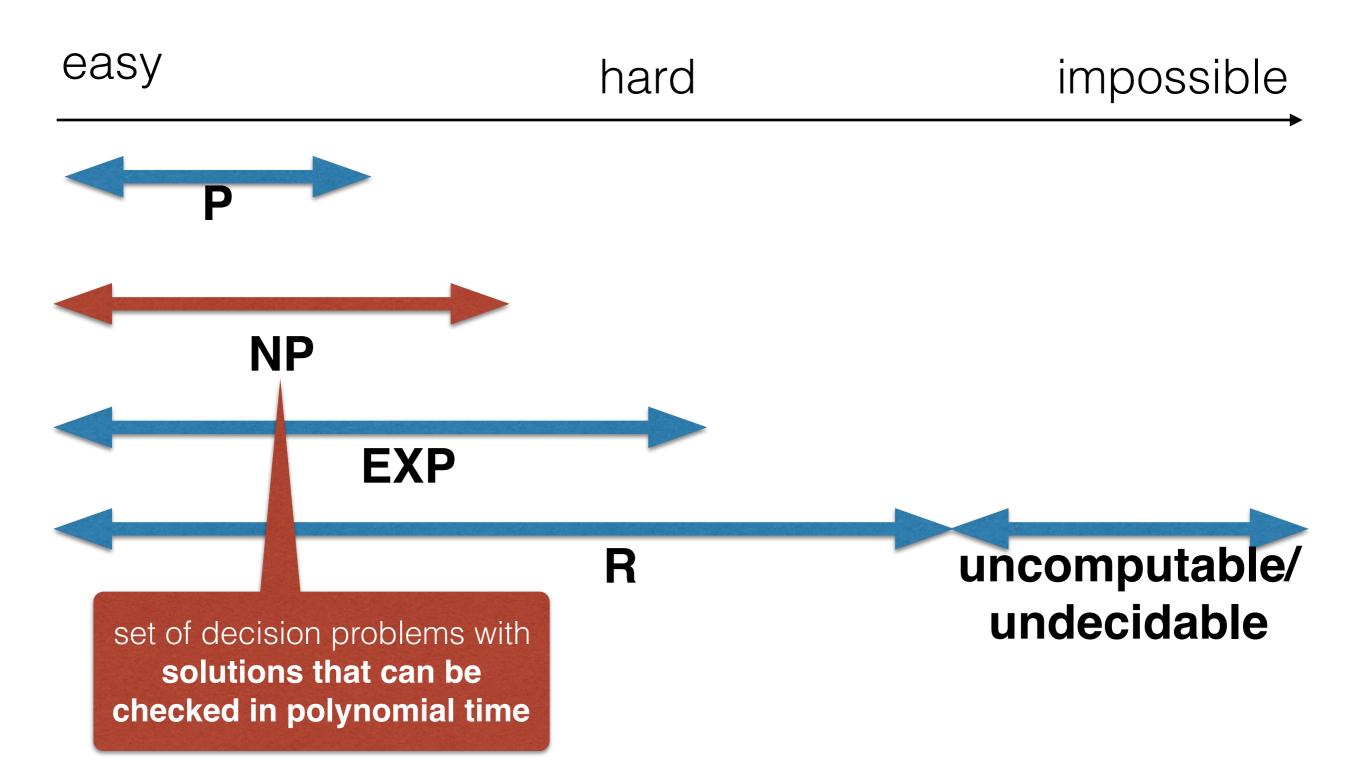
find the minimum change

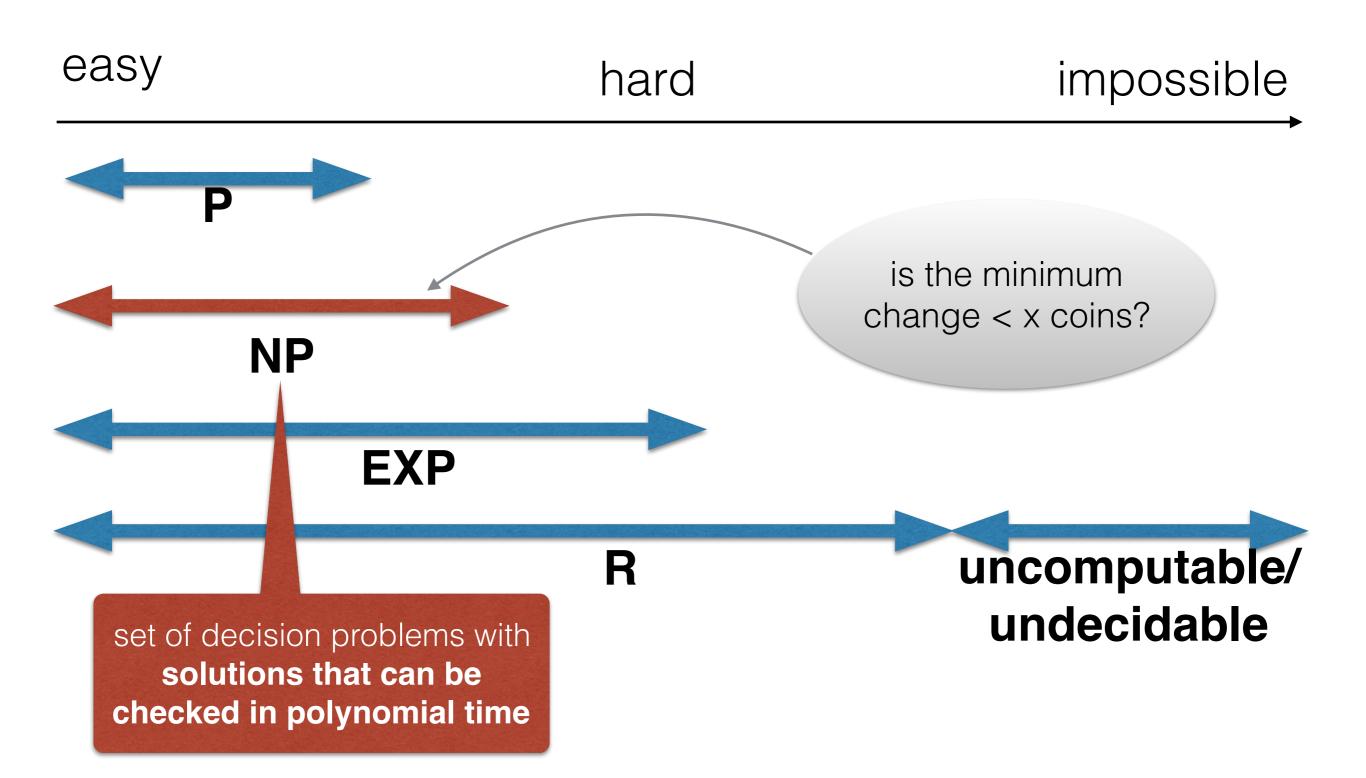
is the max knapsack value > \$x?

knapsack

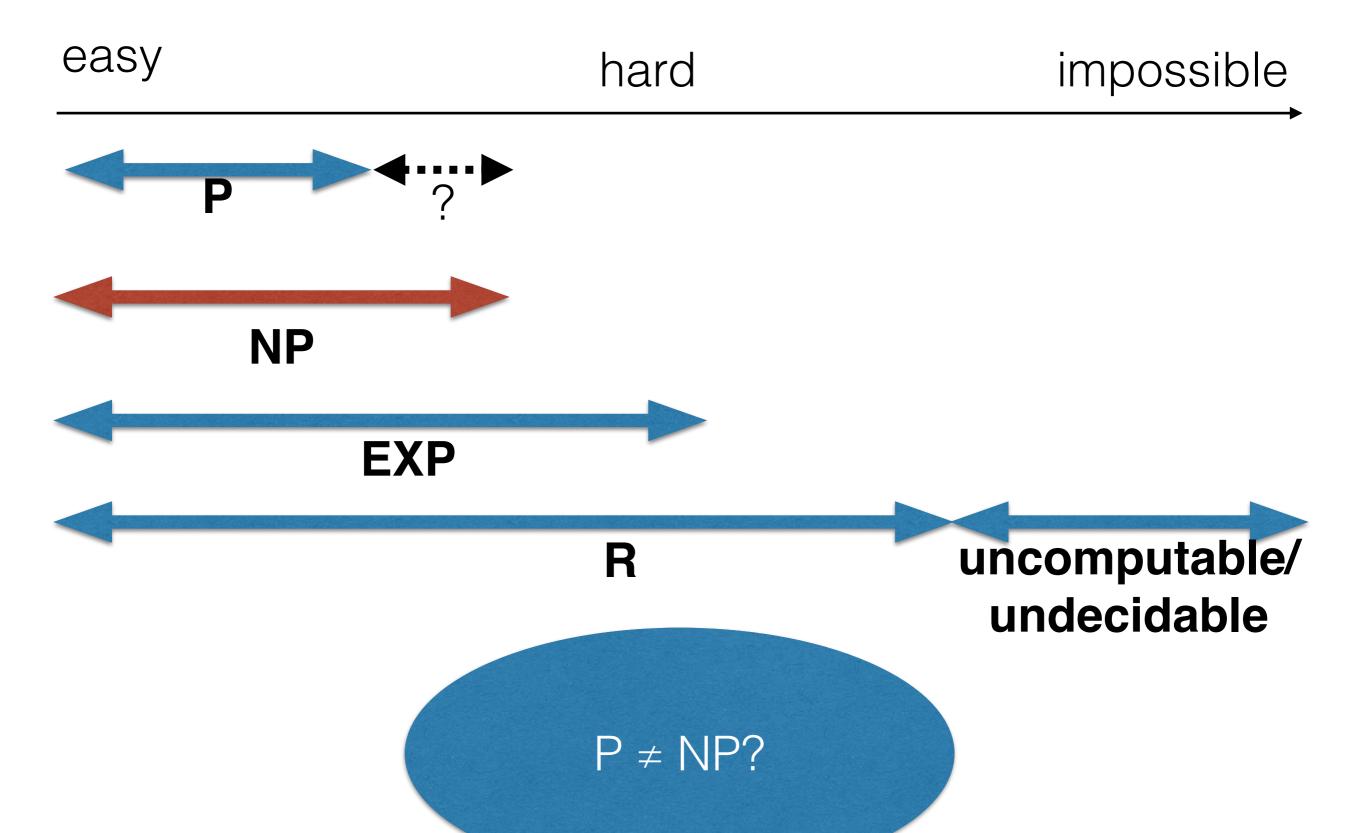








\$1,000,000 conjecture

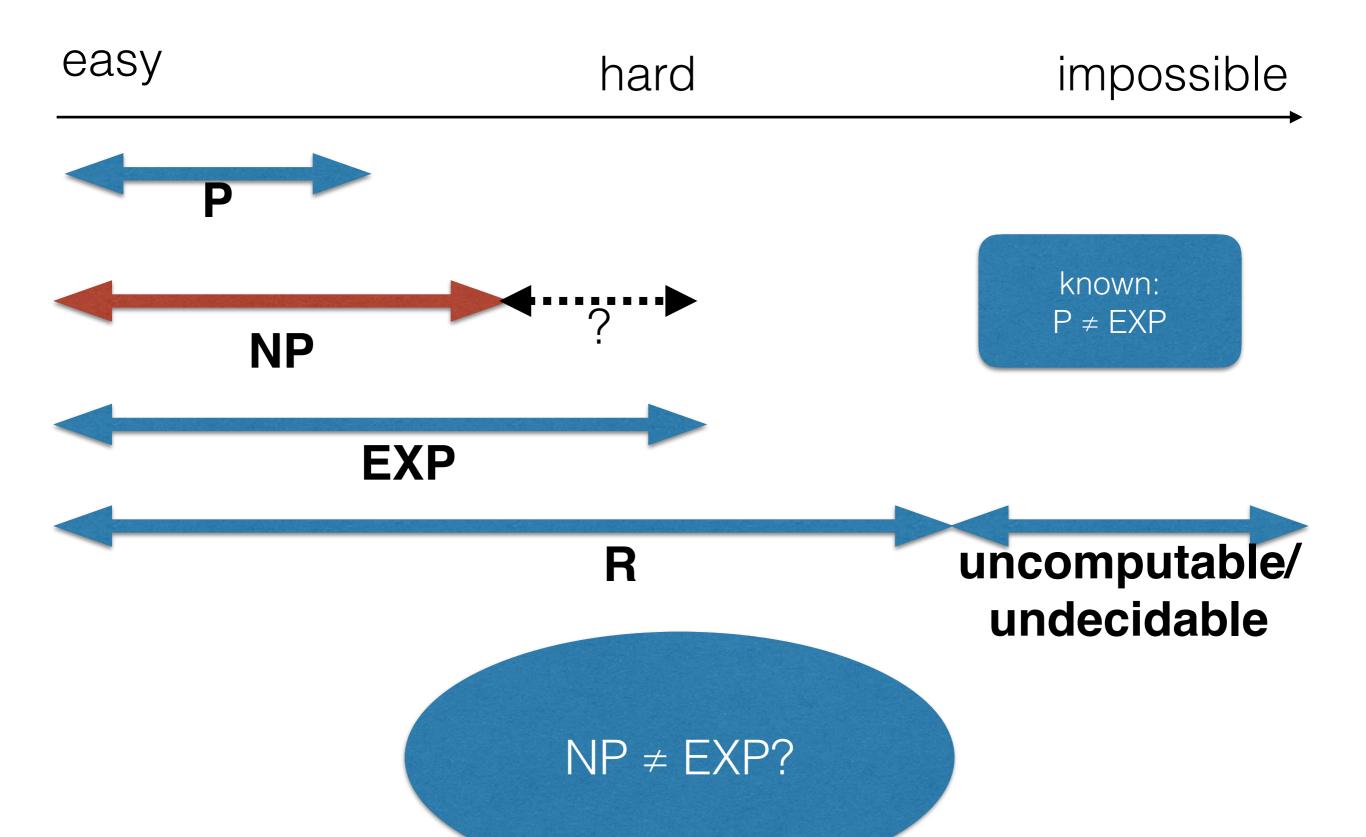


Warning!

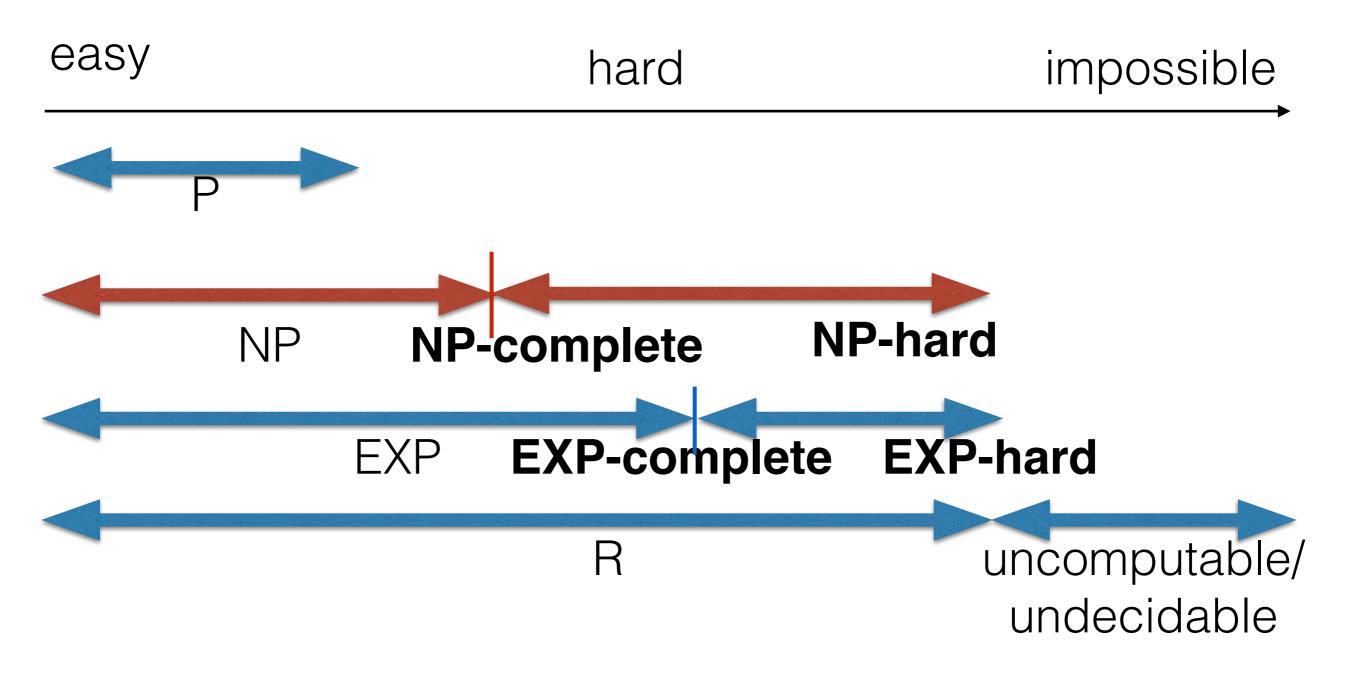
NP stands for Non-deterministic Polynomial

(not non-polynomial)

Also open, but no money



Completeness, hardness

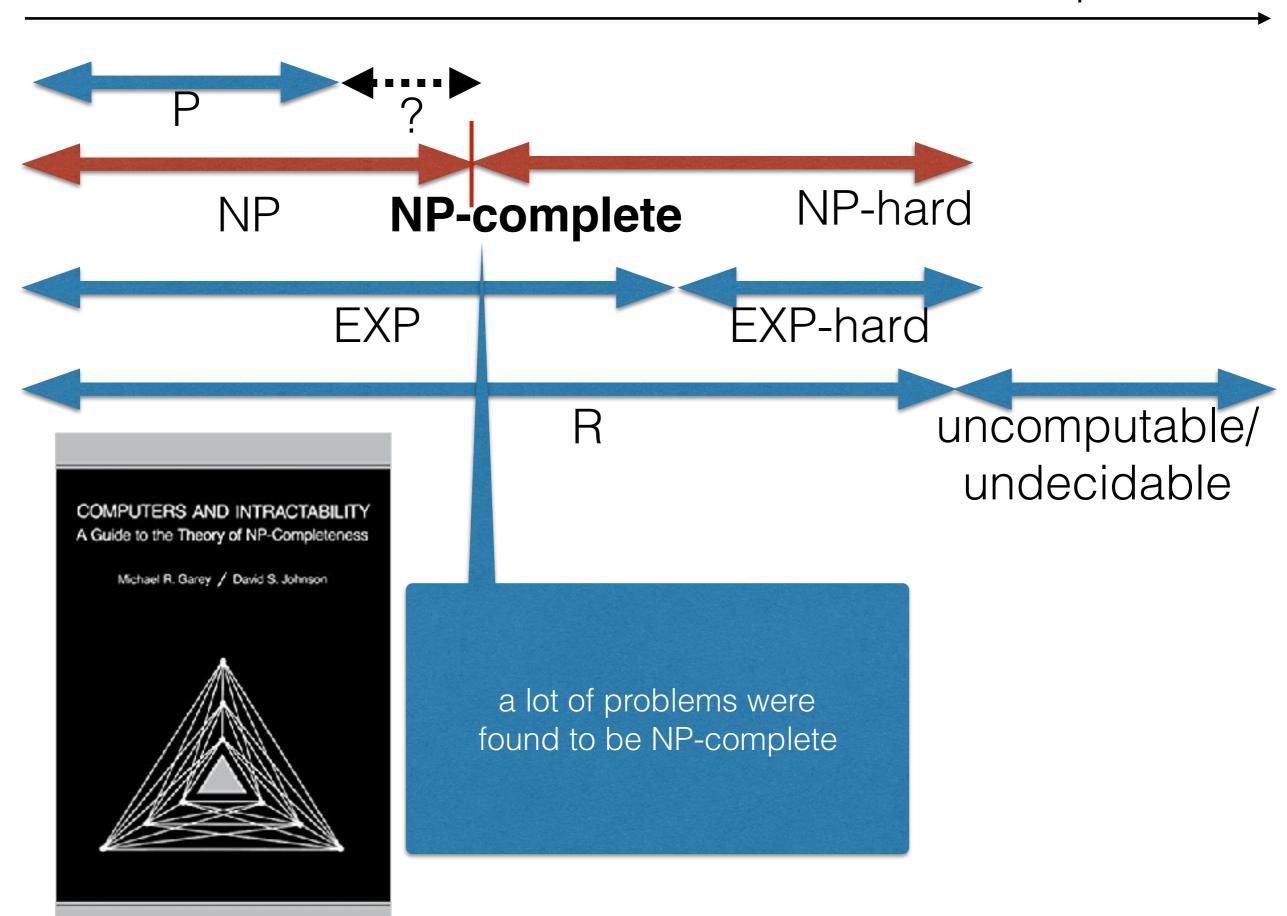


EXP-hard: as hard as any problem in EXP

EXP-complete: in EXP and as hard as any problem in EXP

Reduction

 convert your problem into a problem you already know how to solve, instead of solving your problem from scratch



More open problems

easy hard impossible

P

NP NP-complete NP-hard

almost all interesting problems are known to be in P or are NP-complete

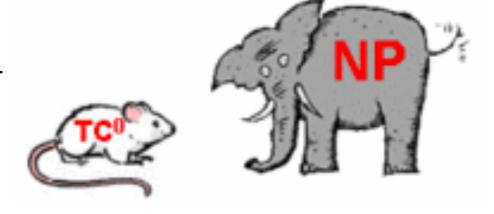
except...

is factoring in P?

is graph isomorphism in P?

But wait, there's more...

http://complexityzoo.com



- → exponential-time algorithms
- what to do then? → approximation algorithms
 - → fixed-parameter tractable algorithms
 - → heuristic search

Acknowledgements

lecture based on Erik Demaine's

http://courses.csail.mit.edu/6.006/fall11/notes.shtml