CS888: Introduction to Profession and Communication Skills
-- Theoretical CS

NITIN SAXENA (NITIN@CSE)

[*WITH HELP FROM INTERNET SOURCES]

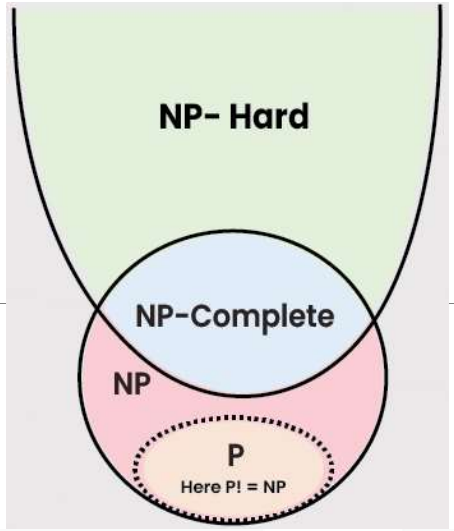
2024; AUG 21, 23, 28, 30; SEP 4, 6

Is life Hard?

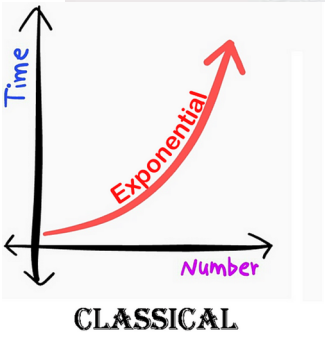
- What does easy or hard mean in CS?
  - Is it in theory or practice?
- Depends on the context:

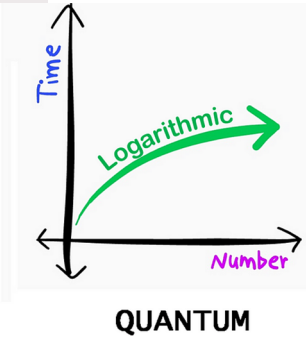
1. Fibonacci heaps are hard to *analyse*.
2. Matrix multiplication is *suboptimal*.
3. Integer factoring is hard to *solve*.
4. Hamiltonian path is hard to *find*.
5. Cycles are hard to *count*.

- Hardness is of diverse types:
  - Insightful Naming is important!

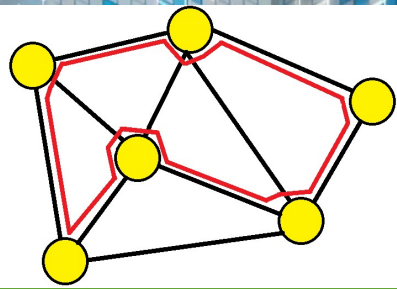


Procedure	Binary heap (worst-case)	Fibonacci heap (amortized)
MAKE-HEAP	$\Theta(1)$	$\Theta(1)$
INSERT	$\Theta(\lg n)$	$\Theta(1)$
MINIMUM	$\Theta(1)$	$\Theta(1)$
EXTRACT-MIN	$\Theta(\lg n)$	$O(\lg n)$
UNION	$\Theta(n)$	$\Theta(1)$
DECREASE-KEY	$\Theta(\lg n)$	$\Theta(1)$
DELETE	$\Theta(\lg n)$	$O(\lg n)$



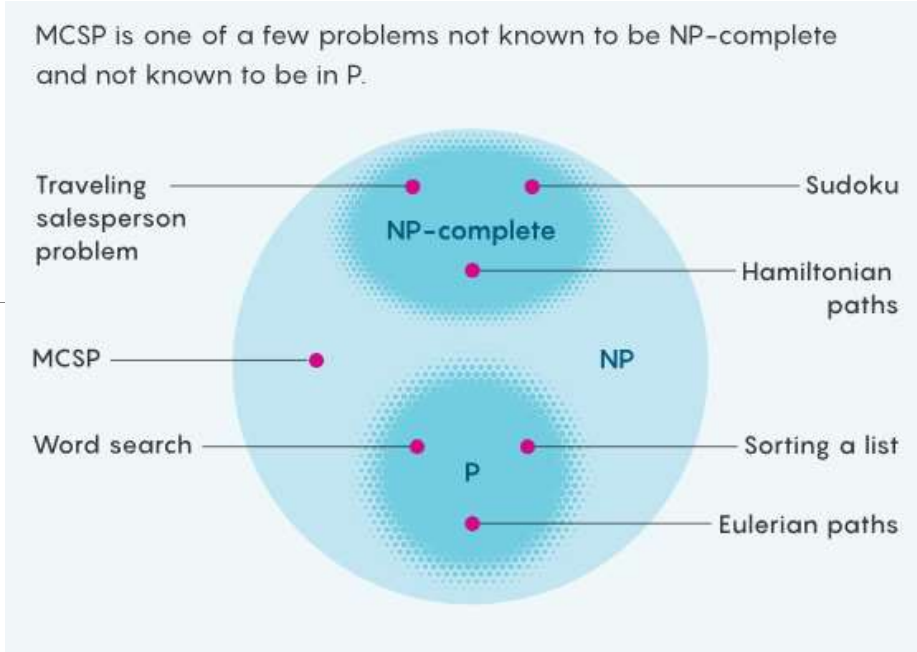


There are only two hard problems in computer science: cache invalidation and naming things.
- Phil Karlton



Is Hardness bad?

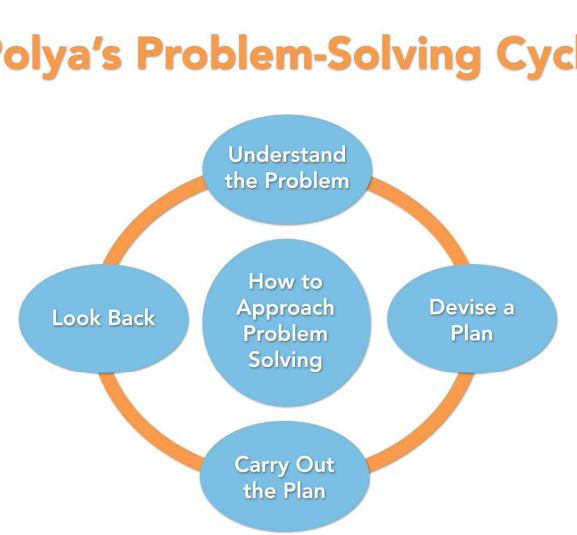
- Do scientists prove hardness only for sadistic fun?!
- We don't want to look for algorithms that don't exist.
- We can try solving for restricted inputs.
- Once we know a problem is hard, we could search for special-case heuristics
  - Approximation
  - Machine Learning, or Deep Learning
- Hard problems help design secure cryptosystems
  - IntegerFactoring, DiscreteLog → RSA
  - ShortestVector (SVP) → Lattice cryptosystem
  - SystemSolver → Multivariate Cryptography



- If a well-known hard problem Y reduces to X, then X is also *hard*.
- Else, we're *stuck* wondering about X.
  - problems of intermediate complexity.

How to survey?

- Recognize your area of interest (say **A**).
  - easier to pick from existing labels
  - internet, copilot, proceedings, journals, manuscripts, magazines
- Read few papers in **A**, make notes, give talks.
  - follow-up on the recent citations
- Identify a problem (say **P**) in area **A**.
- Specialize your search to **P** (and its *vicinity*).
  - read-up its state-of-the-art
  - give talks
  - follow-up on citations
  - be clear about what's done and what's open
  - talk to experts



Assignment 9

https://hello.iitk.ac.in/

deadline <12pm (end of class)