

CSC373 Worksheet 7 Solution

August 14, 2020

1. Notes

- **Decision Problem**

- Is the problem with yes/no solution

- **Alphabet**

- Is a finite set of symbols
- Is denoted Σ

Example:

$$\Sigma = \{0, 1\}$$

- **Language**

- Is any set of strings made of symbols from Σ

Example:

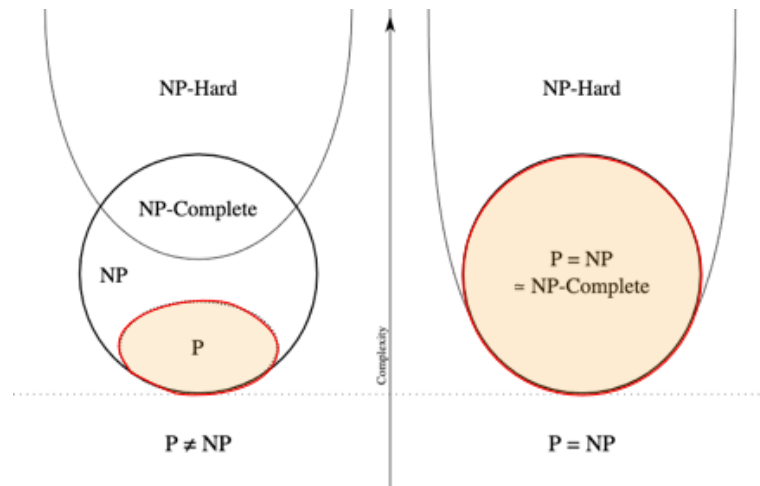
$$L = \{10, 11, 101, 111, 1011, 1101, 10001\}$$

- **P**

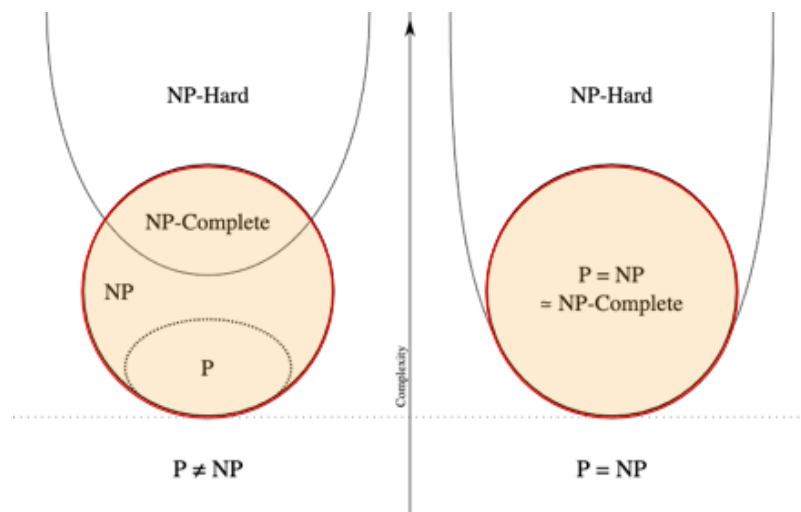
- Is set of problems that can be solved by a deterministic Turing machine in Polynomial time (i.e. $\mathcal{O}(n^k)$) ^[2].

Example:

- 1) Shortest path problems
- 2) Calculating the greatest common divisor
- 3) Finding maximum bipartite matching



• **NP (Non-deterministic Polynomial):**

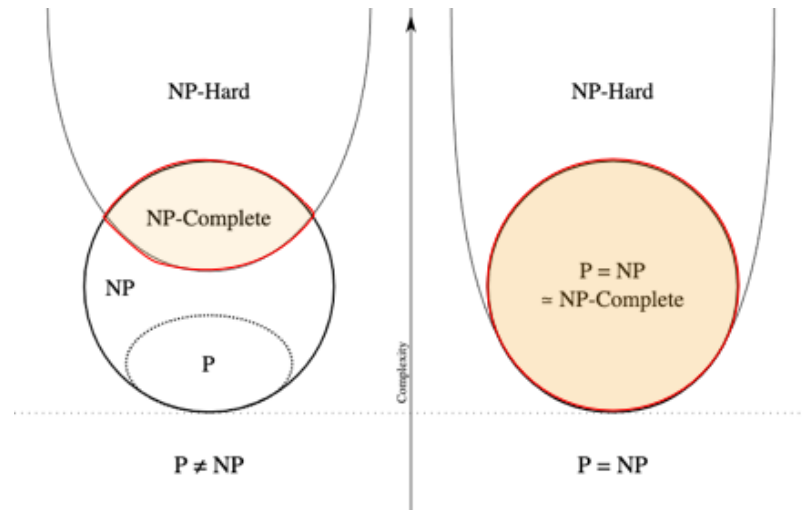


- Is set of decision problems that can be solved by a Non-deterministic Turing Machine in Polynomial time.^[2]
- Has no particular rule is followed to make a guess ^[1].
- Can be solved in polynomial time via a “lucky algorithm”, a magical algorithm that always make a right guess ^[2]
- $P \subseteq NP$

Examples:

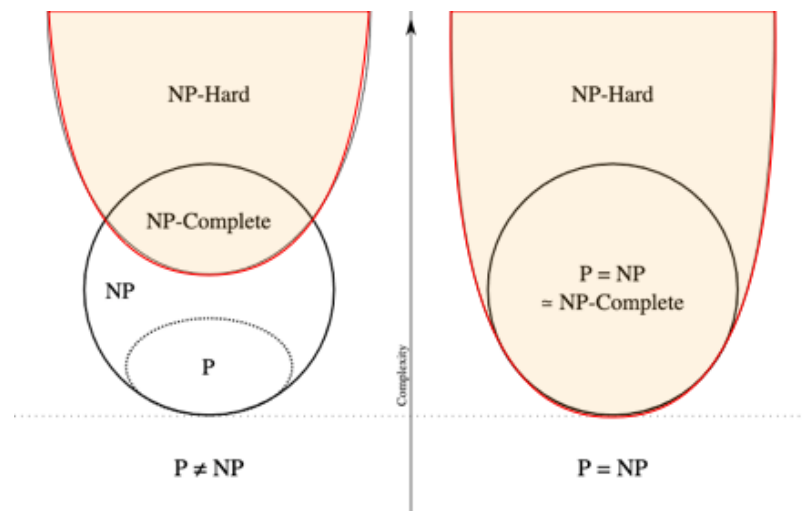
- Longest-path problems
- Hamiltonian Cycle
- Graph coloring

• **NP-Complete Problems:**



- A decision problem A is NP-complete (NPC) if
 - 1) $A \in NP$ and
 - 2) Every (other) problems A' in NP is reducible to A
- Has no efficient solution in polynomial number of steps (not yet) ^[3]
- Is not likely that there is an algorithm to make it efficient ^[3]

• **NP-Hard:**



- A decision problem A is NP-hard if
 - 1) $A \in NP$ (Not necessarily) and
 - 2) Every (other) problems A' in NP is reducible to A
- NP-Hard means “at least as hard as any problems in NP”
- Does not have to be about decision problems

Example:

- 1) Alan Turing's Halting Problem

References

- 1) Encyclopedia Britannica, NP-Complete Problem, [link](#)
- 2) Geeks for Geeks, NP-Completeness, [link](#)
- 3) Wikipedia, NP-complete, [link](#)
- 4) UCLA UC-Davis, ECS122A Handout on NP-Completeness, [link](#)