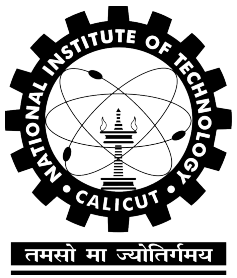
Quantum Computation Project

The essence of problems where quantum computers fail to outperform classical computers



Nithin Puthalath Manoj, Adwaith Ram Kishore,
Pavithra Rajan & Joel Mathew Cherian

Nov 9, 2022

Problem Understanding (Complexity Classes)

- **P-Problems**: Can be solved efficiently in polynomial time
- **NP-Problems**: Can't be solved efficiently in polynomial time, but solutions can be verified easily
- **NP-Complete**: Don't have efficient solutions, but finding one would provide an efficient solution for all such problems
- **PSPACE**: Conventional computers might need polynomial memory but exponential steps
- **BQP:** Includes all P-Problems and few NP-Problems

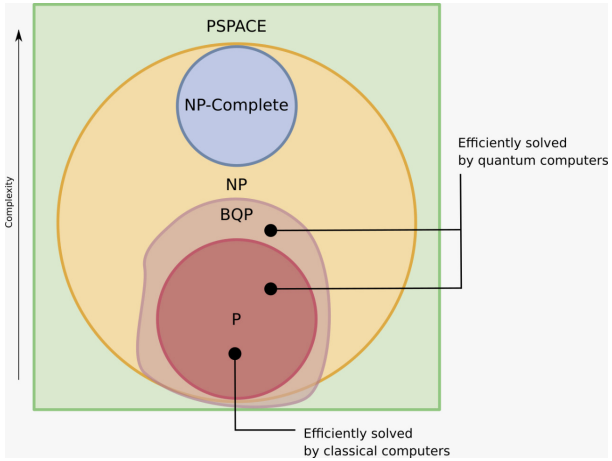


Figure 1: Complexity Classes

Problem Understanding (3 Colouring Graph)

- Given an undirected graph, we have to colour the graph utilising only 3 colours such that each vertex gets a colour that is not the same as its adjacent vertices.
- 3 colouring graph problem is NP-complete.
- In general, graph colouring is useful for solving a variety of practical problems like allocation of broadcast frequencies, register allocation and even puzzles like Sudoku.

Problem Statement

- **Showing that quantum computers cannot significantly outperform classical computers while trying to solve NP-complete problems.**
- One such problem that we picked up is the 3 colouring problem in graph theory which can be solved using quantum approaches such as Grover's search.
- Grover's algorithm performs exhaustive search over the set of all possible solutions to solve NP-complete problems.

Work Plan

1. Implement classical algorithms for solving the three colouring graph problem in Python.
2. Learn Q#/Qiskit
3. Implement Grover's Search (Quantum Algorithm) for the 3 colouring graph problem
4. Analyse the time complexities of classical and quantum approaches to quantify performance improvements offered by quantum algorithms

Bibliography

- Aaronson, S. (2008). The limits of quantum. Scientific American, 298(3), 62-69.
- D'Hondt, E. (2009). Quantum approaches to graph colouring. Theoretical computer science, 410(4-5), 302-309.
- *Diagram Reference:* https://www.quantum-bits.org/?p=2309

THANK YOU