



Quantum Approach To Shortest Path Problem

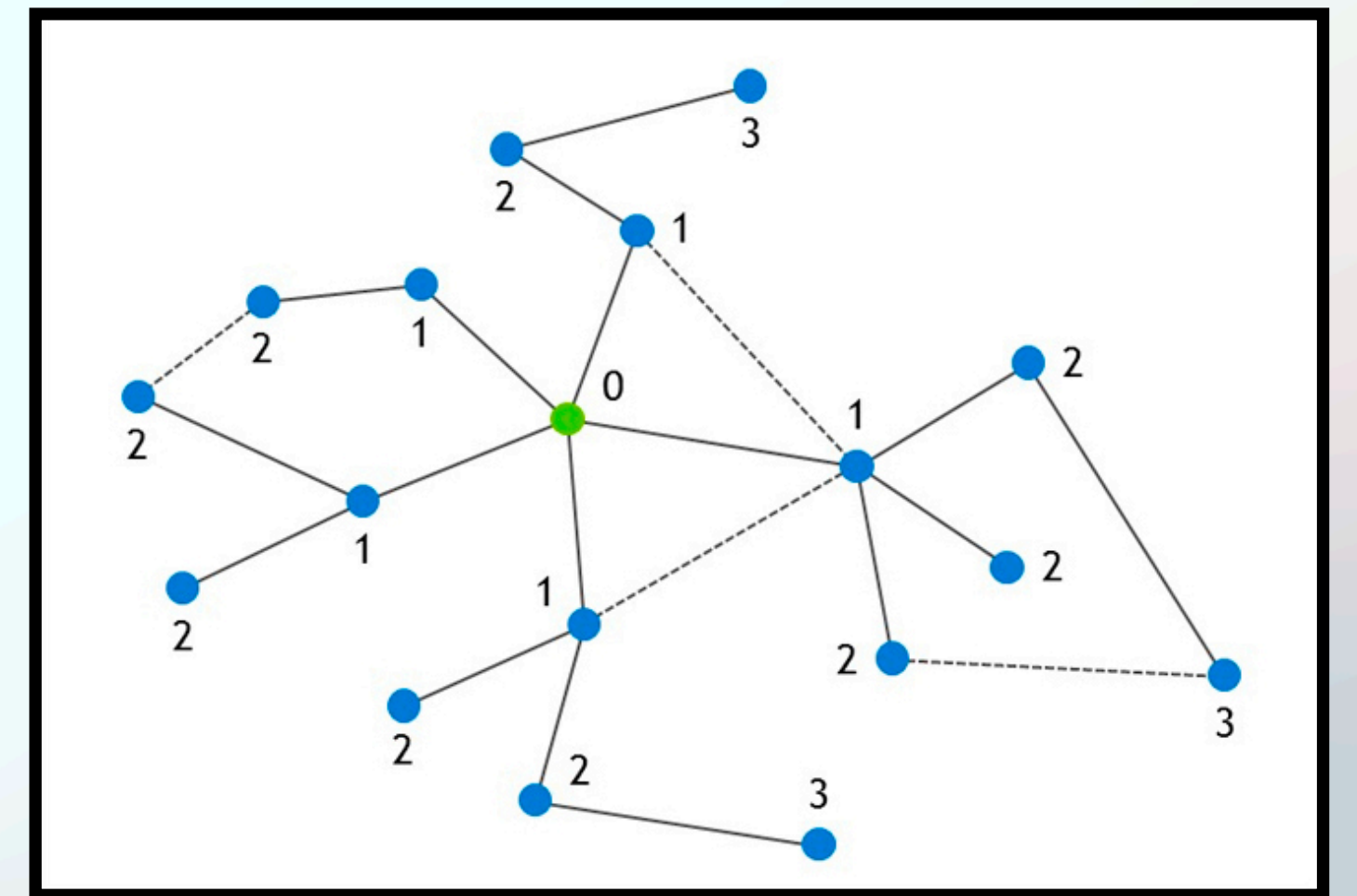
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Outline

- Introduction of Shortest Path Problem
- Discussion of Classic and Quantum Algorithms
- Quantum Approximation Optimization Algorithm (QAOA)
- Quantum Annealing (QA)
- Challenges

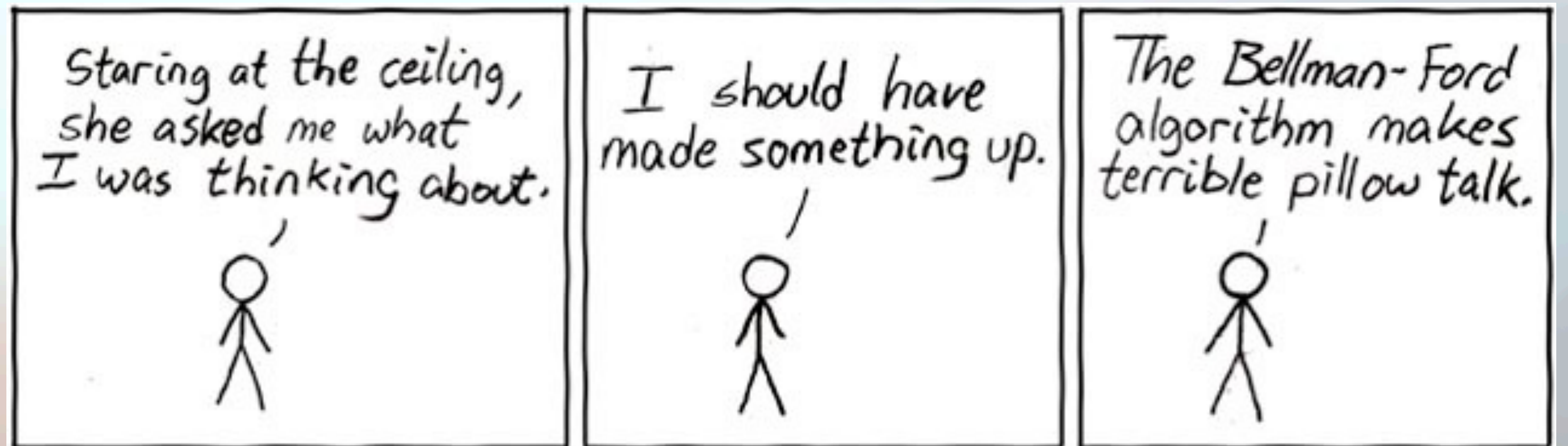
What's "Shortest Path Problem"

- "Finding the shortest path between two nodes in a graph..."
- Different Algorithms for Different Types
- Classic Algorithms
- Applications?



Limitations?

- Computational Complexity
- Scalability



Quantum Approach!

- Exponential Speedups
- Great promises by:
 - Grover for search
 - Shor for factorization
 - QAOA, QA, Quantum Walk

Constraints for SPP

- One and only one path from the source point
- One and only one path to the target point
- One edge in, one edge out
- Directed/Undirected?

QAOA: General Flow of Algorithm

- Problem Transformation
- Construction of Hamiltonian and Quantum Circuit
- Execution and Measurement
- Optimization for Optimal Result with Parameters

QAOA: Challenges!

- Overhead during Parameter Optimization
- Non-Deterministic Nature
- Fidelity, Volume
- Implementation Difficulty!

QA: Flow of Algorithm

- Reformulated as a QUBO matrix, representing SPP
 - (Quadratic Unconstrained Binary Optimization)
- Go through the quantum annealer D-Wave 2000Q
- Lowest-energy state — optimal solution to SPP

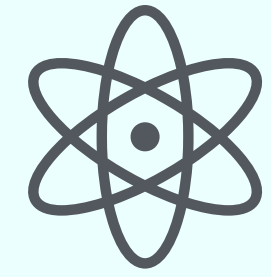
QA: Challenges

- Complexity of QUBO formulation
- Sensitive to noise
- Qubits Requirement

Conclusion

- Introduction of Shortest Path Problem and Algorithms.
- General workflows of QAOA, QA
- Current limitations and challenges

Questions?



Q: How many qubits they use/get involved?

A: Normally around 10 qubits, since the graph has four nodes.

Q: When will a real-world SPP can be solved?

A: For a small town with around 2000 edges, the upcoming D-Wave quantum annealer with over 5000 qubits might succeed.

References

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