

Approximation Algorithms

Approximation Algorithms

1. Definition

- Algorithms designed to find near-optimal solutions to problems for which finding the exact optimal solution is computationally intractable (NP-hard).

2. Why They're Needed

- Many important real-world problems (e.g., Traveling Salesman Problem, Vertex Cover) have no known efficient exact algorithm, so approximation offers a practical alternative.

3. Approximation Ratio

- A measure of how close the algorithm's solution is to optimal - e.g., a 2-approximation algorithm guarantees a solution at most twice the optimal cost.

4. Classic Examples

- Greedy Vertex Cover (2-approximation), the Christofides algorithm for Traveling Salesman (1.5-approximation on metric graphs).

5. Approximation Schemes

- Some problems have algorithms that can get arbitrarily close to optimal at the cost of increased running time (Polynomial-Time Approximation Schemes, or PTAS).

6. Practical Importance

- Approximation algorithms make previously "unsolvable" large-scale optimization problems practically usable in logistics, scheduling, and network design.