Travelling Salesman Problem

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Agenda

- What is TSP ?
- Our Approach - Branch & Bound
- Approaches to TSP
  - Sequential
  - Parallel
- Challenges to our approach
- Applications

What is TSP?

- Given a complete weighted undirected graph G = (V {1,...n}, E) and a cost matrix C, a tour is a circle in G which visits each vertex exactly once.

Applications to TSP

Applications to TSP

- Drilling a Printed Circuit Board.
- Navigating a self driving car.
- Routing in Google Maps.
- Sonet Rings

Approaches to TSP

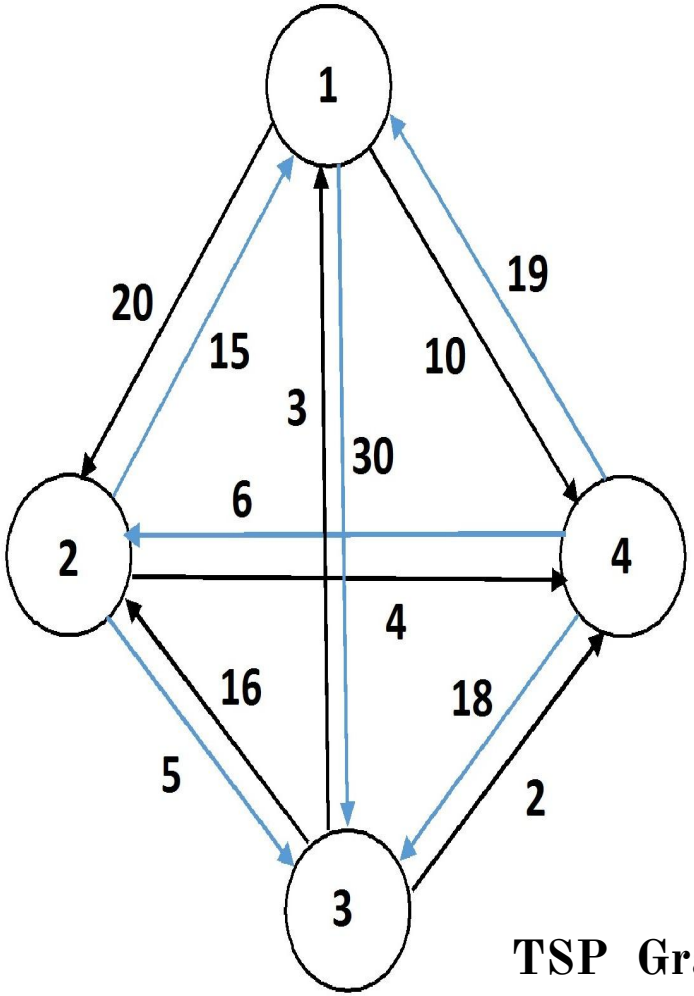
Approaches to TSP

- Branch and Bound Algorithm  **Our Approach**
- Simulated Annealing
- Ant Colony Optimization Algorithm
- Genetic Algorithm
- Lin Kernighan Algorithm
- Held-Karp lower bound Algorithm
- Tabu Search

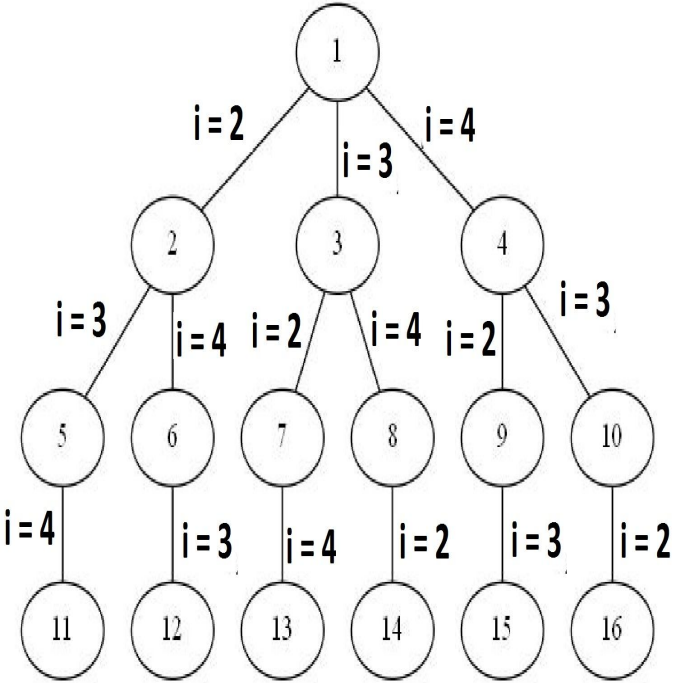
Branch & Bound Algorithm

Branch and Bound Algorithm

- **Select:** A node is selected based on a search criteria
- **Branch:** The selected node from above is subdivided into its child nodes
- **Bound:** Some of the nodes that are created are then pruned
- **Repeat the first 3 steps**

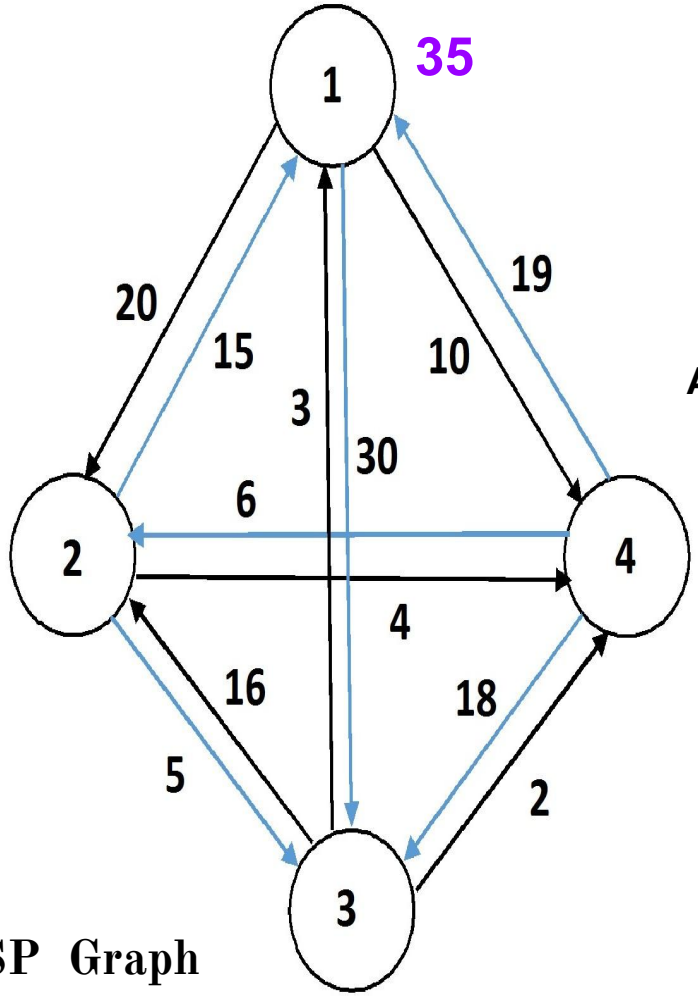


TSP Graph



State Space for B&B

Sequential and Parallel Approaches



TSP Graph

$$\begin{bmatrix} \infty & 20 & 30 & 10 \\ 15 & \infty & 16 & 4 \\ 3 & 5 & \infty & 2 \\ 19 & 6 & 18 & \infty \end{bmatrix}$$

Adjacency matrix of TSP Graph

$$\begin{bmatrix} \infty & 10 & 20 & 0 \\ 11 & \infty & 12 & 0 \\ 1 & 4 & \infty & 0 \\ 13 & 0 & 12 & \infty \end{bmatrix}$$

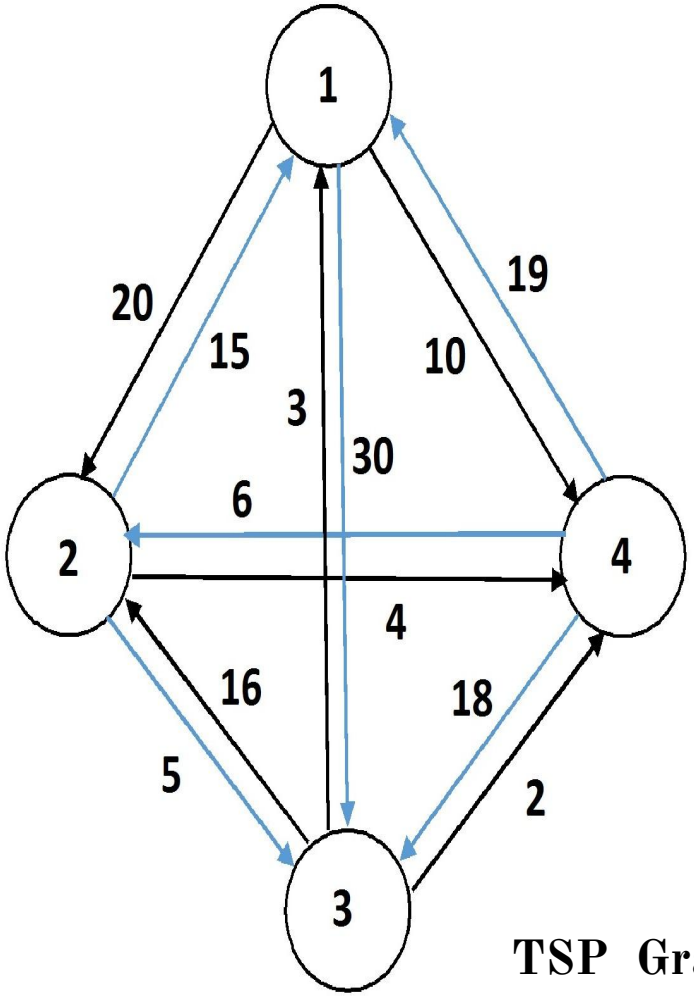
Row Reduced Matrix

Reduced Cost Value:
(10 + 4 + 2 + 6) + (12 + 1) + 0
= 35 for Node 1

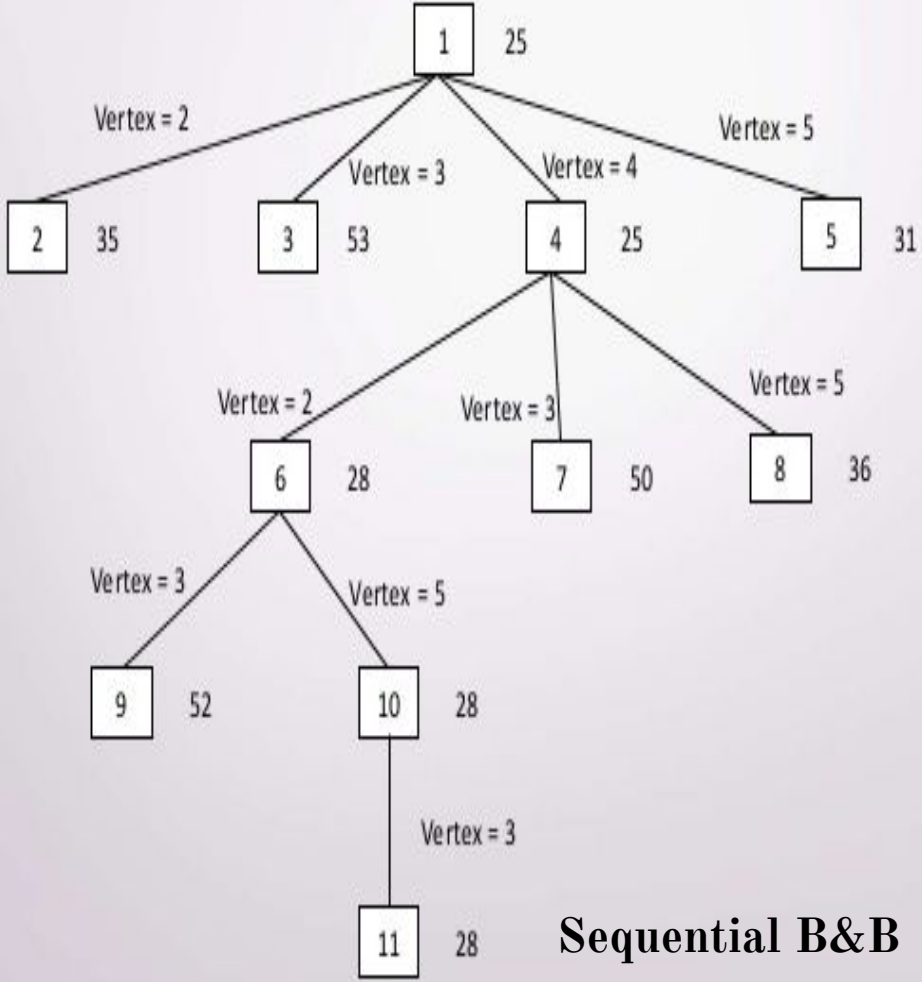
$$\begin{bmatrix} \infty & 10 & 8 & 0 \\ 10 & \infty & 0 & 0 \\ 0 & 4 & \infty & 0 \\ 12 & 0 & 0 & \infty \end{bmatrix}$$

Column Reduced Matrix

Reduced Cost Matrix for B&B approach



TSP Graph

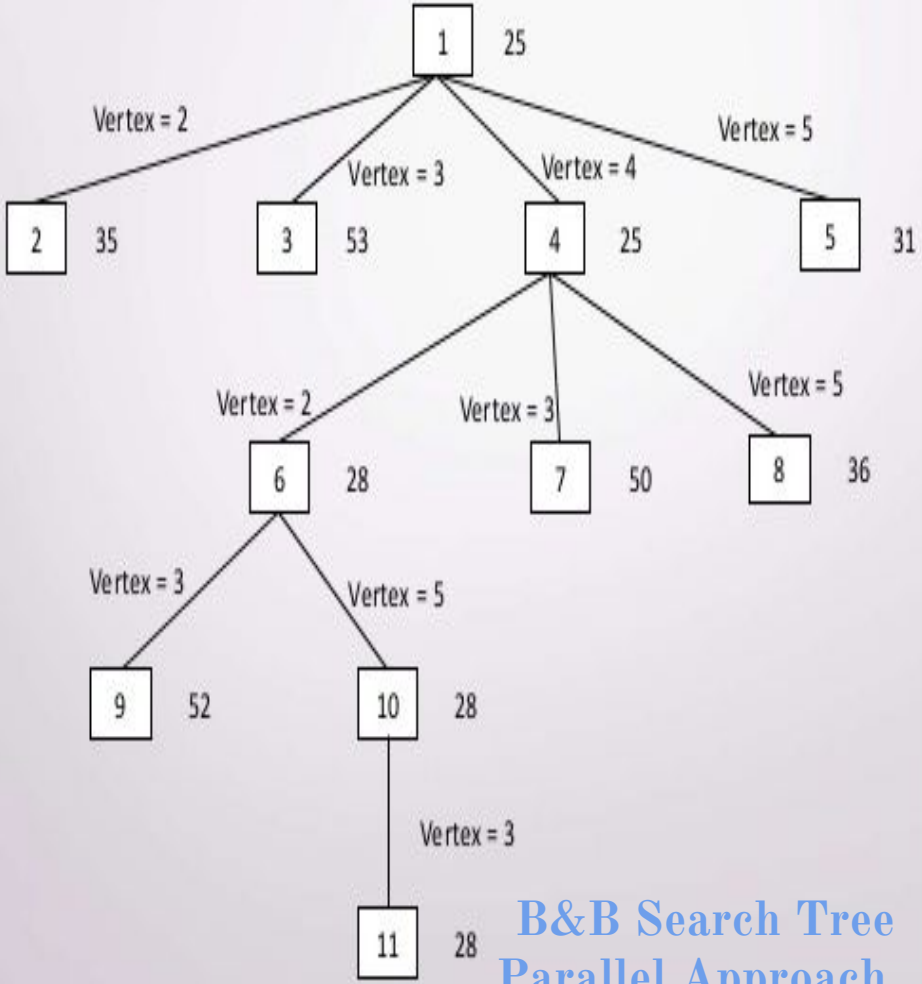


Sequential B&B

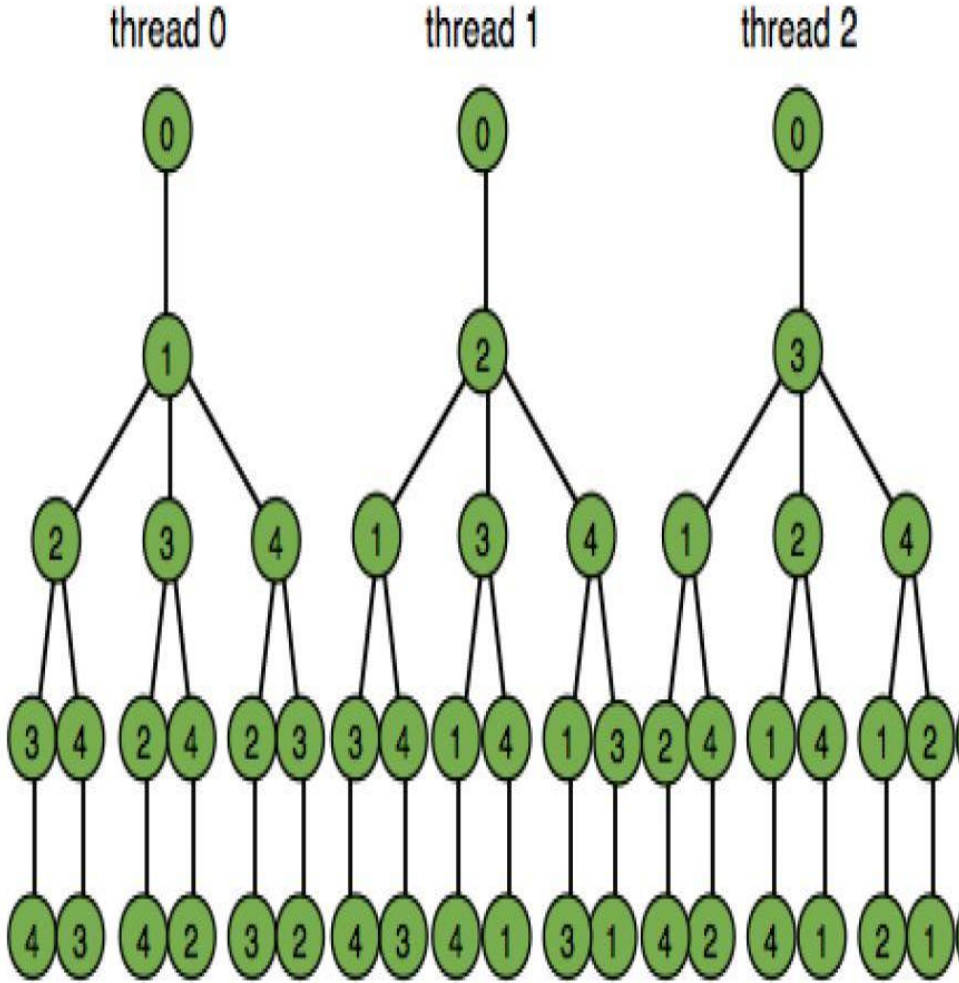
Hypothesis

Sources of Parallelism

- Node-based Strategy
- Tree-based Strategy
  - Depth First Search Algorithm
  - Best-First Search Algorithm



B&B Search Tree
Parallel Approach



References

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- **“Traveling Salesman Problem: An Overview of Applications, Formulations, and Solution Approaches”** by Rajesh Matai, Surya Prakash Singh and Murari Lal Mittal

Questions?