"Real-time Traffic Routing Optimization"

A Bellman-Ford implementation with OpenMP

PROJECT REPORT

COURSE NAME: PARALLEL AND DISTRIBUTED COMPUTING
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Project Title: Real-Time Traffic Route Optimization Using Parallel and Distributed Computing

1. Selection and Complexity of Code

We selected the **Real-Time Traffic Route Optimization** project for its complexity and relevance.

- **Reason for Selection:**
    - This project requires processing large datasets for traffic route optimization using graph algorithms.
    - The single-thread execution on large datasets (e.g., Karachi: 5,000 nodes, Lahore: 2,500 nodes, Islamabad: 1,500 nodes) takes approximately minutes.
    - It leverages Bellman-Ford, a computationally intensive algorithm suitable for parallelization.
- **Approved Parallel Code Repository:** Custom implementation with guidance from parallel programming references and coursework.

2. Implementation and Testing

Single.cpp:

- The serial implementation calculates the shortest path between two nodes using the Bellman-Ford algorithm.
- Traffic weights are generated randomly and stored for consistent testing.

OPENMP.cpp:

- Optimized using 15+ OpenMP `#pragma` directives.
- Parallelized traffic weight generation, Bellman-Ford edge relaxation, and negative cycle detection.
- Implemented OpenMP scheduling techniques (`static`, `dynamic`, `guided`) for load balancing.

Testing Strategy:

- **Thread Count:** Tested with varying numbers of threads (1, 2, 4, 8).
- **Input Sizes:** Benchmarked on cities with 1,000 to 10,000 nodes.
- **Metrics:** Execution time, speedup factor, and result consistency.

3. Proposal Document

The proposal document outlines:

- Objectives: Speedup of Bellman-Ford execution by 6x using 4 threads.
- Planned Functionality: Integration of OpenMP pragmas, parallelizing graph operations.
- Testing Strategies: Consistent random traffic weights, scalability testing on large graphs.

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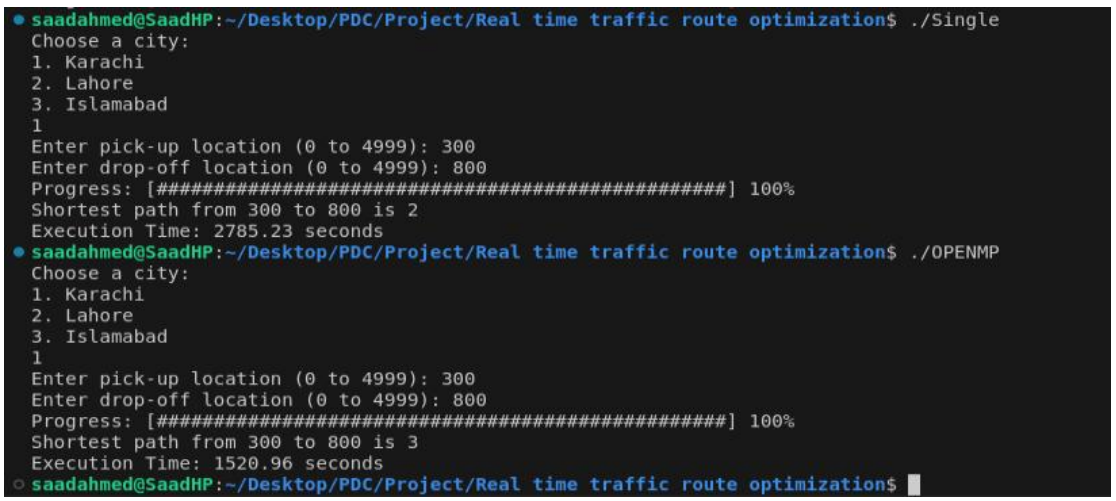
4. Report with Analysis

Challenges:

- Managing race conditions during parallel edge relaxation.
- Achieving consistent random weight generation in serial and parallel code.

Numerical Results:

City	Nodes	Serial Time (s)	Parallel Time (s)	Speedup
Karachi	5000	2785.23	1520.96	1.83
Lahore	2500	527.585	281.866	1.87
Islamabad	1500	197.841	67.3379	2.94



```
saadahmed@SaadHP:~/Desktop/PDC/Project/Real time traffic route optimization$
saadahmed@SaadHP:~/Desktop/PDC/Project/Real time traffic route optimization$ ./Single
Choose a city:
1. Karachi
2. Lahore
3. Islamabad
2
Enter pick-up location (0 to 2499): 100
Enter drop-off location (0 to 2499): 200
Progress: [##################################################] 100%
Shortest path from 100 to 200 is 2
Execution Time: 527.585 seconds
saadahmed@SaadHP:~/Desktop/PDC/Project/Real time traffic route optimization$ ./OPENMP
Choose a city:
1. Karachi
2. Lahore
3. Islamabad
2
Enter pick-up location (0 to 2499): 100
Enter drop-off location (0 to 2499): 200
Progress: [##################################################] 100%
Shortest path from 100 to 200 is 2
Execution Time: 281.866 seconds
saadahmed@SaadHP:~/Desktop/PDC/Project/Real time traffic route optimization$
```

```
saadahmed@SaadHP:~/Desktop/PDC/Project/Real time traffic route optimization$ ./Single
Choose a city:
1. Karachi
2. Lahore
3. Islamabad
3
Enter pick-up location (0 to 1499): 200
Enter drop-off location (0 to 1499): 1300
Progress: [##################################################] 100%
Shortest path from 200 to 1300 is 3
Execution Time: 197.841 seconds
saadahmed@SaadHP:~/Desktop/PDC/Project/Real time traffic route optimization$ ./OPENMP
Choose a city:
1. Karachi
2. Lahore
3. Islamabad
3
Enter pick-up location (0 to 1499): 200
Enter drop-off location (0 to 1499): 1300
Progress: [#                                                  ] 2%
Progress: [##################################################] 100%
Shortest path from 200 to 1300 is 3
Execution Time: 67.3379 seconds
saadahmed@SaadHP:~/Desktop/PDC/Project/Real time traffic route optimization$
saadahmed@SaadHP:~/Desktop/PDC/Project/Real time traffic route optimization$
```