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CSE4001 - Parallel and Distributed Computing

**School of Computer Science & Engineering
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Review-2

Parallelization of Shortest Path Finder between two nodes: Floyd-Warshall Algorithm

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Introduction:

Finding the shortest path between two objects or all objects in a graph is a common task in solving many day to day and scientific problems. The algorithms for finding shortest path find their application in many fields such as social networks, bioinformatics, aviation, routing protocols, Google maps etc. Shortest path algorithms can be classified into two types: single source shortest paths and all pair shortest paths. There are many different algorithms for finding the all pair shortest paths. Some of them are Floyd-Warshall algorithm and Johnson's algorithm.

All pair shortest path algorithm which is also known as Floyd-Warshall algorithm was developed in 1962 by Robert Floyd. This algorithm follows the methodology of the dynamic programming. The algorithm is used for graph analysis and finds the shortest paths (lengths) between all pair of vertices or nodes in a graph. The graph is a weighted directed graph with negative or positive edges. The algorithm is limited to only returning the shortest path lengths and does not return the actual shortest paths with names of nodes.

Abstract:

The project deals with implementation of Floyd Warshall Algorithm i.e. All Pair Shortest Path. This algorithm is implemented using parallel programming concept for faster solution. Floyd Warshall algorithm has overcome the drawbacks of Dijkstra's and Bellman Ford Algorithm. For parallel programming, this project is implemented using open MP for which C programming is used. The purpose of developing this project is to find the shortest path between all the present nodes in a graph.

This project can be implemented for Airline Systems, Transportation services, Courier Services, Networking etc.

Floyd Warshall:

Floyd Warshall algorithm is All Pair Shortest Path finder. It is mainly used to overcome the drawbacks of Dijkstra's and Bellman Ford Algorithm. It considers negative weight present in the graph. In Floyd Warshall algorithm every node of the graph is visited and the shortest path is computed.

The Floyd-Warshall algorithm is an example of dynamic programming

The algorithm is also known as **Floyd's algorithm**, the **Roy-Warshall algorithm**, the **Roy-Floyd algorithm**, or the **WFI algorithm**.

Proposed system:

Hardware Interfaces:

— Intel Core I5 5th Generation.

— 8GB RAM.

Software Interfaces:

Languages Used: C programming, Dynamic programming, OPEN MP

Algorithm:

Sequential algorithm

```
for k = 0 to N-1
    for i = 0 to N-1
        for j = 0 to N-1

             $I_{ij}(k+1) = \min(I_{ij}(k), I_{ik}(k) + I_{kj}(k))$ 

        Endfor
    Endfor
endfor
```

The Floyd-Warshall Sequential algorithm

Sequential pseudo-code of this algorithm is given above requires N^3 comparisons. For each value of k that is the count of inter mediatory nodes between node i and j the algorithm computes the distances between node i and j and for all k nodes between them and compares it with the distance between i and j with no inter mediatory nodes between them. It then considers the minimum distance among the two distances calculated above. This distance is the shortest distance between node i and j. This algorithm requires the adjacency matrix as the input. Algorithm also incrementally improves an estimate on the shortest path between two nodes, until the path length is minimum.

In future we are implementing this sequential floyd-warshall algorithm in to parallel Floyd-warshall algorithm with the help of OPEN MP and compare the time complexity between sequential and parallel algorithms

PSEUDO CODE:

The Floyd-Warshall algorithm compares all possible paths through the graph between each pair of vertices. Consider a graph $G(V, E)$ where V is no. of vertices and E is no. of edges. For computing minimum path between each pair of node W_k . is computed where k ranges from 1 to V. For computing shortest from i to j, $W[i, j] = W[i, k] + W[k, j]$

INPUT: A graph $G(V, E)$ where V is a set of vertices and E is set of weighted edges between these vertices. A source vertex form V.

OUTPUT: The distance of shortest paths between the source vertex and every vertex in G.

Implementations of Floyd Warshall Algorithm:

The Floyd–Warshall algorithm can be used to solve the following problems, among others:

- Shortest paths in directed graphs (Floyd's algorithm).
- Finding a regular expression denoting the regular language accepted by a finite automaton (Kleene's algorithm, a closely related generalization of the Floyd–Warshall algorithm)^[11]
- Inversion of real matrices (Gauss–Jordan algorithm)
- Optimal routing between two vertices such as distance between two cities.
- Fast computation of Pathfinder networks.
- Widest paths/Maximum bandwidth paths
- Computing canonical form of difference bound matrices (DBMs)

References:

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- [3] John D.owens, David Luebke, Naga Govindaraju, Mark Harris, Jens Kruger, Aaron E.Lefohn, Timothy. Purcell,A survey of general-purpose computation on graphics hardware, Computer Graphics Forum 34(March) (2007)80-113.