Multi Modal Routing Problem

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Abstract

The objective of the problem is to transport a series of shipments from their source locations to their target locations using the most cost or time effective means. The route taken by the shipment from the source to target location is comprised of a series of transfers from one mode of transport to another at different intermediate shipping points. As well as transferring modes, shipments also have the ability to transfer between carriers at shipping points. The algorithms used work in conjunction with real-time dynamic agents that can make or take away new options of travel as they become available, to model real world changes in shipping routes.

The MMRP is an NP-complete problem. That is, the time taken to solve the problem increases exponentially with respect to the increase in the number of inputs, namely the shipments. This makes finding an optimal solution difficult when time constraints are factored into the problem. The implemented heuristics generate good real time solutions based on actual shipping data available online.

Current Algorithms

- **A*** - Starts with the starting location and examines all vehicles leaving there within the departure time window. Expands cheapest/quickest route based on shipment priority. This process is repeated at each node until the destination reached. If produced solution is not within arrival window, algorithm continues exploring other options. If no suitable option found it returns closest possible solution.
- **Travel By Type** - A variation of **A*** that limits the routes taken to a specific travel type.
- **Reverse A*** - A variation of **A*** that starts at the destination and then works backwards.
- **Node Crawler First** - First checks for direct connection between starting and ending location. If multiple connections exist between starting and ending a random connection is chosen. Otherwise, traveses graph at random until solution found. If no suitable option found, returns null solution.
- **Best First Find** - Works similar to **Node Crawler First**, choosing best connection between nodes over random connection between nodes.

Preliminary Results

```
DHLTruck1
    From Mobile,AL To Pittsburgh,PA
        Capacity: 100 Actual:0
            Picked up Shipment 13
    From Pittsburgh,PA To Memphis,TN
        Capacity: 100 Actual:8
            Picked Up Shipment 34
    From Memphis,TN To Miami,FL
        Capacity: 100 Actual:62
            Delivered Shipment 13
            Delivered Shipment 34
```

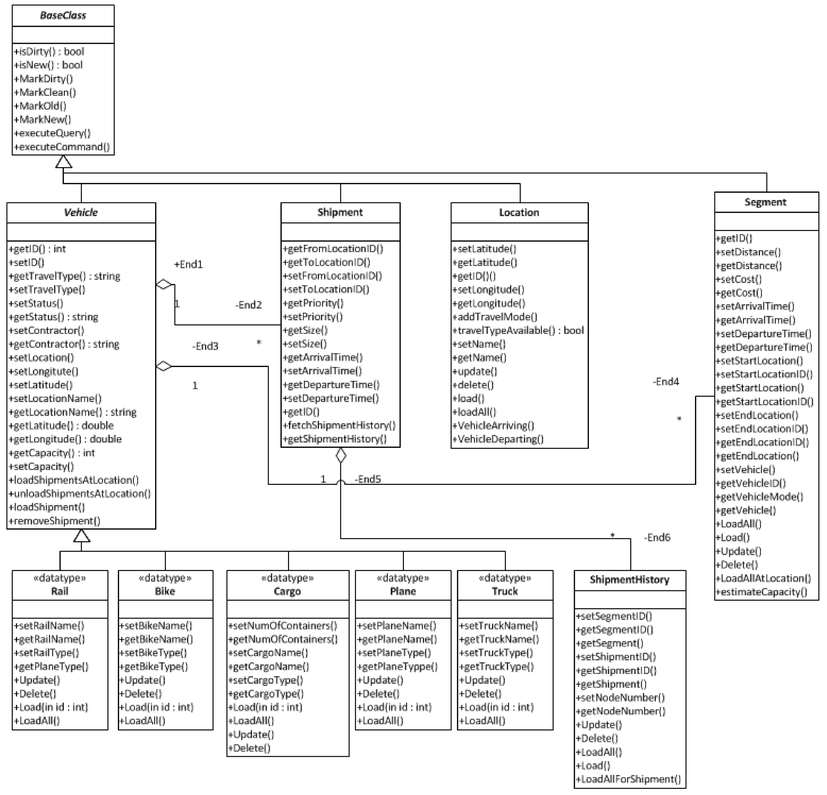
Procedure

The shipment will supply the various algorithms with the data required to determine the 'best' solution. The solution will be determined through a series of different algorithms, with the best solution being stored and tracked for any changes in the route.

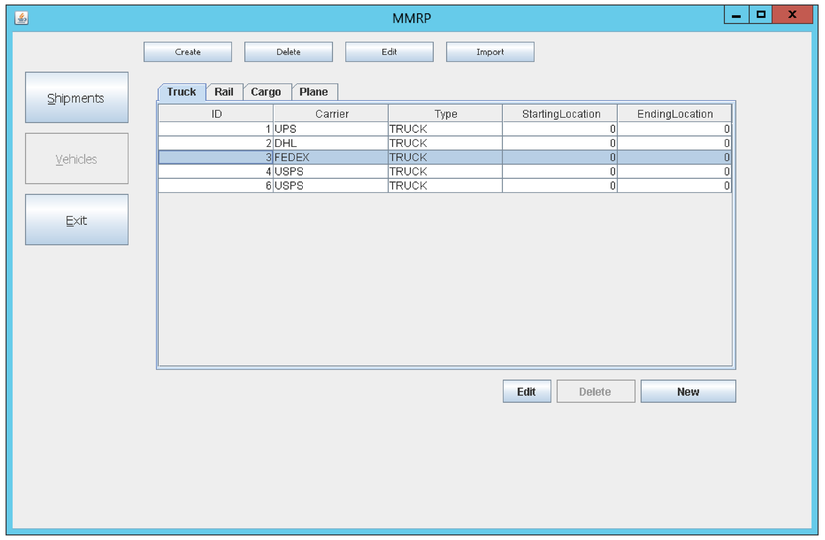
Class Structure

- **Shipment** - All the information about the shipment, including its starting and ending locations, its weight, priority and the time window it must leave its start location and arrive at its destination.
- **Shipment History** - The locations that the shipment has travelled through in the past or will travel through to get from its beginning to its destination.
- **Segments** - A set of a starting and ending location, and a unique vehicle that will travel along that path, along with a cost, travel distance, departure time from the starting location and arrival time at the ending location.
- **Location** - This is a location that acts as a hub for vehicles to travel through.
- **Travel Types** - Planes, Trains, Rails, and Trucks. Each vehicle type has its own set of attributes and restrictions based on the the type of the vehicle.

Class Structure



User Interface



Data Sources

The design choices for the project were based on real world data supplied to us from student conducted research. The rail data is modeled after Norfolk-Southern and FARNAIR for the United Stated and Europe respectively. The other data was created through research into major shipping hubs in the United States and Europe. The idea was to keep the graph size small enough to allow a brute-force approach to be completed for comparison.
The database design has data duplication, however, this was done by design to allow the algorithms fast access to the data needed to find good solutions as quickly as possible.

Future Work

1. Addition of dynamic agents that will break and alter routes in progress to simulate real world changes.
2. Intelligent algorithms including Simulated Annealing and Genetic Algorithms that can work asynchronously and exchange partial solutions.
3. Eanble algorithms to run in parallel with each algorithm using its own thread. From there only the best solution would be taken.

References

- Solomon C, Schiller J. Heuristics for Solving the Multi-Modal Routing Problem. Poster session presented at: Undergraduate Research in Science, Technology, Engineering, and Mathematics . 1st Annual Conference of the Pennsylvania State System of Higher Education; 2013 November 15-16; Slippery Rock, PA.
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