PROJECT PART 2 REPORT

CAP6685

ROHINI KAR
UFID – 67308301
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Semester Project Report

PROJECT DESCRIPTION/GOAL – The project required us to design a program to help schedule package pickups and delivery across Florida for a company of Orlando, Florida called Packages-Are-Us Delivery Service. The forward reasoning inference engine provided by the CLIPS Expert System Shell have been used for this project. The project was divided into two parts:

First Part – In the first part of the project, we were provided with a map of the cities in Florida along with the distances between them and a dataset consisting of 6 trucks and 20 packages that were to be delivered by the trucks. All the trucks started from Orlando and carried only one package at a time. Whenever a package arrived at a particular city, a truck sitting at Orlando will start from Orlando to pick it up. Once picked up, the truck travels to the destination city of the package and after delivering the package, has to return back to its base i.e. Orlando. All the travelling of the truck, from Orlando to depart city of package, depart city to destination city of package and destination city to Orlando has to be covered by the shortest path.

Second Part – In the second part of the project, we were provided with the same map of cities and three datasets, first one consisting of 6 trucks and 30 packages, second one with 10 trucks and 50 packages and the last one with 7 trucks and 50 packages to be delivered. In this part, the trucks were allowed to carry multiple packages and there was no restriction on the part of pick-up and delivery of packages by trucks. The trucks were also neither required to start from Orlando, nor were they required to return back to Orlando after delivering packages.

DESIGN – The design strategy used for the two parts of the project are given in detail below:

First Part – The first part was designed according to the specifications given: the trucks all started from Orlando, went to pick-up a package on arrival and travelled from arrival city of package to destination city of package. After delivery, each truck returned back to Orlando and each of these traversals were made using the shortest path. Each truck can carry a single package at a time. Set of rules were created to find the shortest path and another set of rules to increment the clock time. An event-time was associated with each package and truck, which denoted the next time instant when that particular package or truck will perform an event. The clock was incremented to the next lowest event-time of a truck or package. Whenever a package arrived, a truck (if available at Orlando) was checked if its available space was greater than or equal to the size of the arriving package. If so, the truck was dispatched to pick-up the package by the shortest route available. The truck, after picking up the package, travelled to the destination city, again using the shortest route, and returned back to Orlando after delivery, covering the minimum distance possible. Once all the 20 packages were delivered and all the 6 trucks returned to Orlando, the program terminated with the generation of three reports. One report was

generated for individual trucks indicating the total wait time at Orlando, the total busy time, total time spent travelling to pick-up a package and return back to Orlando(i.e. non-delivery travel time) and actual total time spent in travelling from arrival city of package to its destination for delivery. Similar report was generated for individual packages indicating its pick-up time by a truck, its delivery time, whether it was delivered on-time or late and the total time it had to wait before a truck arrived to pick it up. A third report was also generated to show the number of packages delivered on time, number of packages delivered late, average wait time for packages and average lateness for all packages and also for late packages.

Second Part – In the second part, the trucks were spread out in different locations in the graph in the beginning.

Whenever a new package arrives, it is checked if an empty truck, with available capacity greater than or equal to the size of the arriving package, is available at its arrival city. This case can happen if a truck had previously delivered its last package at the arrival city of the current package and thus is waiting idle in that city after delivery. Two cases are considered here- one where the arrival city of the package is directly linked to the destination city and the other where there are other cities between the two. The truck starts from its current city with the package and travels to the destination city using the shortest route.

A second case may occur where a new package arrives at a city and there is a non-empty truck in that city at that particular instant. If the truck has enough space, then the package is picked up by the truck and the truck continues on its delivery.

A truck delivers packages in FCFS manner i.e. the package picked up by the truck first, will be delivered first at its destination, then the package picked up second and so on.

A third case may occur where a package arrives at a particular city and there is no truck available in that city at that instant. In such a situation, the nearest idle truck with enough space for the arriving package is dispatched for its pick-up. When such an idle truck goes to pick-up the newly arrived package, it travels directly from its current location to the depart city of the package without stopping at any intermediate location, even if a package is available on its way.

A fourth case may arise when a new package arrives and there is neither any truck at its arrival city nor any idle truck with enough space available. In such a situation, the package is inserted into a queue.

A truck while carrying packages, checks at each intermediate city, if there is any package in queue for that city. If there is, and also if the truck has got enough space, it picks up the package and continues towards its original destination.

The trucks, at all points of time, use the shortest route between cities to travel from one place to another and separate cases are considered to address the case when the current location of truck is directly linked to the truck's current destination city and when there are intermediate cities. When all the packages have been delivered, the program stops with generation of three reports as in the first part of the project.

CHANGES MADE SINCE PART 1 – The report generated in the first part of the project has been modified to make it accurate. Some improvements made in the second part since the first part:

- Trucks are not required to return to Orlando after delivery of the packages it is carrying.
- Trucks are positioned at various locations in the map given, at the beginning of the simulation.
- The nearest idle truck with available space was dispatched to pick-up a package without requiring the truck to always travel from Orlando or any specific city.
- A truck, when dispatched to pick up a package, travels directly to the arrival city of the package.
- A truck, while carrying packages to their destinations, checks if any unassigned package is present in any of the intermediate cities. If so, it picks it up.
- The truck delivers packages in the order in which they were picked by it. Otherwise, it can happen that the first package to be picked up by a truck, is delivered last by the truck, much after its expected delivery time whereas later arriving packages are delivered much before their expected delivery time.

RATIONAL FOR THE CHANGES MADE – The goal has been to minimize the average wait time for packages and maximize ON-TIME delivery of packages, and in order to do so, a newly arrived package is either assigned to a truck currently present at its arrival city or else the nearest idle truck is dispatched to pick it up in the minimum time possible (without stopping at any intermediate city).

Trucks are located in different cities in the beginning, which is more optimized than placing all trucks at the same location. This helps in a uniform distribution of trucks so as to maximize efficiency of new arriving package pick-ups.

The packages carried by a truck are delivered in FCFS manner so that maximum number of packages are delivered on time and no package has to wait a large amount of time.

In order to reduce the non-delivery travel time for trucks, they are kept at cities where they have delivered their last package and are not required to travel to Orlando.

IMPROVEMENTS RESULTED (BOTH GOOD AND BAD) –

After executing the first and second parts of the project code on the dataset provided in the beginning of the project, the following results were obtained:

- The "Wait Time" for trucks reduces in the second part.
- The "Non Delivery Travel Time" decreases for the second part, as a result of which, the total busy time and the percentage time busy have also reduced.
- Another improvement that we see in the second part is that while in the first part, only 4 out of 6 trucks were used, in the second part, all the 6 trucks were used to deliver packages and thus uniformity of usage was obtained without overburdening any particular truck.
- Slight improvement in "Total Wait Time" and "Pick Up Time" for packages were also observed.
- The "AVERAGE WAIT TIME FOR PACKAGES" has also reduced from 3.15 to 2.85.
- There has been several cases in which an ON-TIME delivery is not possible. This is because the shortest distance between two cities will make the package reach its destination late.

However, no improvement was seen in the number of packages delivered late from the first part of the project.

These can be verified from the dribble files submitted with the code for the second part.

IF GIVEN A CHANCE TO START OVER – Given a chance to start over again, I would try to design the entire flow and knowledge base in a more structured and organized manner. Also, I would like to improve the logic of the code so as to have a more efficient scheduling of pickups and deliveries of packages. Some possible improvements in heuristics would be:

Trucks (idle) picking up packages from intermediate cities while on their way to pick a currently arrived new package.

Trucks carrying packages exchange one or more packages, if they meet on their way, in order to improve delivery time of packages.

Note:-The code and datasets to be run have been specified in the README file submitted with the code for the second part of the project.