12th DIMACS Implementation Challenge: SDVRP track

November 21, 2021

1 Introduction

The SDVRP is one of the many challenging variants of the CVRP. As for all tracks of the 12th DIMACS Implementation Challenge, it is expected that participants of the SDVRP track contribute with results, articles and discussions for either exact or heuristic methods. Those potentially rich exchanges will first happen in a free format, as messages in a mail list, significant contributions and decisions being consolidated as posts in the DIMACS page. Then, there will be presentations in the workshop and, finally, submissions to journal special issues. However, this document is about the algorithm evaluation portion of the competition in its narrow sense.

2 Split Delivery Vehicle Routing Problem (SDVRP) Statement

The Split Delivery Vehicle Routing Problem (SDVRP) is a relaxation of the classical Capacitated VRP (CVRP) where each customer can be served by more than one vehicle.

Input for SDVRP consists of locations for the depot and the set of n customers $\{1, \ldots, n\}$ and a fleet of M vehicles $\{1, \ldots, M\}$. The depot is located at node 0. Each vehicle has capacity Q. Each customer i is associated with a demand q_i. Each customer can be served by one or multiple vehicles, provided that the corresponding demand is fully satisfied. A matrix D specifies the distance (or some other cost) to travel between each pair of nodes. The goal of the SDVRP is to determine the minimum cost set of routes serving all customers and satisfying vehicle capacity.

2.1 Solution cost

All instances are Euclidean, so the node locations provided in the input file correspond to Euclidean coordinates for the nodes. To calculate the transportation cost, we will use a rounded Euclidean distance between consecutive customers

i and j. That is calculated using the following formula to compute d_{ij}, the cost to travel from customer i to customer j.

$$d_{ij} = int((sqrt((x_i - x_j)^2 + (y_i - y_j)^2) + 0.5)$$

where "sqrt" is the square root and "int" is a function truncating to the integer value.

3 Participation

Participation in the competition is open to any person or group. However, it is necessary to perform a registration, informing names and affiliations for each person in the group, choosing a Competitor ID and a Solver Name.

4 Instances

SDVRP instances are provided in zipped directory in the track webpage. All instances are Euclidean.

A description of the instances is provided in the PDF file available in zipped directory.

Competing solvers will be evaluated for their performance on the set of all instances as provided in the website of the track.

5 Input File Format

Each SDVRP instance is given in a separate file whose format is as follows. In the first line there are two parameters:

n Q

where

- n = number of customers;
- Q = capacity of the vehicles.

The second line contains customers demands.

The remaining $n+1$ lines of the file contain the coordinates of the depot location, followed by those of each customer location. (The first pair of coordinates are always those for the depot.)

6 Solution File Format

The solution file name must be of the form "out_INSTANCE.txt", where "INSTANCE" is the name of the instance. For example, the output file associated with the instance "SD1" would be "out_SD1.txt".

The output file should be formatted such that each row in the file corresponds to a route in the solution. Routes should be numbered from 1 to K, where K is the total number of routes in the solution. Since each route begins and ends at the depot, each route provided in the output should begin and end at node 0. The customers on the route should appear in order, each followed by the amount of demand delivered to them on this route in parentheses. The routes should be provided from 1 to K in the first K rows of the file.

The last three rows of the file summarize the solution cost and time by providing:

- Total cost
- Processor as listed in PassMark (see Section 7.1)
- Solution time (wall clock)

The format of the output is as follows:

Route 1: 0 – customer (quantity delivered) – . . . customer (quantity delivered) – 0
Route 2: 0 – customer (quantity delivered) – . . . customer (quantity delivered) – 0
⋮
Route K: 0 – customer (quantity delivered) – . . . customer(quantity delivered) – 0
Total cost
Processor
Solution time

A few points to clarify details about the format:

- Nodes in routes are separated by "blank_space – blank_space"
- The quantity delivered to each customer is reported after the customer node identifier this way: "customer_node blank_space left_parenthesis blank_space quantity blank_space right_parenthesis".
- The following is an example of example of a route that delivers 10 units to node 2 and 15 units to node 5:

  0 – 2 (10) – 5 (15) – 0

Output files will be read and processed automatically. Therefore, **files that do not comply with the format described above will be discarded**.

7 Algorithm evaluation

The Implementation Challenge will recognize solvers in a variety of ways. Some recognitions will be across all variants, while others will be within a single variant. The full VRP Implementation Challenge committee will review all entries with respect to cross-cutting recognition categories, such as novelty of the approach taken and simplicity and versatility of a solver to work well on multiple different variants. We hope to recognize multiple entries for these attributes. Additionally, each variant will hold its own competition in which entries are scored based on a set of quantitative measures to produce a ranking that does not depend on the subjective assessments of the committee. A set of top-scoring entries will be invited to present at the workshop, provided that they conform to the competition rules and document their approach and results in a suitable extended abstract.

This section describes the quantitative algorithm evaluation for the SDVRP portion of the Challenge. Stated briefly, a solver will be assessed based on the quality of the solutions obtained within a given amount of time. To mitigate the effect of processor speed, the time limit will be scaled for each individual processor. Details on the solution scoring follow.

7.1 Computational environment

Participants will perform SDVRP algorithm evaluation using their own computers. **Solvers must run on a single thread.** If a solver solves linear relaxations or mixed integer linear programming problems, any commercial solver may be used as long as the commercial solver is run on a single thread.

A time limit will be set for the solution of each instance. That limit will be standardized to take into account different machines and platforms according to the CPU marks provided by PassMark Single Thread Performance[1]. Runs must be performed on a processor listed in PassMark.

Currently, the top single thread CPU mark is 3,730, but the test results are updated daily and change frequently. Mid-range desktop processors have marks around 2,000. For this reason, we will use the mark 2,000 to define our standardized times. This means that if a run is performed on a processor (say AMD Ryzen Threadripper 2920X) that has mark 2,500, the time allowed will be scaled by 0.8, allowing less time than on a "Standard Processor".

7.2 Time limit

The time limit for each instance is to be 30 minutes on a processor with a CPU mark of 2,000.

If we let C denote the CPU mark for a given computer, the scaling factor associated with that computer is S, where $S = 2,000/C$. The time limit allowed for each instance is $S \times 30$ minutes. Thus, faster CPUs are afforded less time and slower ones more time.

[1] `https://www.cpubenchmark.net/singleThread.html`

This time limit ($S \times 30$ minutes) must be set for each instance. **All times are wall clock time**. It is up to the competitor to perform runs on a machine that is not heavily loaded.

8 Scoring solver performance

Let BKS be the value of the best known solution for a given instance and v be the solution found by the solver when the time limit was reached. The solver's score on that instance is calculated as:

$$SCORE = 100 \times \left(\frac{v}{BKS} - 1 \right). \quad (1)$$

A threshold of $1.1 \times BKS$ will be set on solution values v. Solution values exceeding this threshold will be set to $1.1 \times BKS$. The same value will be attributed to infeasible solutions or failure to provide a solution. In all of these cases, the corresponding score will be 10, which is the worst possible score.

If the solver finds a solution that is better than the best known solution, it is possible achieve a negative score.

The scores of individual instances are then converted into points: for each instance tested, all competing solvers are ranked according to their individual score. The best-scoring solver gets 10 points, the second 8, then 6, 5, 4, 3, 2, 1. Solvers that are not among the top 6 do not receive any points for that instance. In case of ties, the points at play are evenly split among the solvers involved. For example, if two solvers are tied in the first position, each solver will receive $(10 + 8)/2 = 9$ points; if three solvers are tied in seventh place, each solver will receive $(2 + 1 + 0)/3 = 1$ point.

The total points for a solver is the sum of its points over all test instances. The competitor rankings will be based on total points, ties being broken by the average SCORE over all test instances.

The top THREE competing solvers will be tentatively designated as the SD-VRP "finalists."

9 Article Submission and Invitations to Present at the Workshop

All competing teams should submit a short article describing their solver and results. These articles may be heavily based on work that is published elsewhere as long as this is clearly indicated.

Articles are limited to six pages, not counting possible appendices with detailed tables of results. An optional template will be available for download from the Implementation Challenge website.

The submitted articles will help the committee select which teams will be invited to present at the workshop (though we hope all competitors will be able to attend). Final versions of the articles will also be posted to the workshop

website to share information among participants and with the community more broadly.

There are two pathways to being invited to present at the workshop:

- The tentative Finalists will be automatically invited to present, *provided that the article submitted adequately describes the methods used by their solver*. (Failure to submit an adequate description will forfeit the finalist designation and associated invitation to present at the workshop.)
- Additional competitors will also invited to present at the workshop. Selection will be based on algorithmic performance, as well as potentially broader criteria such as originality, strong performance on multiple variants, simplicity of approach, clarity of exposition, etc. (In addition to the finalists for each variant, we expect to select 10-15 additional papers across all variants for presentation.)

Solvers competing in multiple variants may choose to submit only one article. With permission from the Challenge committee, such articles may be slightly longer.

10 Journal Submissions

Competitors are encouraged to submit a full article to one the journal special issues associated with the Implementation Challenge. Such articles should be of substantially new content and not published elsewhere. All submissions will be subject to the journal's usual review process and must meet its standards for publication through this process. There is no guarantee that submitted articles will be accepted for publication.

11 SDVRP Competition Schedule

The SDVRP competition is officially underway. The relevant dates for the SDVRP competition are:

May 10 – Release of the initial version of the SDVRP competition rules.

December 1, 2021 – Release of the final version of the SDVRP competition rules. (Only very minor changes are expected afterward).

December 8, 2021 – Deadline for competitors to register for the competition.

December 15, 2021 – Official list of competitors posted.

January 16, 2022 – Deadline for competitors to send all output files.

January 23, 2022 – Competition results are posted.

February 1, 2022 – Deadline for competitors to send documents in article format.

February 15, 2022 – Invitations to present at the workshop are sent.

March 15, 2022 – Deadline for competitors to submit the final versions of articles to post.

April 6-8, 2022 – 12th DIMACS Challenge Workshop.