

**Vehicle Routing Problem
Software**

Users' Manual

**Universitat Pompeu Fabra
2013**

Quick Guide

1. C&W Algorithm with Google Maps

- Choose a .txt file from your computer
- Read .txt file
- Send to C&W
- Wait for the distance matrix to be completed
- Clarke and Wright button
- Plot Clarke & Wright
- Export to file

2. Create a locations dataset

- Add each location: Name, Address, Demand
- The demand for home is the load capacity
- Send to C&W
- Follow the explained in 1

3. Calculate distances and time matrix

- Choose a .txt file from your computer (*seleccionar archivo*)
- Read .txt file
- Start distances calculation
- Save to file

4. Check solutions

- Download the excel template file
- Complete the information required and export the file in xml
- Choose the xml file from your computer (*seleccionar archivo*)
- Read
- Validation

5. Step by step C&W algorithm

- Select the number of customers (nodes)
- Write the demand of each client
- Write the cost (distance) between the depot and the client
- State the maximum load capacity
- Compute the cost (distance) matrix
- Compute the savings matrix
- Solve the problem (C&W)

Introduction

The vehicle routing problem, so on refer as VRP, is a typical problem in logistics and supply chain management but yet one of the most challenging. It basically consists on creating efficient routes - i.e. the ones that save more time or costs- for a fleet of vehicles using a heuristics approach.

The classical example is given by a manager that wants to design the routes for its fleet of trucks in order to serve all clients- therefore, meeting all the demand- in the minimum time or lowest cost but taking into account two restrictions: (1) truck capacities and that the route should (2) start and end in the warehouse, also known as depot spot.

The software developed by the CQUID is an educational tool aimed to help students in solving this type of problem in an easy, quick and visual way. It provides learners the opportunity to efficiently deal with real-life problems. It is based on the Clarke and Wright algorithm and thanks to its integration with Google Maps it is easier to see – using common sense- how the routes are planned and designed.

Based on the input data –location of the warehouse and delivery destinations, demands, and truck capacity- the software is able to find in a few minutes the savings matrix and the optimal delivery route. There are several ways to upload the information. We are going to explain all the functions in the following sections.

0. Getting started

The software is designed with an academic purpose. This is why in the home page you can find six boxes that are links to different ways of using the algorithm. Our intention is to provide the student with as many tools as possible to understand the Clarke & Wright procedure and at the same time to help the professor correcting the exercises done in class.



**Universitat
Pompeu Fabra
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Vehicle Routing Problem
Business Analytics Research Group

1 C&W Algorithm with Google Maps

(With previously generated data.)

Upload your previously generated locations set

2 Create a locations dataset

You will be able to save your set for future use.

Geolocate your locations and process the dataset with C&W.

3 Templates and user manual

Descriptions of every input and output method.

Examples and explanation on the use of the application

4 Calculate distances and time matrix

Listing and Matrix file outputs available.

Geocode and distances/time from a node set

5 Check solutions

You must already be familiar with the application.

Correct previous generated route sets

6 Step by step C&W algorithm

Solve a Clark and Wright algorithm from the first stage to a feasible routes set.

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Now we are going to explain in more detail how each box works. In order to show it we are going to go through this small example with 8 nodes.

Abaco's is an important stationary shop in Spain and it provides books and other goods to Universitat Pompeu Fabra (UPF). Due to the recession all the firms in the market are competing on prices. **Abaco's** cannot lower further its prices unless they reduce costs. In order to do so, the manager is wondering if the routes the trucks follow when delivering the merchandise can be improved. In the following table you have a list of the addresses of each UPF center, its demand and the address of **Abaco's** warehouse. Each truck has a maximum capacity of 50 boxes. Which are the optimal routes?

ADDRESS		La Rambla, 30-32	10
Passeig Fabra i Puig, 196	0	Plaça de la Mercè, 10-12	10
Roc Boronat, 138	40	Passeig de Circumval·lació, 8	20
Balmes, 132	15	Ramon Trias Fargas, 25-27	50
Passeig Pujades, 1	10	Doctor Aiguader, 80	30

1. C&W Algorithm with Google Maps

This is the easiest and fastest way to use the software. What you first need to do is to upload a .txt file with all the data. Those files should contain the destinations (addresses) and the corresponding daily demands of every client specified in the following way: direction; "demand". Notice that the first entry is always the depot and therefore, its demand, will be the load capacity of the trucks.

E.g.: Ramon Trias Fargas, 25-27, 08005 Barcelona, Spain; "50"

The system reads your file and with the help of Google Maps it locates all the destinations in the space. If everything is correct the locations will appear on the right-hand side of the screen. It is advisable to check whether the addresses that appear match the original ones.

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Upload a locations set:
Seleccionar archivo
Read txt File
Done.

Upload the file (txt)

Mapa Satélite

Santa Coloma de Gramenet

0 Passeig Fabra i Puig, 190, 08016 Barcelona
1 Roc Boronat, 138, 08018 Barcelona
2 Balmes, 134, 08008 Barcelona
3 Passeig Pujades, 1, 08003 Barcelona
4 La Rambla, 30, 08002 Barcelona
5 Plaça de la Mercè, 10-12, 08002 Barcelona
6 Passeig de Circumval·lació, 8, 08003 Barcelona
7 Ramon Trias Fargas, 25-27, 08005 Barcelona, España
8 Doctor Aiguader, 80, 08003 Barcelona

Send to CW

Move to the next screen

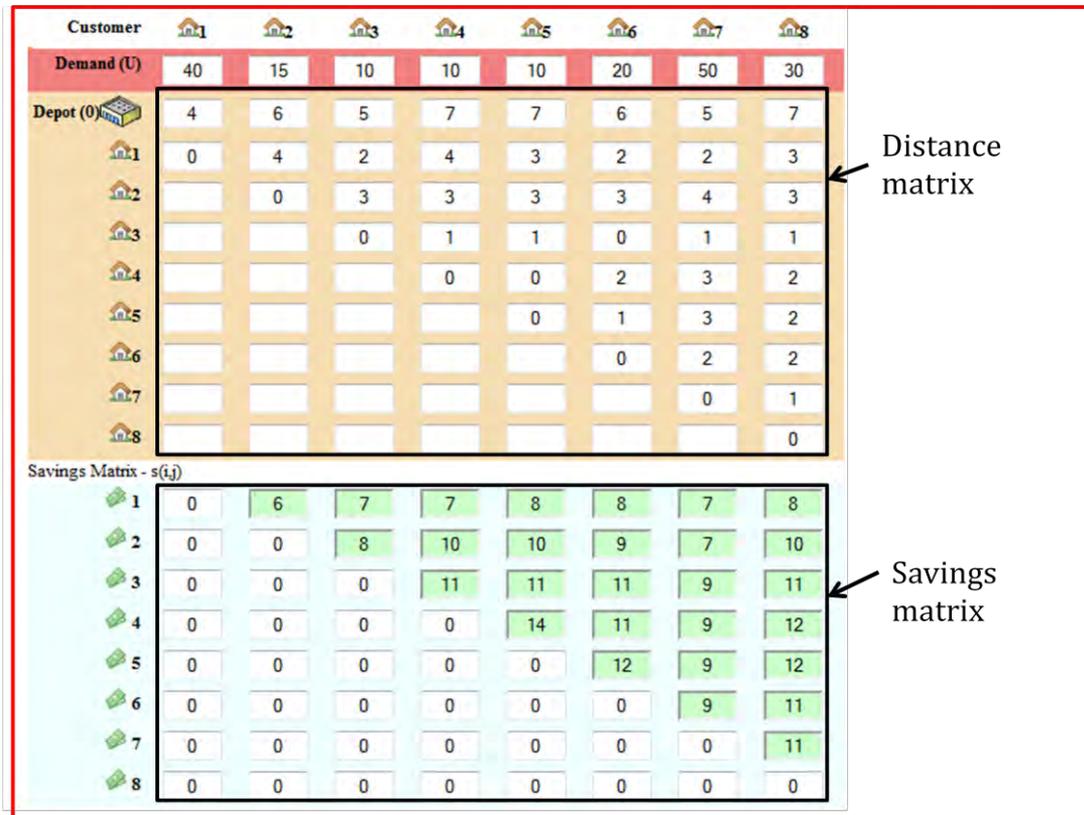
Addresses appear in the list and in the map

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Now that we have the locations we are going to proceed to use the C&W algorithm. By clicking on the button SEND TO CW we move to the following screen, where we are going to solve the problem.

At this point, you can change the capacity of a truck (top-left). Notice that it should be specified in the same units as the demand. Right after this you can see the distance matrix (automatically computed by the algorithm).



Afterwards, you solve the optimization problem by clicking CLARKE & WRIGHT and using the algorithm¹ it calculates the optimal routes and savings matrix automatically.

Once the problem is solved the results obtained are the following:

- Demand (U) matrix: input demands.
- Distance Matrix: displays the distance between the depot and each client location.
- Savings Matrix: displays the savings obtained by the designed route.
- Route, assignation and visit order matrix: displays the assignation of the trucks through the different locations. This means, the destinations at which every truck has to deliver and in which order. Notice that the user can modify this matrix.
- U Matrix: displays the total loads of each truck after the assignation.
- Costs Matrix: displays the total distance covered by each truck, which can help the user to calculate the transport costs.

¹ Algorithm implemented by Francesc Roig.

Route assignments and visit order

	1	2	3	4	5	6	7	8
1	1	-	-	-	-	-	-	-
2	-	3	-	-	-	-	-	-
3	-	1	-	-	-	-	-	-
4	-	-	2	-	-	-	-	-
5	-	-	3	-	-	-	-	-
6	-	2	-	-	-	-	-	-
7	-	-	-	1	-	-	-	-
8	-	-	1	-	-	-	-	-

Route assignment

(U)	40	45	50	50	0	0	0	0
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U-Matrix

Cost	8	14	16	10	0	0	0	0
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Cost Matrix

Cost total: 48

The PLOT CLARKE & WRIGHT ROUTES button displays the route of each truck in the map. It is important to notice that it displays the Route Assignment Matrix, which means that if you change the assignment manually the plot will be modified. Finally, you can also export all these results in a .txt file by clicking the EXPORT button (top-left).



2. Create a locations dataset

The problem resolution works the same way as in the previous box, but the different feature here is the data input. Now instead of uploading the whole txt matrix with all the information you can write down each address one by one in the right-hand side.

The screenshot shows the 'Vehicle Routing Problem' web application. On the left, there is a form titled 'Add a Point to the Map' with the following fields and values:

Field	Value
Location Name	3
Address	Passeig Pujades, 1.080
Demand	10

Below the form are buttons for 'Add Point' and 'Send to CW'. The central part of the interface is a map of Barcelona with several points marked. On the right, there is a table with the following data:

Point Name	Demand
Home	null
1	null
2	null

At the top right, there are buttons for 'Export', 'Clear map', and 'Help'.

Once you have typed all the points and the correspondent demands you should click on SEND TO CW and proceed to solve the problem- as explained in point 1. Remember that the first location you add is the depot point and its demand should be the load capacity of trucks.

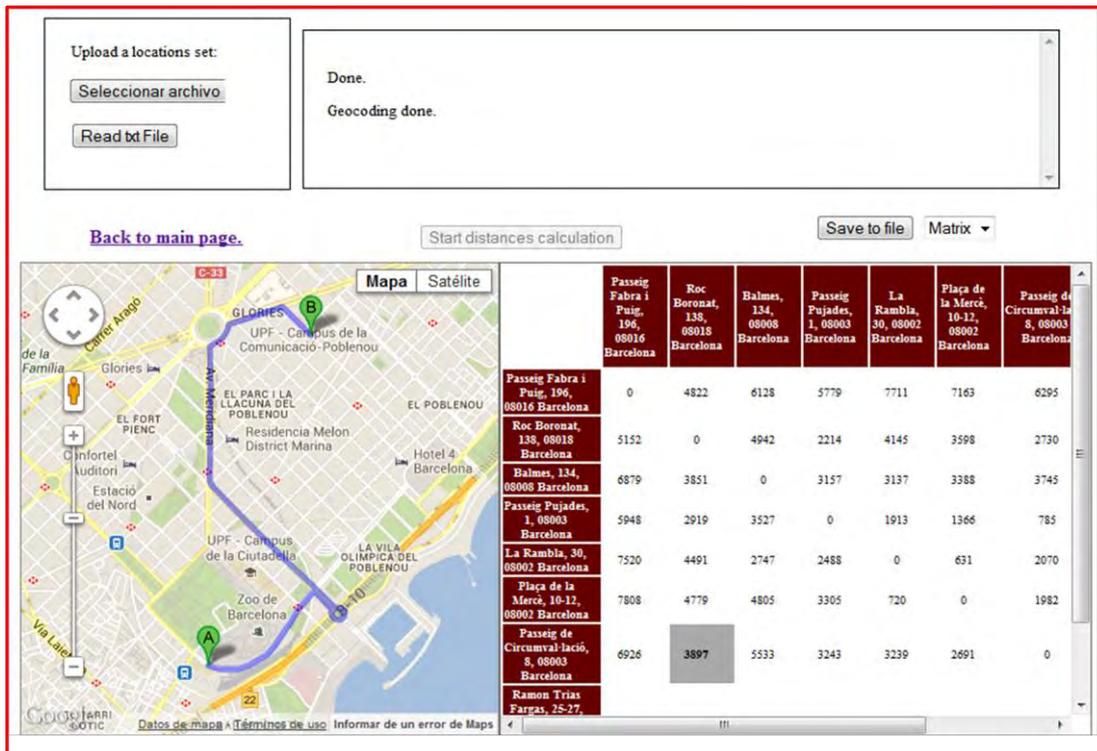
3. Templates User and Manual

The aim of this section is to provide a proper and complete understanding of the resource to the user. Here you can find (and download) the users' manual as well as a detailed description (with downloadable examples) of how the data should be introduced in the txt file.

4. Calculate distances and time matrix

By uploading a .txt file with the addresses of each point, the software, using Google Maps, will compute the distance matrix between all the locations in the data set. You can see the results in a matrix and in a list form.

This is useful, for instance, when professors want to give a real example to their students but with the distance matrix already computed.



The screenshot displays a web application interface for calculating distance matrices. On the left, there is a map of Barcelona with a blue route highlighted between points A, B, and C. The map includes labels for various locations such as 'UPF - Campus de la Ciutatella', 'Zoo de Barcelona', and 'LA VILA OLÍMPICA DEL POBLENOU'. On the right, there is a table showing the distance matrix between seven locations. The table has a dark red header and a white body. The locations listed in the header are: Passeig Fabra i Puig, 196, 08016 Barcelona; Roc Boronat, 135, 08015 Barcelona; Balmes, 134, 08008 Barcelona; Passeig Fajades, 1, 08003 Barcelona; La Rambla, 30, 08002 Barcelona; Plaça de la Mercè, 10-12, 08002 Barcelona; and Passeig de Circumval·lació, 8, 08003 Barcelona. The table shows distances between these locations, with the diagonal elements being 0. The value 3897 is highlighted in a grey box in the cell corresponding to the distance between 'Passeig de Circumval·lació, 8, 08003 Barcelona' and 'Roc Boronat, 135, 08015 Barcelona'.

	Passeig Fabra i Puig, 196, 08016 Barcelona	Roc Boronat, 135, 08015 Barcelona	Balmes, 134, 08008 Barcelona	Passeig Fajades, 1, 08003 Barcelona	La Rambla, 30, 08002 Barcelona	Plaça de la Mercè, 10-12, 08002 Barcelona	Passeig de Circumval·lació, 8, 08003 Barcelona
Passeig Fabra i Puig, 196, 08016 Barcelona	0	4822	6128	5779	7711	7163	6295
Roc Boronat, 135, 08015 Barcelona	5152	0	4942	2214	4145	3598	2730
Balmes, 134, 08008 Barcelona	6879	3851	0	3157	3137	3388	3745
Passeig Fajades, 1, 08003 Barcelona	5948	2919	3527	0	1913	1366	785
La Rambla, 30, 08002 Barcelona	7520	4491	2747	2488	0	631	2070
Plaça de la Mercè, 10-12, 08002 Barcelona	7808	4779	4805	3305	720	0	1982
Passeig de Circumval·lació, 8, 08003 Barcelona	6926	3897	5533	3243	3239	2691	0
Ramon Trias Fargas, 25-27, 08003 Barcelona							

5. Check solutions

This tool is designed for teachers. Once the students have computed their results, how can we know if the proposed route is correct? Here you can upload the file with the input data computed by students and also the possible solution routes. The algorithm will compute the feasibility of the solutions and the costs of it.

First, if you have not done it yet, you should go to HELP and download the template generator. It is an excel file where students should write down their solutions. Once you have all the files with the solutions you upload it to the web (*seleccionar archivo*) and read the file.

The excel file has four sheets: location, supply cost, savings and routes. The first page is a geo-location of all the demand nodes and the depot spot. In the last column you should write the demand. Take into account that in the demand for the depot you should write down the load capacity of the truck.

The second sheet contains the distance matrix (distances between all the spots). In the third page we can find the savings matrix, each cell should contain a "0". Finally, in the last page you can write the routes that the student purposes. Once you have written down the routes, you should go to the first sheet and click on export and save it as XML (Route checker).

Now you have created the file that you want to check. The next step is to upload it and go to validation.



The last screen, validation, shows whether each route is feasible or not and the cost of each route as well as the total cost.

Since this tool completely solves the problem (it says whether the solution is fine or not) the students will not have access to it while they are studying.

6. Step by step C&W algorithm

This is a link to the first version of the algorithm. It uses a more basic approach, and you need to type all the data manually. It is useful for students when they want to practise before the exam because they need to do all the calculations. The algorithm just corrects the exercise. It helps to understand how the Clarke & Wright algorithm works.

7. Some extra practice: Shopping Centres

The owner of a known clothing store in Barcelona, **Julia Co**, has shops in 20 different shopping centers in Barcelona and its surroundings. Part of the merchandise needs to be replaced every day, so several trucks deliver the goods on a daily basis.

The logistics planner would like to minimize the transportation cost. He has asked to his new assistant which routes the vehicles should implement in order to minimize distances, taking into account that they should always start and finish its route in the depot place and that the maximum load is 100 boxes.

In the following table you can see the addresses of the different shopping centers and the warehouse, as well as each demand. Can you help the assistant?

SHOPPING CENTER	ADDRESS	DEMAND
Warehouse	Avinguda Parc Logistic, 2-10, Barcelona.	Depot
CC Arenas de Bcn	Gran Via de les Corts Catalanes, 373, Barcelona.	20
Bulevard Rosa	Passeig de Gràcia, 53, Barcelona.	14
CC Diagonal Mar	Avinguda Diagonal, 3, Barcelona.	60
CC El Triangle	Plaça de Catalunya, 4, Barcelona.	10
Maremagnum	Moll d'Espanya, 5, Barcelona.	15
CC La Maquinista	Carrer Potosí, 2, Barcelona.	50
CC Gran Vía 2	Avinguda de la Granvia de l'Hospitalet, L'hospitalet.	60
CC L'illa Diagonal	Avinguda Diagonal, 557, Barcelona.	70
Pedralbes Centre	Avinguda Diagonal, 609, Barcelona.	50
CC Splau!	Avinguda del Baix Llobregat, Cornellà.	30
CC Barnasud	Carrer Progrés, 69, Gavà.	60
CC Glòries	Avinguda Diagonal, 208, Barcelona.	65
CC L'Ànec Blau	Avinguda del Canal Olímpic, 24, Castelldefels.	70
CC La Farga	Avinguda Josep Tarradellas i Joan, 0, L'hospitalet.	40
La Roca Village	La Roca Village, Sant Agnès de Malanyes.	30
CC Parc Vallès	Avinguda Tèxtil, Terrassa.	40
CC Heron City Bcn	Passeig Andreu Nin, Barcelona.	65
Mataró Parc	Carrer Estrasburgo, 5, Mataró.	20
CC Baricentro	Ctra. N-150 Km. 6,7, Barberà del Vallès.	35
Paddock-Bulevard	Avinguda de Francesc Macià, 46, Barcelona.	55