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Dissertation Submitted in partial fulfilment of the requirements for the degree of **Master in Computer Science**  
Option: Decisional Informatics And Optimization

# Development of a tool for optimizing vehicle routing problem (VRP)

Presented Publicly: **24 Jun 2018**. By: **HAMANI Amir**  
To the jury:

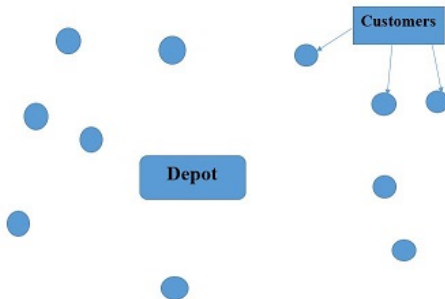
M. BAHACHE.  
B. LOUNNAS.  
M. BOUCETTA.

MAB.  
MCB.  
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University Mohamed Boudiaf of M'sila.  
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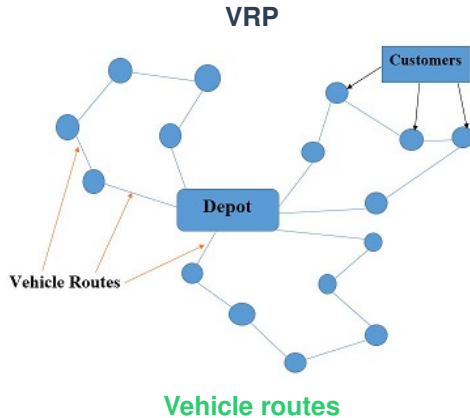
President.  
Reporter.  
Examinator.

## VRP





## Solution



## Solution

**Find best vehicle routes to serve a set of customers.**

**Best routes may be :**

- ▶ Minimum cost
- ▶ Minimum distance
- ▶ Minimum travel time
- ▶ ...

## Summary

### The objective of our work



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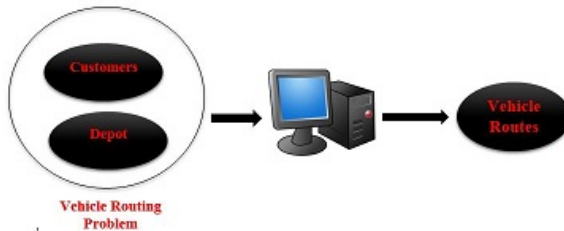
### The objective of our work

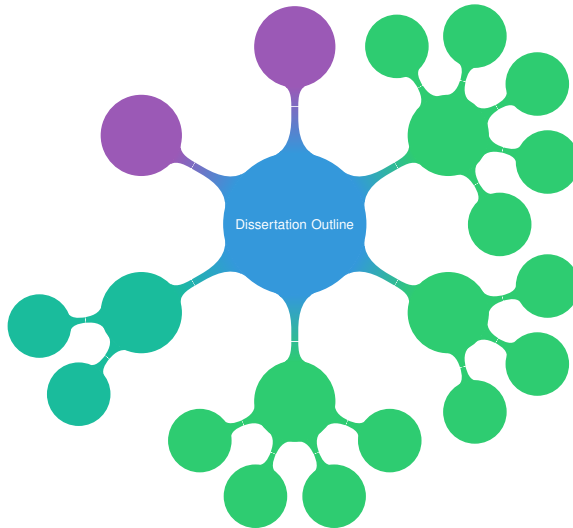


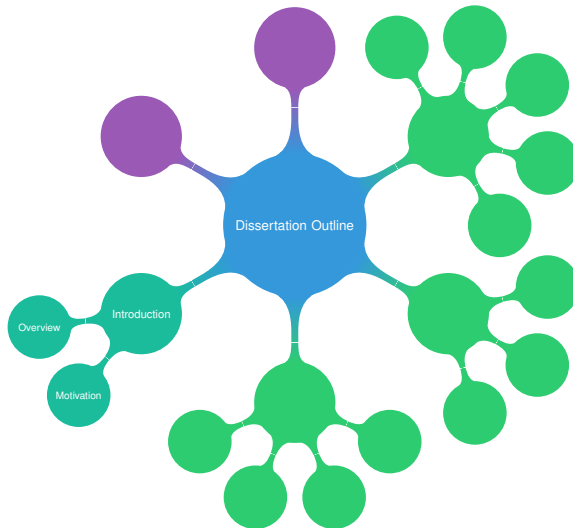


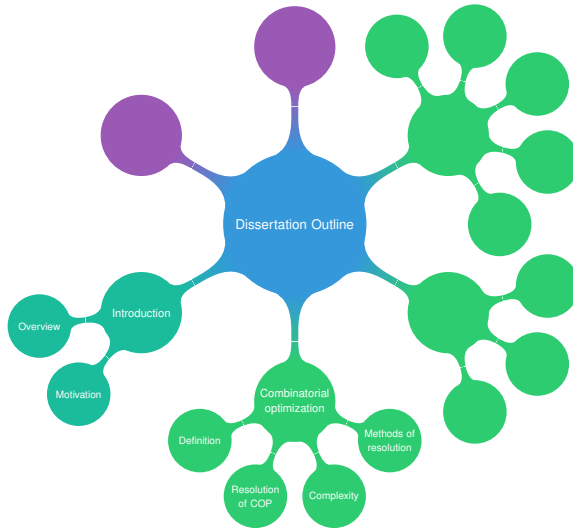
## Summary

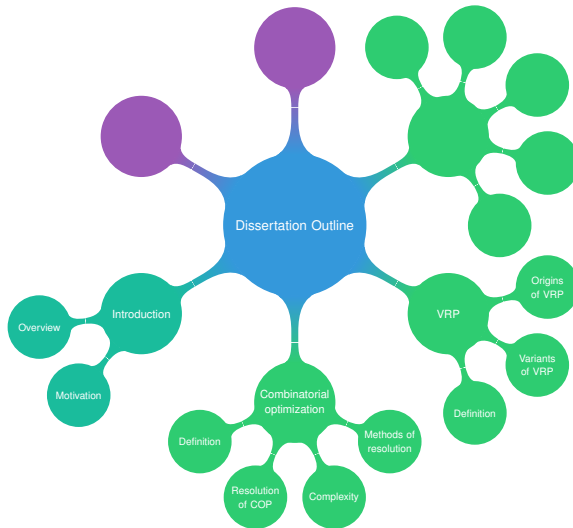
### The objective of our work

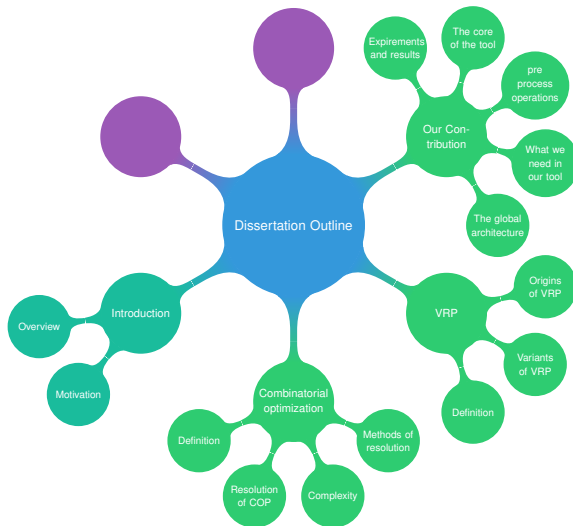


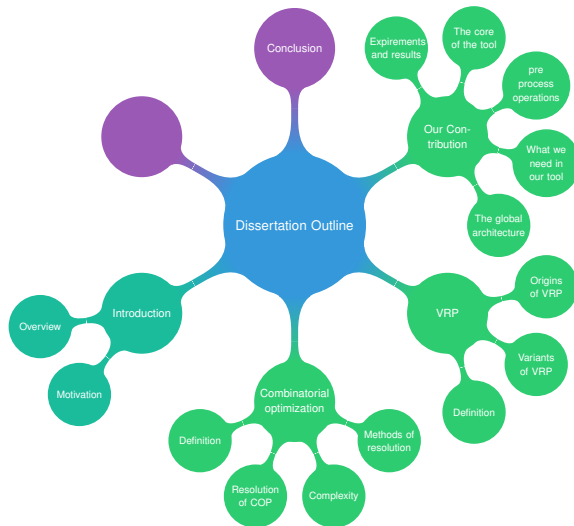
















# Combinatorial Optimization

Combinatorial optimization occupies a very important place in research operational, in discrete mathematics and computer science. Its importance is justified on the one hand by the great difficulty of optimization problems and on the other hand by many practical applications that can be formulated in the form of a combinatorial optimization problem .

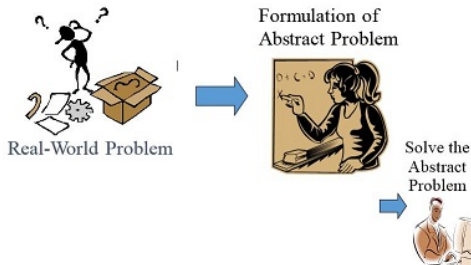
## Overview



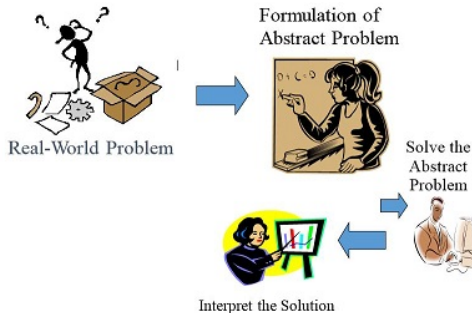
# Real-World Problem

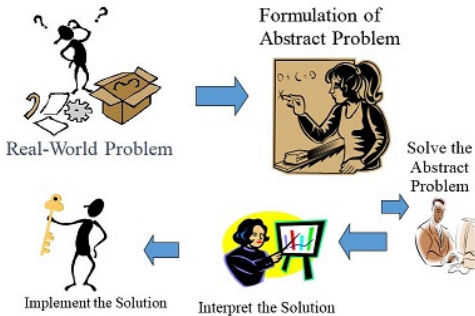


## Overview



## Overview





## Overview

### Vehicle Routing Problem

The vehicle routing problem (VRP) is overwhelmingly described as the problem in which vehicles based on a central depot are required to visit a set of geographically scattered customers in order to fulfill recognized customer demands. The objective is to construct a minimum cost, feasible set of tracks one for each vehicle.

## Motivation

The motivation behind our study of the vehicle routing problem (VRP) came as a result of the multiplying applications in the real world to these problems represent. For this reason, the VRP is a very active field of research and has witnessed an astonishing interaction amidst theory and practice.

### The applications of vrp

- ▶ The VRP is a main link in the field of logistics
- ▶ The VRP is part of our daily life, starting with the newspaper distribution, school bus, etc.
- ▶ ...



## Definition

### Combinatorial Optimization

Combinatorial optimization is to minimize or maximize a function often called cost function, of one or more variables subject to constraints.

## Resolution of a COP

Solving a **COP** requires the study of three points particulars:

- 1-Definition of the set of feasible solutions.
- 2-The expression of the objective to be optimized.
- 3-The choice of the optimization method to use.

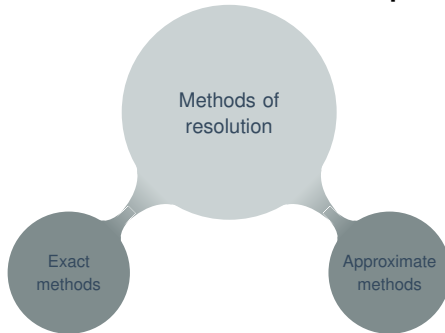
## Complexity

we distinguish essentially four classes of problems:

- ▶ Class P.
- ▶ Class P-Complete.
- ▶ NP Class.
- ▶ NP Hard Class.

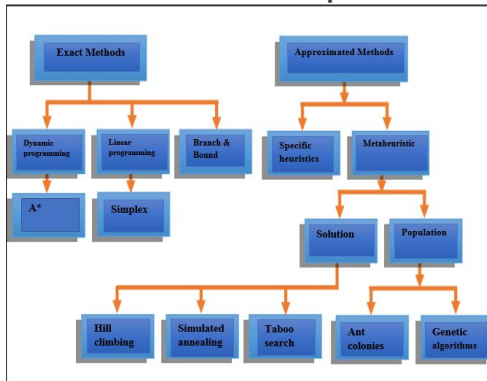
## Methods of resolution

**Optimization methods can be divided into two broad classes of methods for problem solving:**



## Methods of resolution

### Classification of combinatorial optimization methods



## Definition

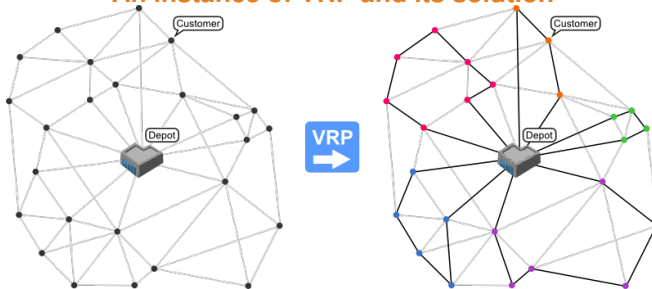
The (VRP) is a set of problems in which set of routes for a fleet of vehicles based at one or several depots are to be formed for servicing the customers dispersed geographically. In the Vehicle Routing Problem (VRP), multiple vehicles leave from a single depot and must return to that location after completing their assigned tours.

### The Objective of VRP

The objective of the VRP is to form a route with lowest cost to serve all customers

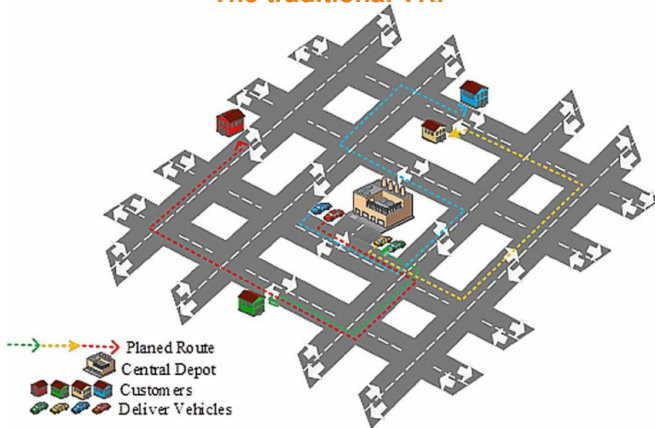
## Definition

### An instance of VRP and its solution



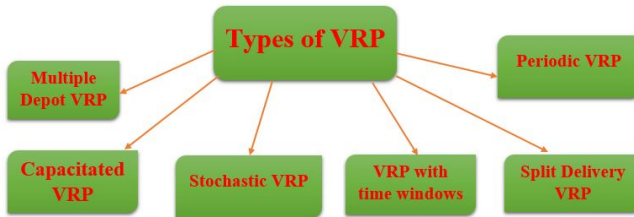
## Definition

### The traditional VRP





## Types of VRP



## Origins of VRP

One of the simplest, but still NP-hard, routing problems is probably the traveling salesman problem (TSP).

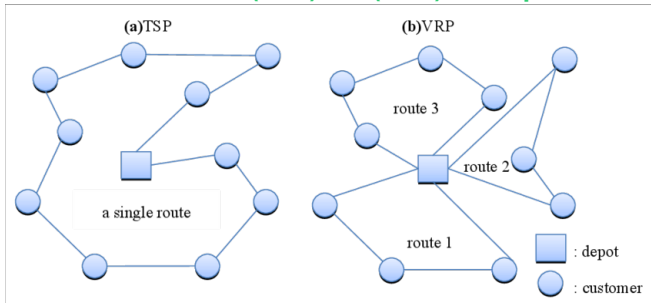
## Definition

### TSP

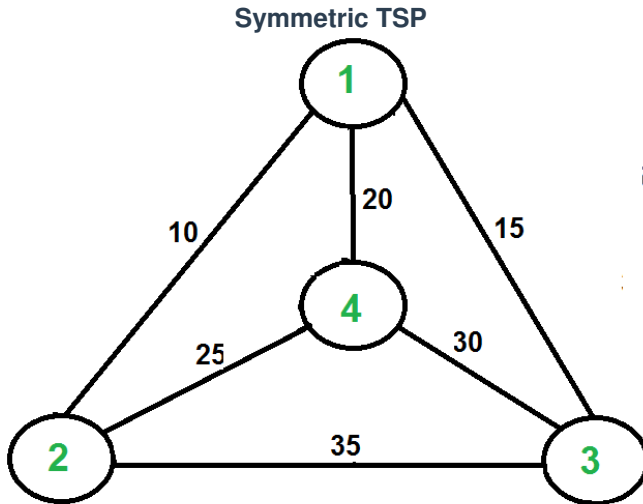
Given a set of cities and the cost of travel (or distance) between each possible pairs, the TSP, is to find the best possible way of visiting all the cities and returning to the starting point that minimize the travel cost.

## Definition

### Illustration of the(TSP) and(VRP) route patterns

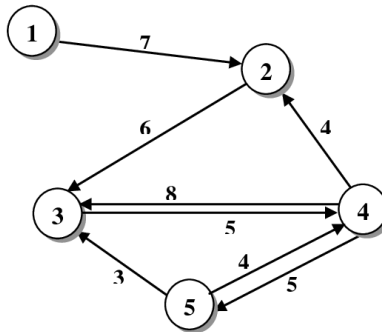


## Classification of TSP

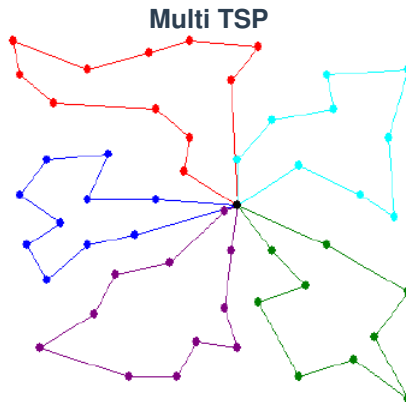


## Classification of TSP

### Asymmetric TSP



## Classification of TSP



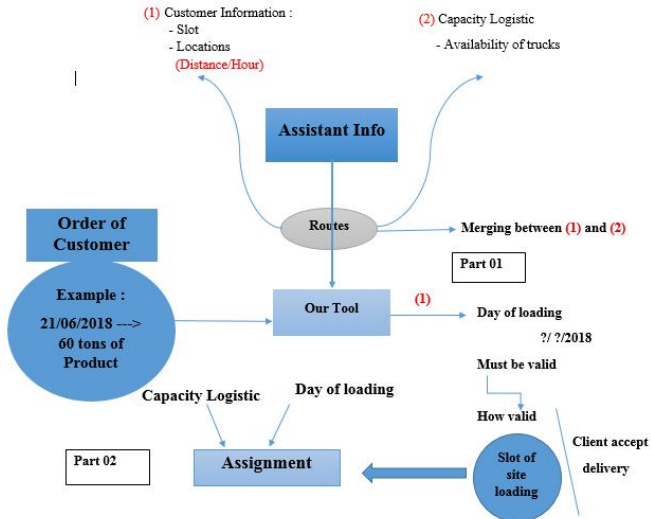
## Global architecture

The architecture of our tool is based of multiple characteristics which are :

- ▶ The main depot of the company
- ▶ Customers
- ▶ Logistics
- ▶ Planning of routes
- ▶ Assignment



## Global architecture



## What we need in our tool

Our model uses the following data that is available as inputs :

**Product** : An article or substance that is manufactured for sale. The unity of measuring of any product it's by kilograms (KG).

## What we need in our tool

**Logistics** : Here we are talking about the availability of the fleet of trucks that serve the customers from one depot.

The most important thing here is that we have (03) different types of trucks that are :

## Types of trucks

- 1- The owned trucks by the company.
- 2- Available trucks or (Rented Trucks).
- 3- Spot trucks .



## What we need in our tool

**Customer** : Every client have characteristics which are the following :

- **Locations** : Every customer have a location and could have a multiple locations , it could be in the same place or a different place from the first location .

Every location of a customer is far from the depot by a distance and time. The unity of measuring the distance is by Kilometres (km) and the unity of measuring the time is by hours .


## Customer

- **Slot (Time Windows)** : A fixed interval of time, where the delivery locations of the customers have time windows within which the deliveries (or visits) must be made.

Every customer have a specific day to serve him, in this specific day the customer have an interval of time , the earliest and the latest times.

## Order of a product

Here we can see the orders of the customers during the whole week



## Préparation planification

Code	Date	Utilisateur	Commentaire			
▼ W 1	18/04/2018 11:01:43					

Détails de planification

Site	Priorité	Emballage	Duré	Samdi	Dimanche	Lundi	Mardi	Mercredi	Jeudi	Vendredi	Samdi	Tot
LCM	0	Mila Sac	0	15	0	0	0	0	15	0	0	30



## Order of a product

### Add Of An Order Of Product

Ajouter une detaille de planning

Information generale

Site:\* LCM

Client:\* 0001 - sofyar

Site de livraison:\* Msila centre

Produits:\* !

Information de quota

Samedi: 0 Dimanche: 0 Lundi: 0

Mardi: 0 Mercredi: 0 Jeudi: 0

Vendredi: 0

Priorité

Priorité calculé: 0 Priorité peut être changée

Autre information

Duré de trajet: 0

Total quota:

Save

## Capacity logistic



In this figure we see the logistic capacity of the company of the whole week

Code	Date	Utilisateur	Commentaire	
W 1	18/04/2018 11:07:43	admin		

Samedi	Dimanche	Lundi	Mardi	Mercredi	Jeudi	Vendredi
--------	----------	-------	-------	----------	-------	----------

Parc	Camion	Attelage	Chauffeur	Status
Park M'sila 1	001005-508-16	00676-807-16	Chauffeur 01	OK
Park M'sila 1	000874-507-16	00443-806-16	Chauffeur	OK
Park M'sila 1	001006-508-16	01260-805-28	Chauffeur	OK
Park M'sila 1	001004-508-16	00675-807-16	Chauffeur	OK
Park M'sila 1	000878-507-16	00671-807-16	Chauffeur	OK
Park M'sila 1	000898-507-16	00549-803-28	Chauffeur	OK
Park M'sila 1	000890-512-16	01255-805-28	Chauffeur	OK
Park M'sila 1	000884-507-16	00436-806-16	Chauffeur	OK
Park M'sila 1	000886-507-16	00684-807-16	Chauffeur	OK
Park M'sila 1	000882-507-16	00679-807-16	Chauffeur	OK

## Capacity logistic

### Add of logistic capacity

Ajouter une capacity de transporteur

Transporteur:\*

Type:\*

Quantité:\*

Tonnage:\*

Save

Transporteur Spot

Transporteur MAD

!

!


!

!

!

## Generation of routes

The generation of roads it is the merging between the order of purchasing and the priority of the customer

 **Routes**

Code	Date	Utilisateur	Commentaire
▼ W 1	11/06/2018 11:24:01		

Détails de route

Priorité	Embalage	Client	Livraison	Produit	Durée	Distance	Samdi	Dima
0	Msila Sac	0001	Msila centre	Pro1	2	2 Km	15	0


## The Core of our tool

In this section we'll describe the two main parts of our algorithm wich are :

- ▶ The day of loading
- ▶ Assignment

## The day of loading

This part consist of knowing the date of loading , and to know the date of loading we need an essential information which is the customer and his informations

 **Plannification de Route**

Code	Date	Utilisateur	Commentaire
▼ W 2	02/01/2017 12:16:44	admin	


Samedi Dimanche Lundi Mardi Mercredi Jeudi Vendredi

**Le : 7/1/2017**

Client	Site de livraison	ProductCement	Qnt	ProductCement	Date Chargement	Slot Chrg	Slot Livr	Duré Mission	Duré Réel	Distance
1296	In alger	Matine	250 Tn	MATI-V	6/1/2017	10:00 - 12:00	08:00 - 10:00	9 H	23 H	263 Km
1296	In Msila	Matine	700 Tn	MATI-V	7/1/2017	08:00 - 10:00	08:00 - 10:00	3 H	3 H	20 Km

## Assignment

This part it's a merging between the day of loading and the logistic capacity.



Les affectations de : W 2

Code

Recherche

	Client	Site de livraison	ProductCement	Qnt	Date Chargement	Slot Chrg	Slot Livr	Duré	Duré	Dista
▶	1296	In alger	MATI-V	250 Tn	6/1/2017	10:00 - 12:00	08:00 - 10:00	9 H	23 H	26 Km
▼	1296	In Msila	MATI-V	700 Tn	7/1/2017	08:00 - 10:00	08:00 - 10:00	3 H	3 H	20 Km

Type	Camion	Attlage	Chauffeur	Tonage	Rotation	Return Duration
Owned	001005-508-16	00676-807-16		45	2	16
Owned	000874-507-16	00443-806-16		45	2	16
Owned	001006-508-16	01260-805-28		45	2	16
Owned	001004-508-16	00675-807-16		45	2	16
Owned	000878-507-16	00671-807-16		45	2	16
Owned	000898-507-16	00549-803-28		45	2	16
Owned	000890-512-16	01255-805-28		45	2	16
Owned	000884-507-16	00436-806-16		45	1	16

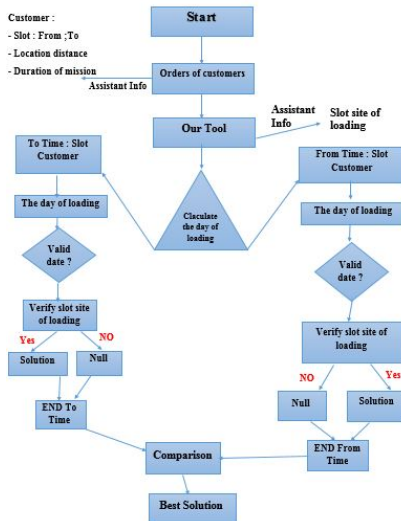
▶	2002	In sidi belaabas	MALAKI-V	40 Tn	7/1/2017	10:00 - 12:00	08:00 - 10:00	10 H	24 H	130 Km
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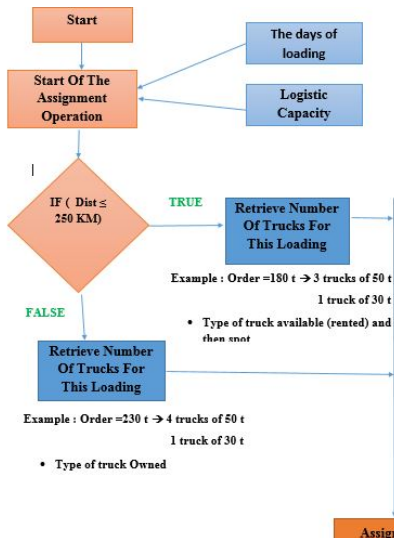
2

## How to calculate the day of loading





## How to assign trucks



## Pseudo algorithm of the day of loading

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### Algorithm 1 : Loading Day

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*Requirement :*

*Start driving , Safety driving, Slot day of loading*

- 1: *Initialization : M settings, Duration of loading, Duration of unloading, Driving from, Driving to*
  - 2: *For all (Slot customer) of selected day*
  - 3: *Time := Select (Slot from)*
  - 4: *Day of loading := 0*
  - 5: *t := Time - Duration of mission*
  - 6: *If t < Start driving from*
  - 7:   *Day of loading ++*
  - 8:   *Do rest := Time - Duration of mission*
  - 9:   *Duration of mission copy := Duration of mission - Do rest*
  - 10: *Day of loading := Day of loading + (Duration of mission copy / Driving day)*
  - 11: *Calculated time := Duration of mission copy % Driving day*
  - 12:   *If Calculated time := 0*
  - 13:   *Day of loading -*
  - 14:   *Slot loading time := Start driving - Calculated time*
  - 15: *Else*
  - 16:   *Slot loading time := Time - Duration of mission*
  - 17:   *Select slot loading := Null*
  - 18: *For all slot loading of day (selected day - loading day)*
  - 19:   *If slot loading time ≥ from And slot loading time ≤ to*
  - 20:   *Select ( slot day of loading)*
-

## Pseudo algorithm of the assignment

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### Algorithm 2 : Assignment

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```

1: Initialization :  $D, W$ 
2: Set  $J := \text{Select}(\text{only owned})$ 
3: For all  $j$  from  $J$ 
4:   If  $D > 250$  assign normally ( $j$ )
5:   If  $W_j < 20$ 
6:     If  $W - w_j * 2 \geq 0$ 
7:       Assign with rotation ( $2, j$ )
8:        $W_{res} := W_{res} - (W_j * 2)$ 
9:   Else
10:    If  $W_{res} - w_j \geq 0$ 
11:      Assign with rotation ( $2, j$ )
12:       $W_{res} := W_{res} - w_j$ 
13:   Else
14:     If  $w_j \geq 75\%$ 
15:       Last assign rotation ( $2, j$ )
16:   Else generation shit
17:     If  $w_j := 0$ 
18:       Break

```

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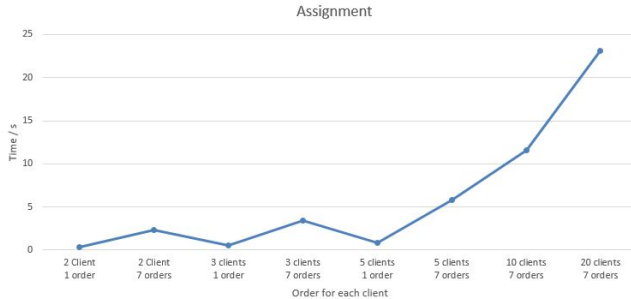
## Experiments and results

In this section a collection of experiments and results are provided. Our experiments was tested on a 1.70 GHz i3 laptop Pc with 4 GB RAM. This machine are running Microsoft Windows 7 operating system. The results obtained from 8 experiments are summarized in the following charts. Our experiments are divided into two parts the planning of routes and assignment.

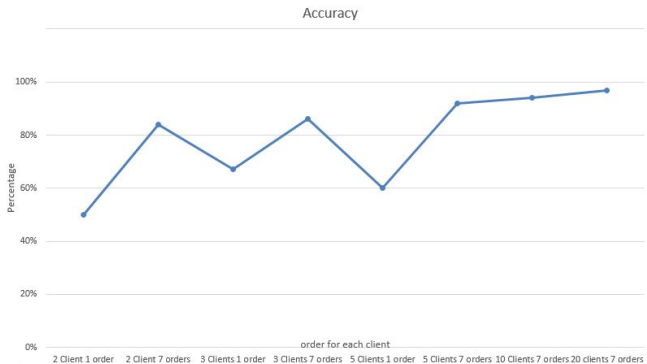
## Chart of planning routes



## Chart of assignment



## Chart of accuracy



## Weakness points

Our tool have a weakness points which is the following :

- The first weakness it's that our tool when it comes to the part of planning of routes to generate the day of loading, it only calculate on the edges of the slot (time windows) of the client. So the weakness here it's when the calculating of the day of the loading starts From time to time, we can fall into a trap of not finding a solution on the edges of the slot. Our tool doesnt look in the middle of the interval which is a weakness, because we can found a solution in the middle of the interval.



## Weakness points

- ▶ Another weakness which is in a specific slot of day of loading we have a specific amount of product in the site of loading. If we can find a solution of the day of the loading we need to check to and verify the the amount of product in the site of loading in that specific slot. If the tonnage in the order of the client surpass the tonnage of product in the site of loading we cannot fulfil the demand of the customer, so here it's a diffucilty for us.

## Conclusion

### Conclusion

Vehicle Routing Problem (VRP) was defined as determining the appropriate delivery routes for a series of given customers , so that the vehicles can depart from the distribution center and return to the original center after servicing all customers, with certain constraints (such as vehicle capacity, customer demand, time window, etc.), in order to achieve certain goals (shortest distance, least cost, etc.).

### Experimental results

- ▶ Average accuracy : 79%
- ▶ Average runtime of planning of routes : 9 S
- ▶ Average runtime of assignment : 6 S

## Future works

By the application of the genetic algorithms we assume that we can change our tool to the best, by finding the best possible solution.

By apply the GA we can search for the solution in the middle of the interval. This is our main objective in the near future.

THANK YOU FOR YOUR ATTENTION