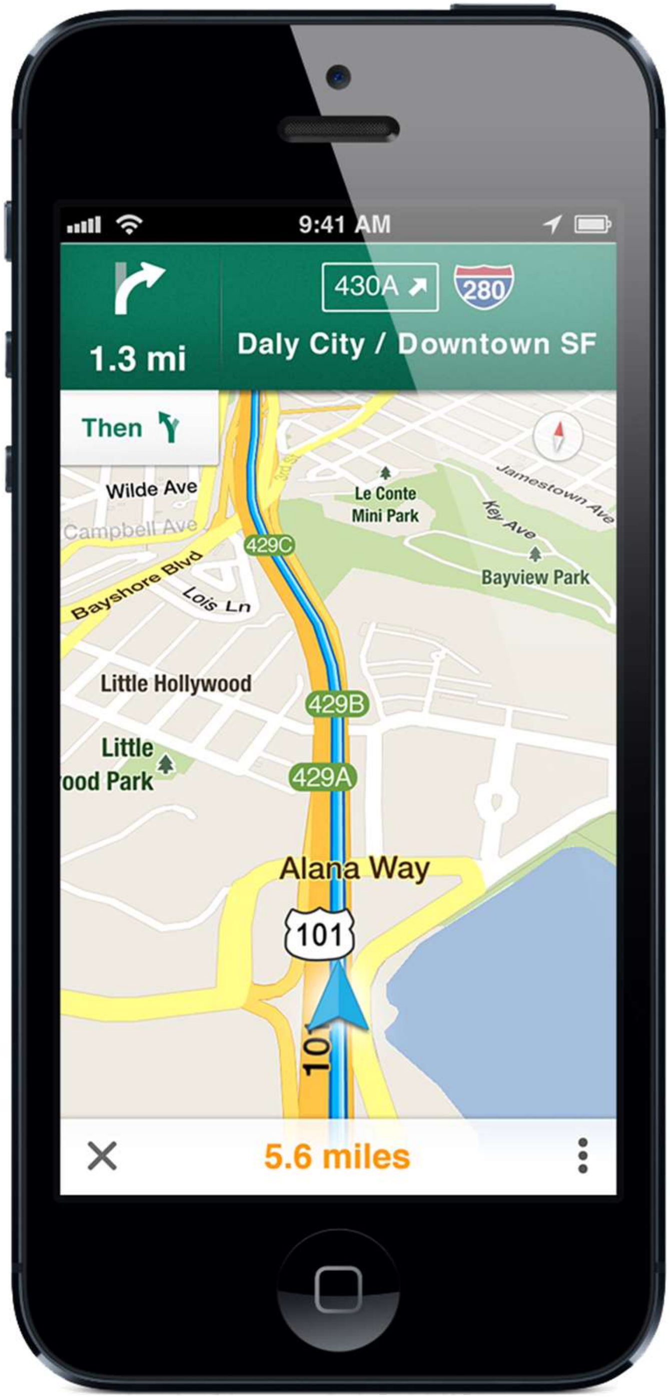


PROJECT 1:

Navigator

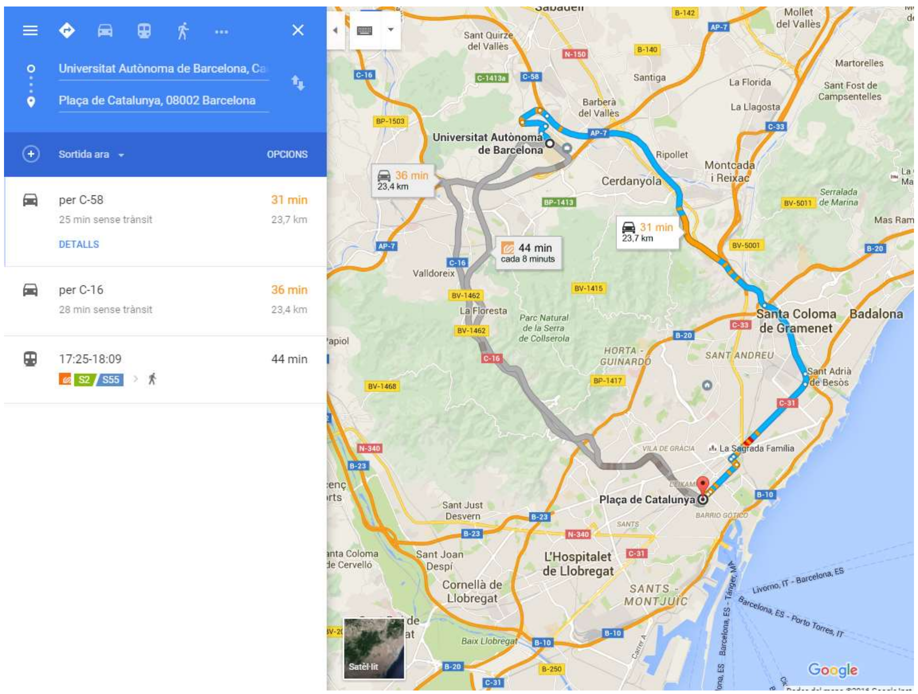
Artificial Intelligence

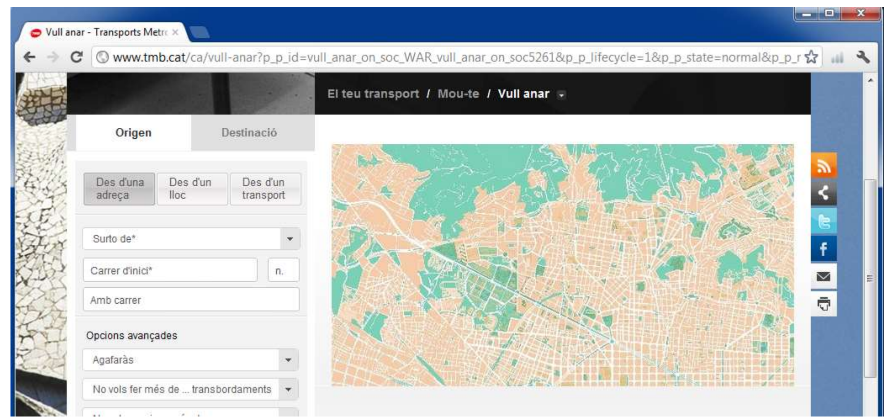
2023-2024

Universitat Autònoma de Barcelona

Project 1

Goal: To make a Navigation application, where the user give origin and destination and selects the preference criterion for the path search strategy.





Project 1

It can be very complex!!! ⟶ **We will simplify it**

Simplifications:

- We only consider **Metro Maps**
- Origin and destination will be given by the names of the stations or in **cartesian coordinates**, no use of street names and house numbers.
- The path between origins and destinations are provided in cartesian coordinates, and the distance between user and metro stations will be assumed as a **straight line**.
- The **preference criteria** can be the following, considered separately:
  - <u>Time</u>, this is to arrive as soon as possible (Minimum time)
  - <u>Distance</u>, ensure not to be doing unnecessary ways (Minimum distance)
  - <u>Line-Changes</u>, we do not want to move around a lot. (Minimum number of line changes)
  - <u>Other</u> criteria ...

Project 1

Note: The concept of **STOP** can be ambiguous!!!, we define it like this:

Definition: A stop is **a trip between two stations or a change of line**.

Example: Let us assume the route

Fontana L3 → Diagonal L3 → Diagonal L4 → Verdaguer L4

$$\underbrace{\text{Fontana L3} \rightarrow \text{Diagonal}}_{\textit{STOP}}\ \overbrace{\underbrace{\text{L3} \rightarrow \text{Diagonal L4}}_{\textit{STOP(*)}}}^{\textit{Line change}}\ \underbrace{\rightarrow \text{Verdaguer L4}}_{\textit{STOP}}$$

(*) To unify a change of line is considered as a STOP

Project 1

Problems to be solved to implement a Navigator:

Navigator

Defining a **Representation for City Data**

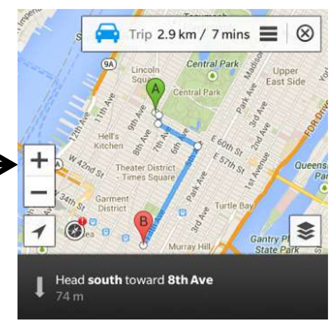
Defining the **Search Algorithms** for the best route

Defining the **Optimality Criteria**

Data about a City

Origin
Destination
(criterion)

User



Route

Project 1

Problems to be solved to implement a Navigator:

Navigator

Defining a **Representation for City Data**

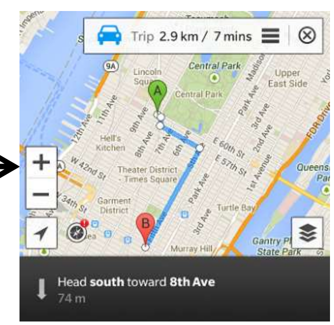
Defining the **Search Algorithms** for the best route

Defining the **Optimality Criteria**

Data about a City

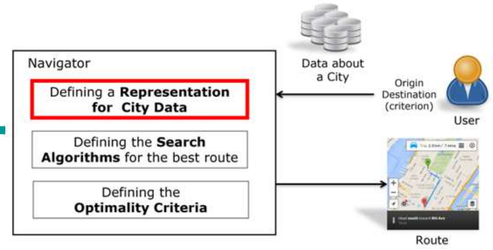
Origin
Destination
(criterion)

User

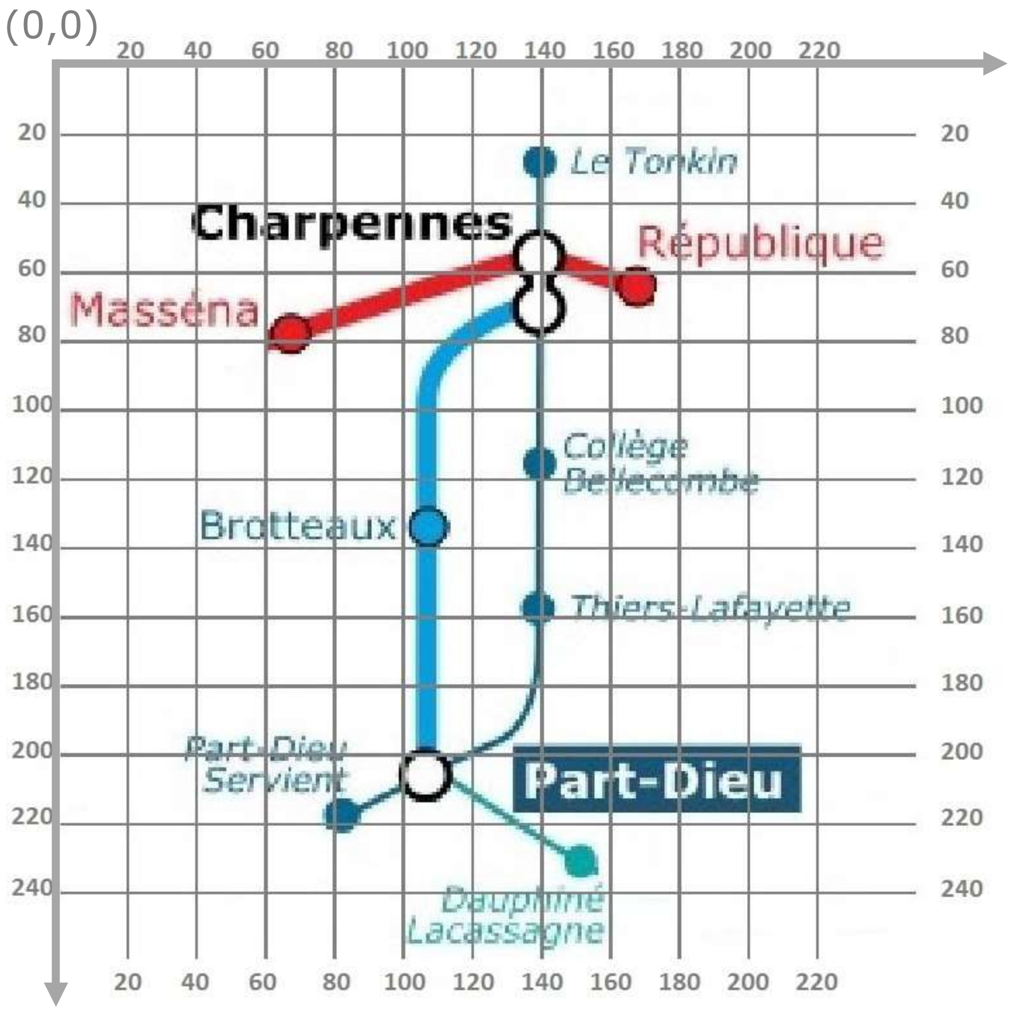


Route

Project 1



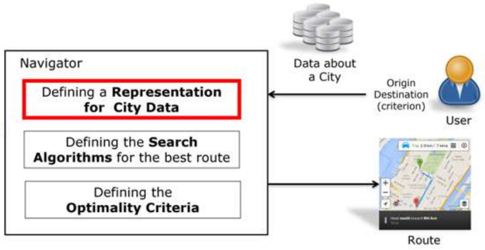
How we do represent the metro map?



We need to represent **3 elements:**

- **Stations**
- **Connections**
- **Line-Changes**

Project 1



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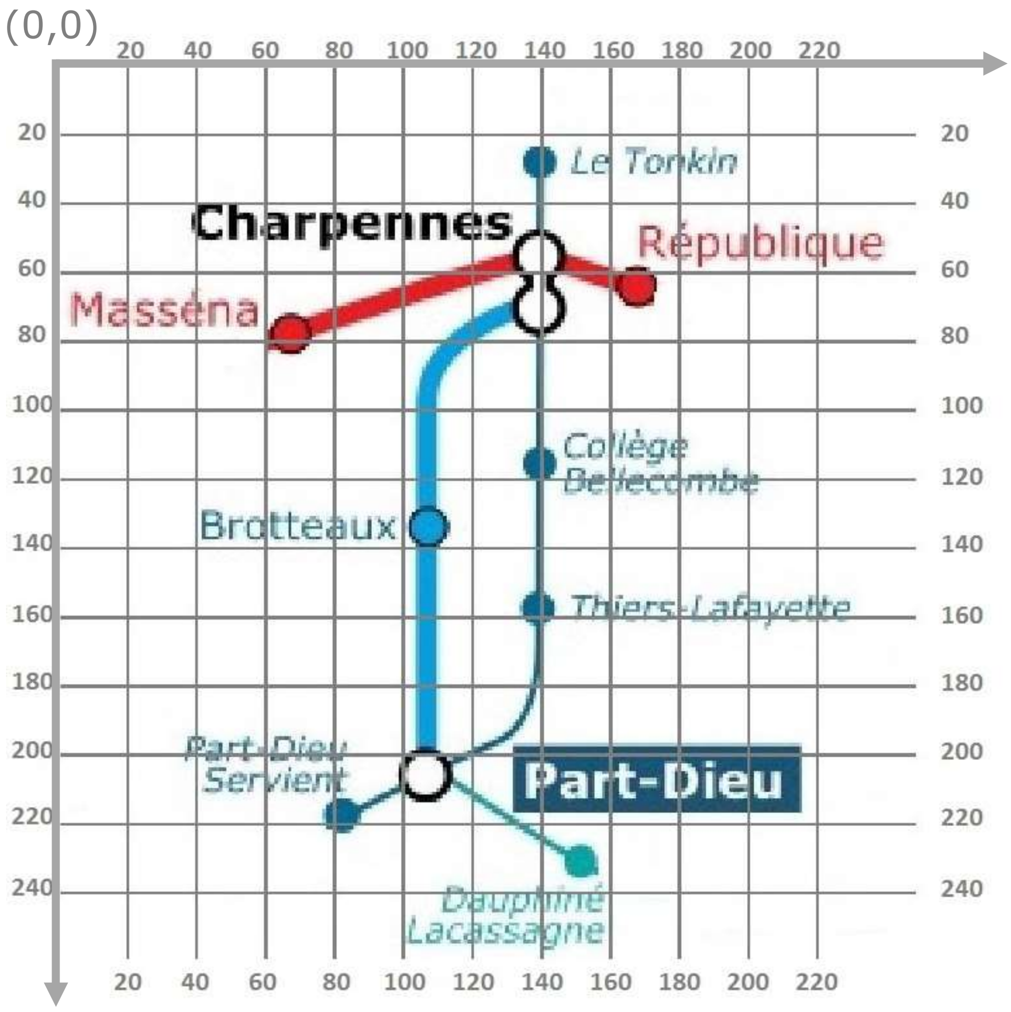
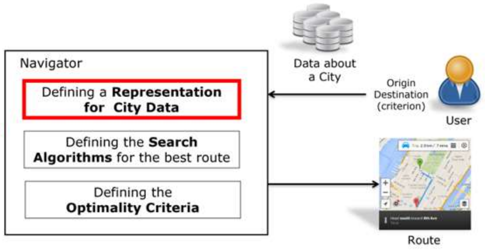


Stations

- **Name**
- **Line** where it belongs to
- **Coordinates** *(position in the map)*

Project 1



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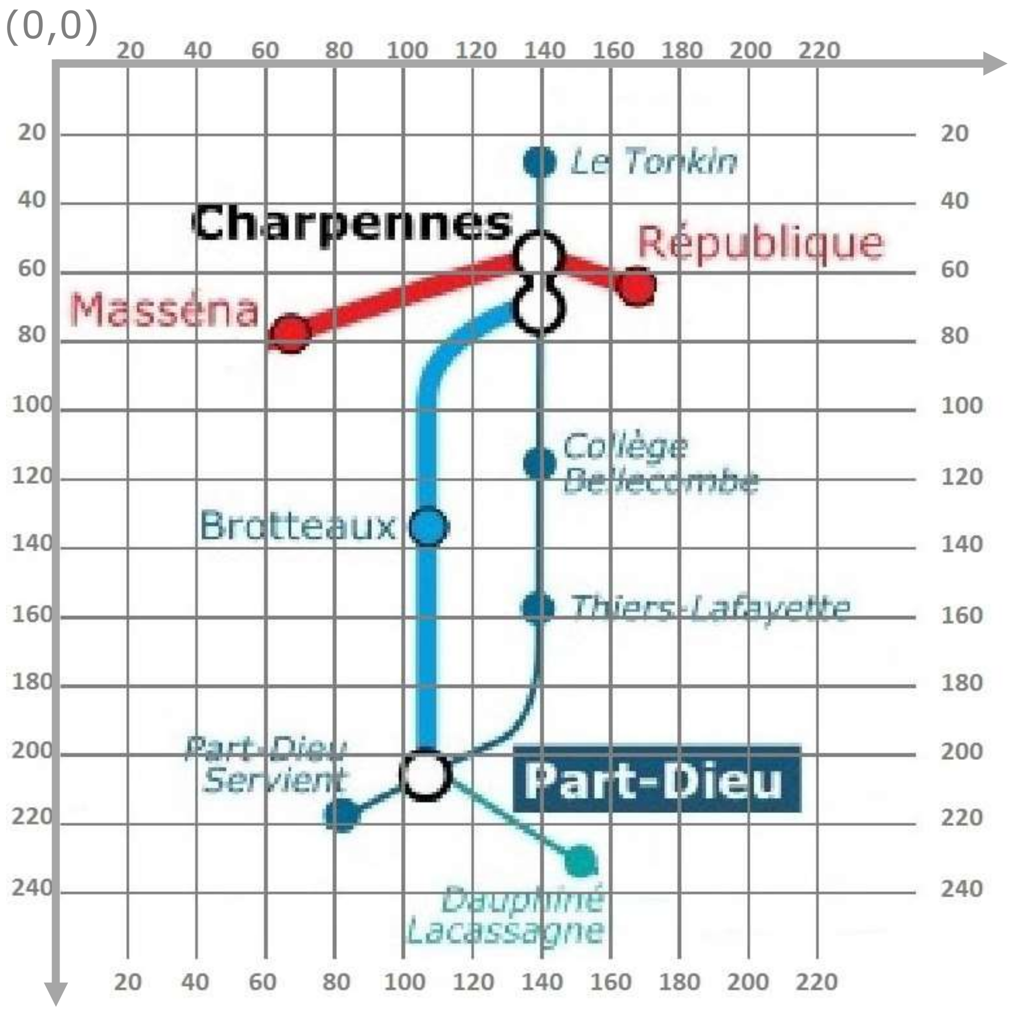
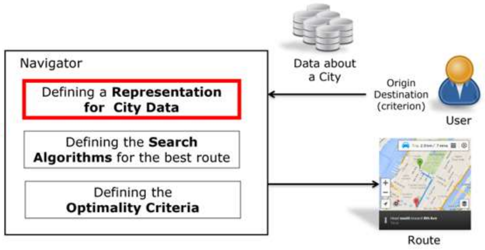


Station's Table

Name – Line - Coordinates

Station	Line(s)	X	Y
Masséna	1	67	79
Charpennes	1,2,3	140	56
République	1	167	64
Le Tonkin	2	140	27
Collège Bellecombe	2	140	115
Thiers-Lafayette	2	140	157
Part-Dieu	2,3,4	108	206
Part-Dieu Servient	2	82	217
Brotteaux	3	108	134
Dauphiné Lacassagne	4	152	230

Project 1



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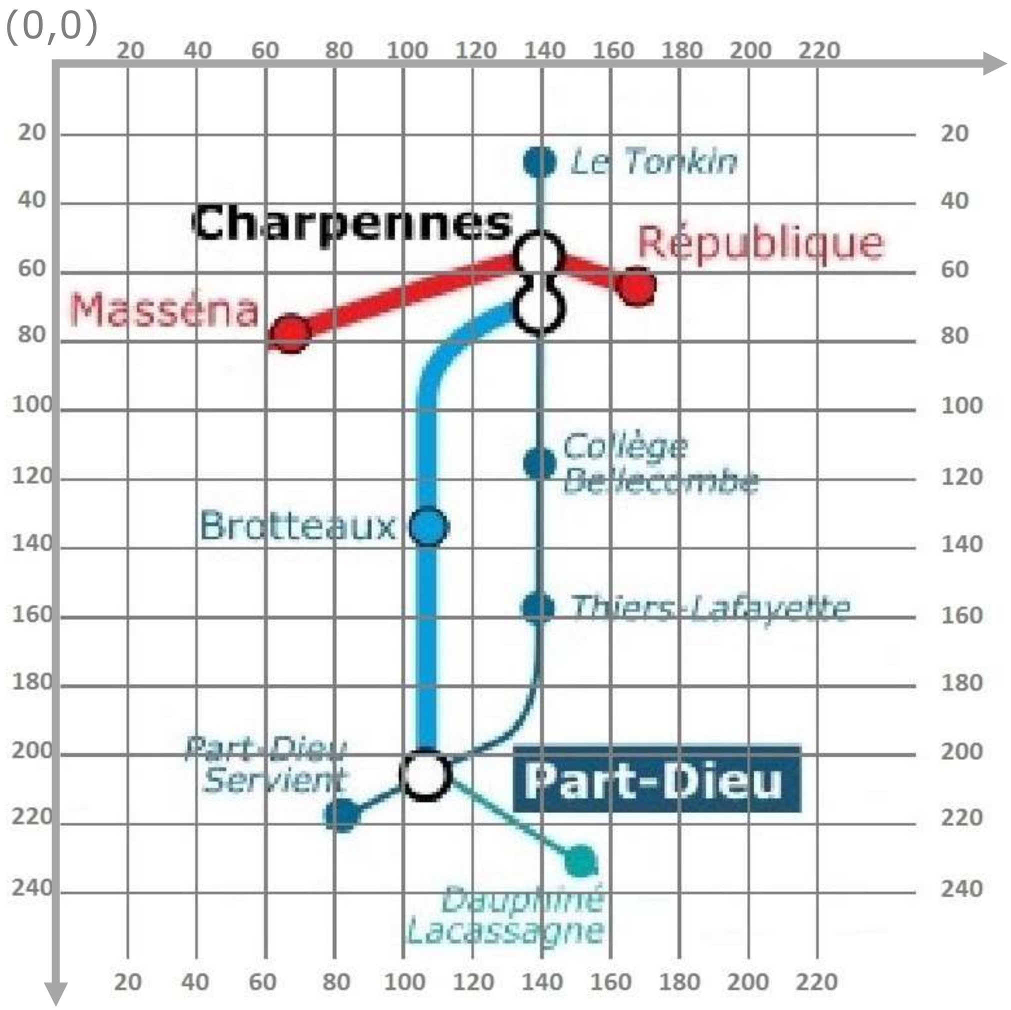
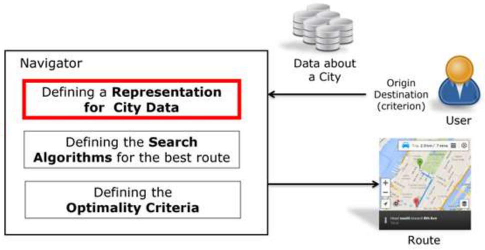


We need to represent **3 elements:**

- **Stations** √
- **Connections**
- **Line-Changes**

Project 1



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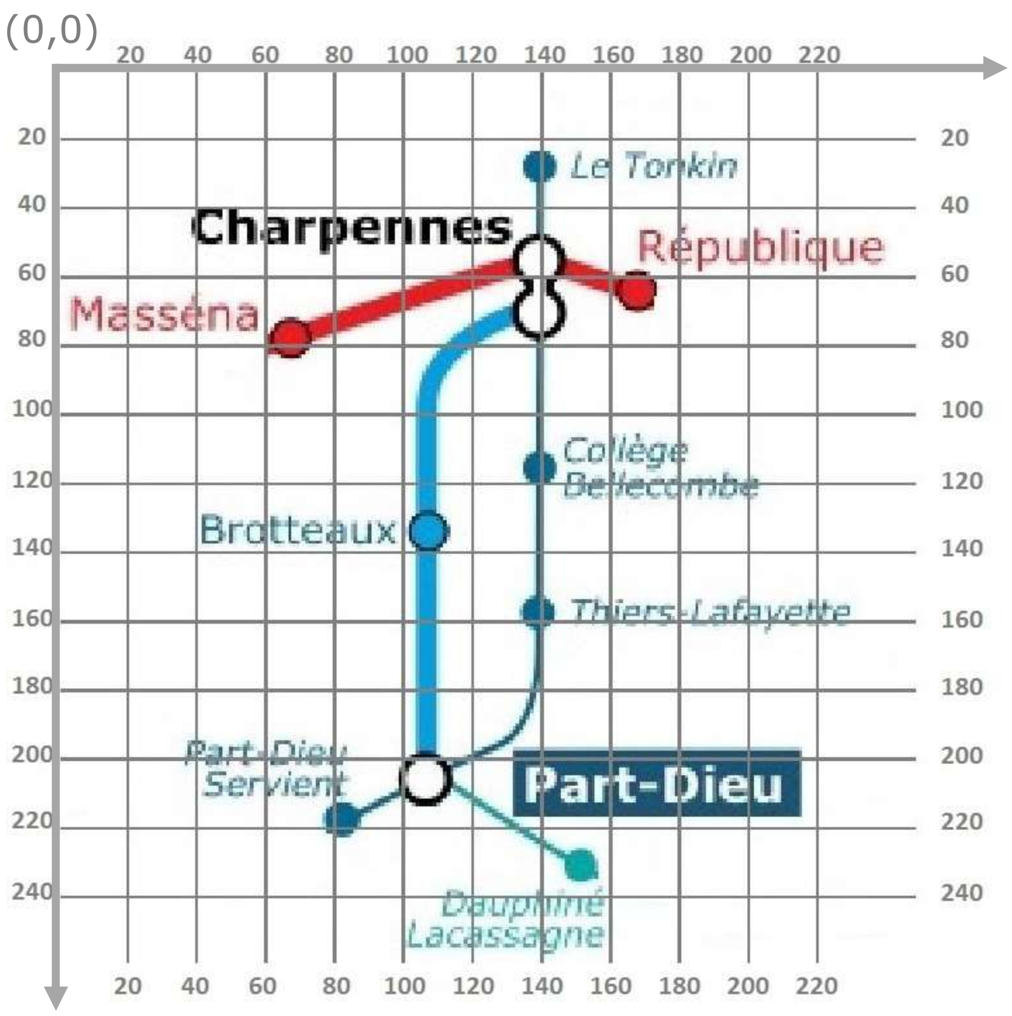
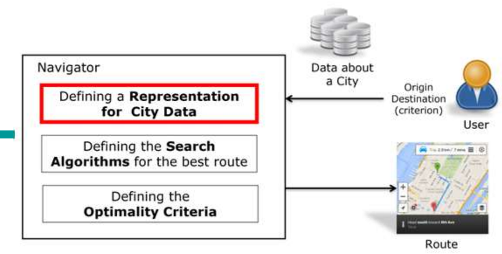


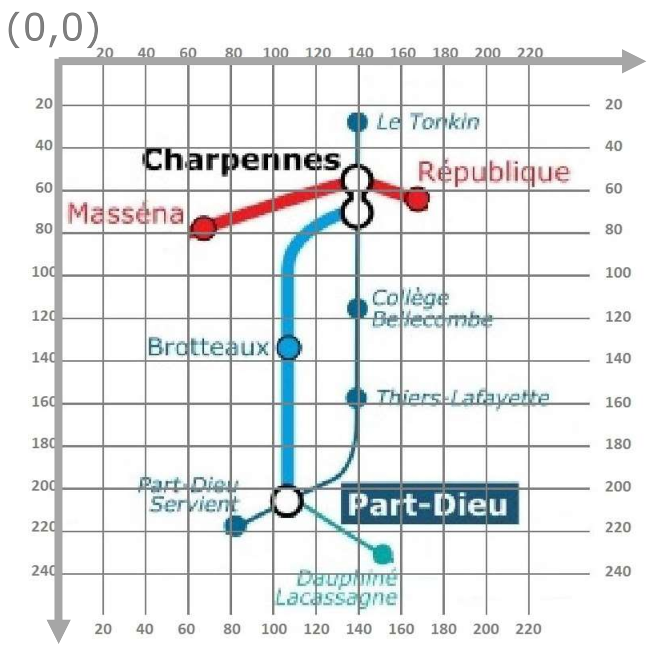
Connections:

- **Adjacency Matrix**

Project 1



Example of adjacency matrix

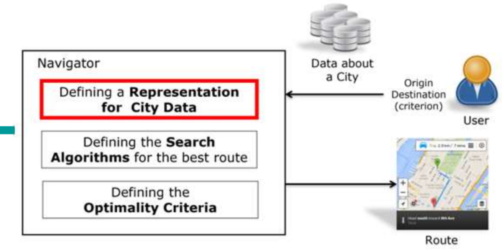


Adjacency Matrix

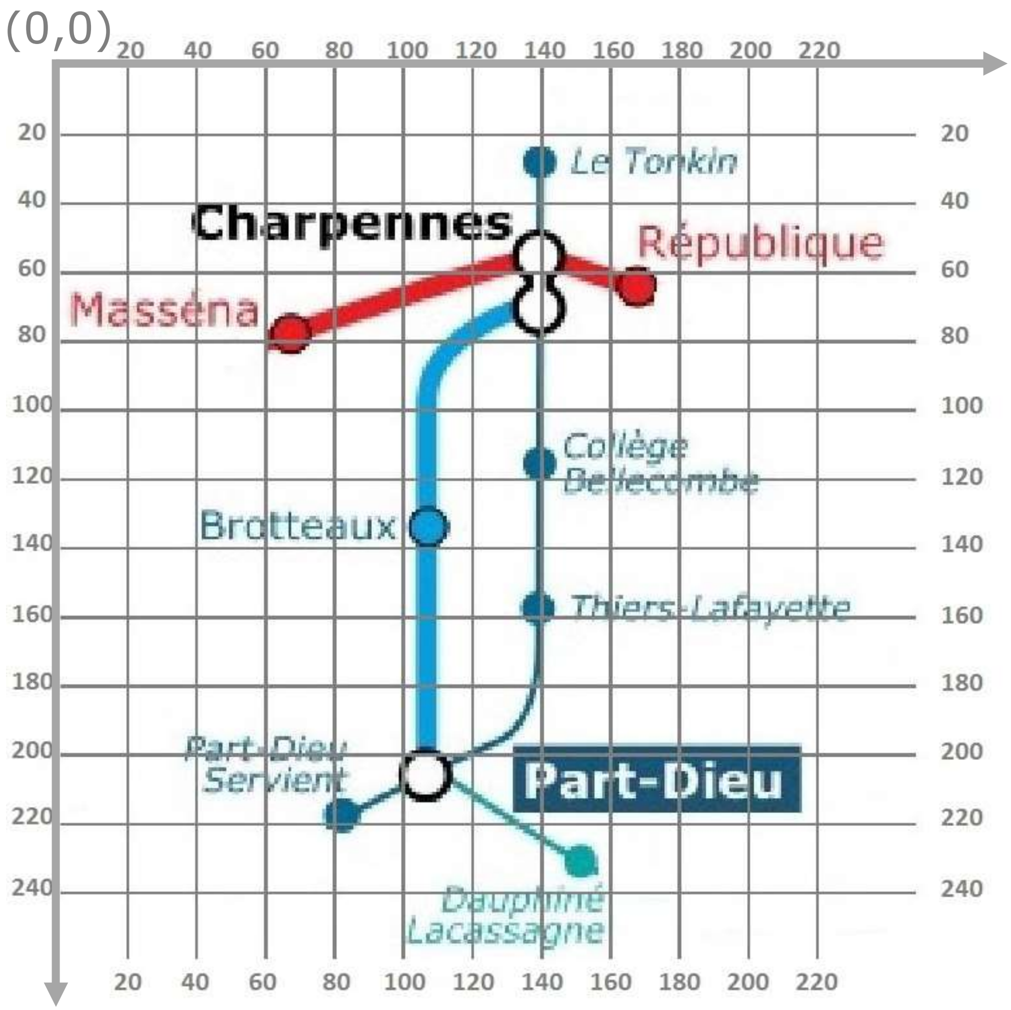
	Masséna	Charpennes	République	Le Tonkin	Collège Bellcombe	Thiers-Lafayette	Part-Dieu	Part-Dieu Serv.	Servient Brotteaux	Dauphiné Lacassagne
Masséna	0									
Charpennes	1	0								
République		1	0							
Le Tonkin		1		0						
Collège Bellecombe		1			0					
Thiers – La fayette					1	0				
Part-Dieu						1	0			
Part-Dieu Servient							1	0		
Brotteaux		1						1	0	
Dauphiné							1			0

symmetric

Project 1



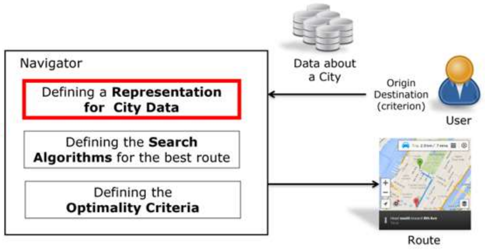
How we do represent the metro map?



Connections

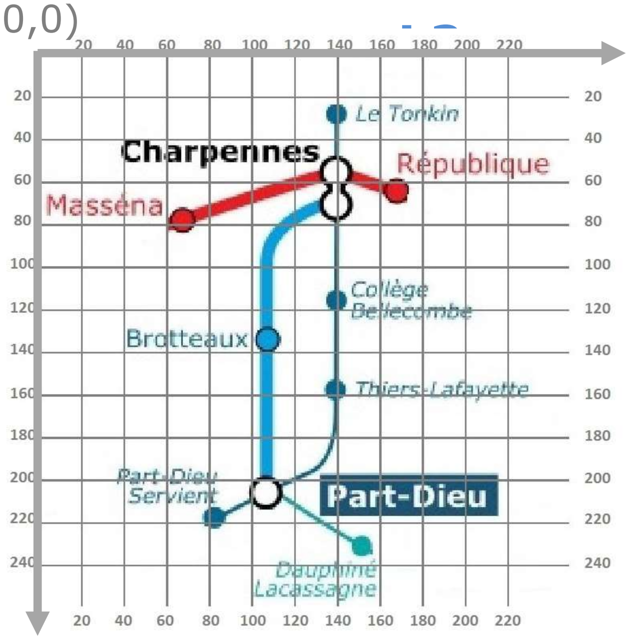
- **Adjacency Matrix** √
- **Costs**
  1. Time
  2. Distance
  3. #Line-Changes
  4. #Stops

Project 1



Example of a time cost matrix
(it will always be given)

(0,0)

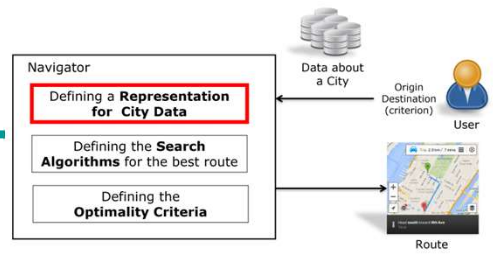


Cost Matrix (Time)

	Masséna	Charpennes	République	Le Tonkin	Collège Bellcombe	Thiers-Lafayette	Part-Dieu	Part-Dieu Serv.ient	Brotteaux	Dauphiné L
Masséna	0									
Charpennes	9	0								
République		4	0							
Le Tonkin		5		0						
Collège Bellecombe		7			0					
Thiers – La fayette					4	0				
Part-Dieu						6	0			
Part-Dieu Servient							2	0		
Brotteaux		2					2		0	
Dauphiné L.								21		0

Folder: `CityInformation`
File: `Time.txt`

Project 1



Assumptions to compute costs:

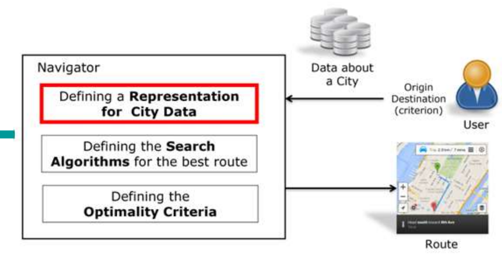
- Each line goes always at a constant speed

Folder: `CityInformation`
File: `Infovelocity.txt`

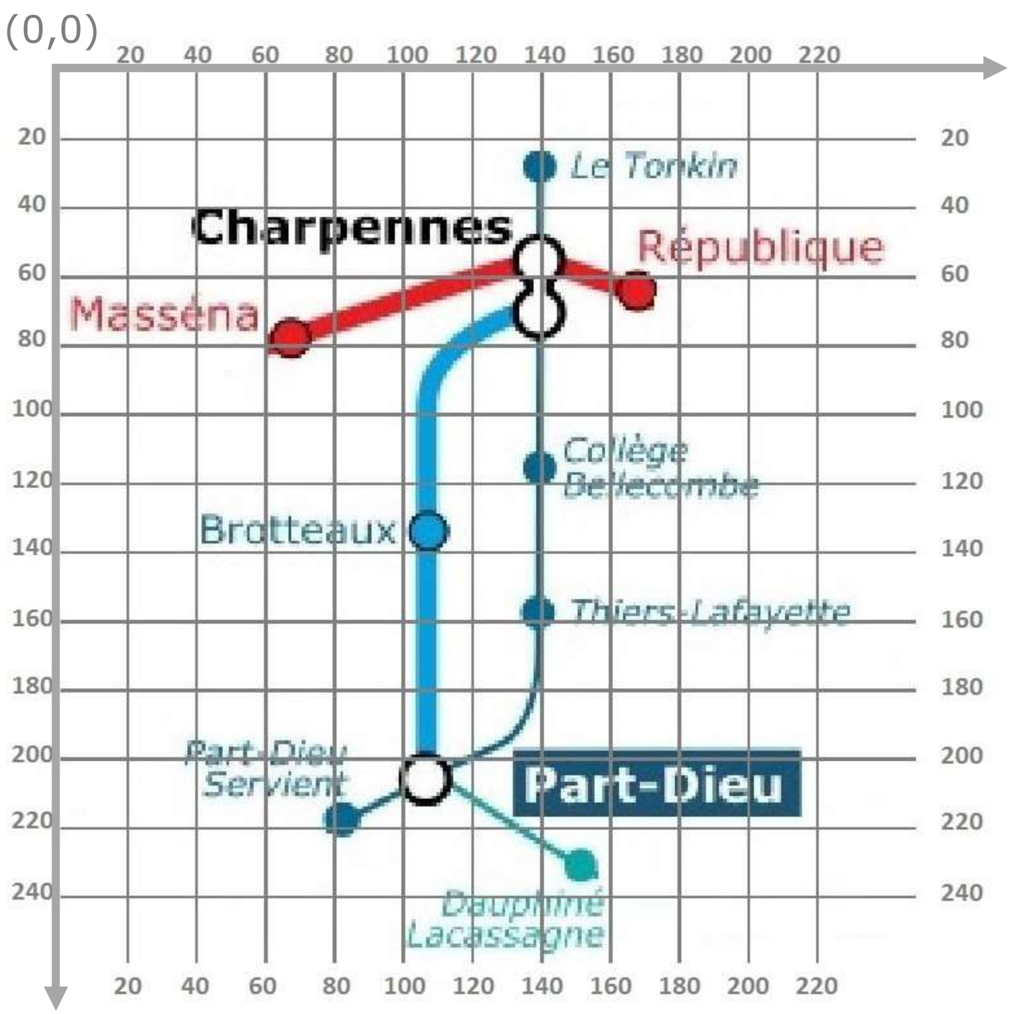
- The railways connecting between two stations are not always straight.

- We will always have the Cartesian coordinates of all the station positions.

Project 1



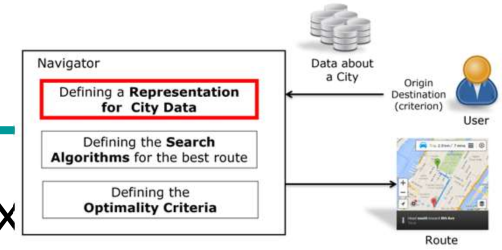
How we do represent the metro map?



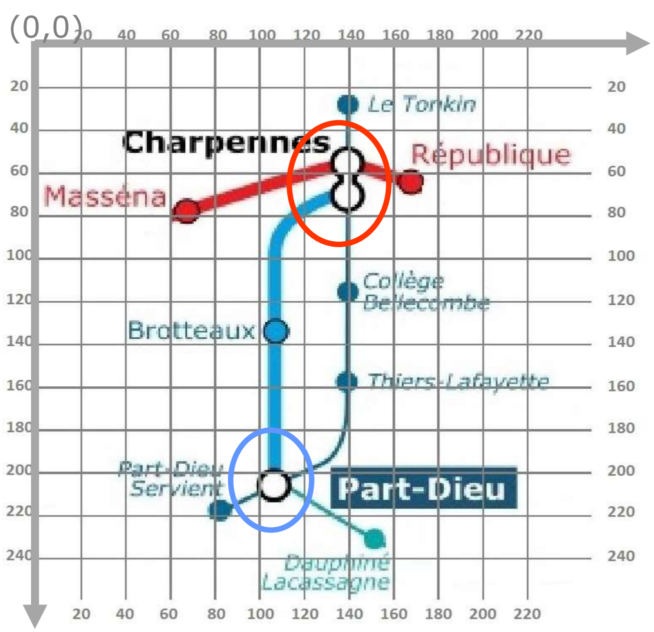
We need to represent
3 elements:

- **Stations** √
- **Connections** √
- **Line-Changes**

Project 1



Previous examples, adjacency matrix and cost matrix



Adjacency Matrix

	Masséna	Charpennes	République	Le Tonkin	Collège Bellecombe	Thiers-Lafayette	Part-Dieu	Part-Dieu Servient	Brotteaux	Dauphiné L.
Masséna	0									
Charpennes	1	0								
République		1	0							
Le Tonkin		1		0						
Collège Bellecombe		1			0					
Thiers – La fayette					1	0				
Part-Dieu						1	0			
Part-Dieu Servient							1	0		
Brotteaux		1						1	0	
Dauphiné							1			0

Cost Matrix (Time)

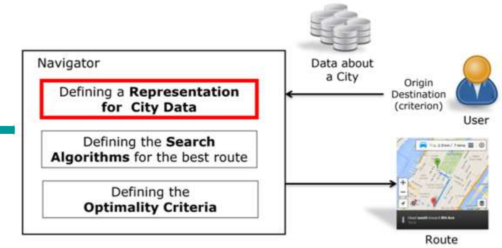
	Masséna	Charpennes	République	Le Tonkin	Collège Bellcombe	Thiers-Lafayette	Part-Dieu	Part-Dieu Serv.ient	Brotteaux	Dauphiné L
Masséna	0									
Charpennes	9	0								
République		4	0							
Le Tonkin		5		0						
Collège Bellecombe		7			0					
Thiers – La fayette					4	0				
Part-Dieu						6	0			
Part-Dieu Servient							2	0		
Brotteaux		2					2		0	
Dauphiné L.								21		0

How do we represent the Line-Change?

There are two: *Charpennes* (3 lines) and *Part-Dieu* (3 lines)

We said Line-Changes would be regarded as **STOPS**

Project 1



Solution: Repeat stations belonging to more than one line

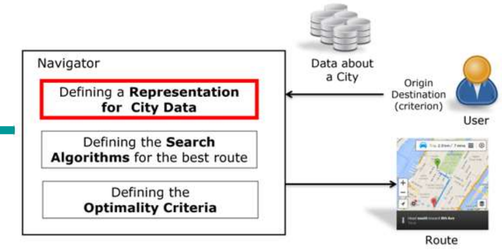
Example: Adjacency matrix

	Masséna	Charpennes	République	Le Tonkin	Collège Bellcombe	Thiers-Lafayette	Part-Dieu	Part-Dieu Serv. Servient	Brotteaux	Dauphiné Lacassagne
Masséna	0									
Charpennes	1	0								
République		1	0							
Le Tonkin		1		0						
Collège Bellecombe		1			0					
Thiers – La fayette					1	0				
Part-Dieu						1	0			
Part-Dieu Servient							1	0		
Brotteaux		1						1	0	
Dauphiné							1			0

	Masséna L1	Charpennes L1	República L1	Le Tonkin L2	Charpennes L2	Collège Bellecombe L2	Thiers Lafayette L2	Part-Dieu L2	Part-Dieu Servient L2	Charpennes L3	Brotteaux L3	Part-Dieu L3	Part-Dieu L4	Dauphiné L. L4
Masséna L1	0													
Charpennes L1	1	0												
República L1		1	0											
Le Tonkin L2				0										
Charpennes L2		1		1	0									
Collège Bellecombe L2					1	0								
Thiers Lafayette L2						1	0							
Part-Dieu L2							1	0						
Part-Dieu Servient L2								1	0					
Charpennes L3		1			1					0				
Brotteaux L3										1	0			
Part-Dieu L3								1			1	0		
Part-Dieu L4								1				1	0	
Dauphiné Lacassagne L4													1	0

Result: Move from a 10x10 matrix to a 14x14 matrix
(Charpennes x 3) i (Part-Dieu x 3)

Project 1



Solution: Repeat stations belonging to more than one line

Example: Cost Matrix

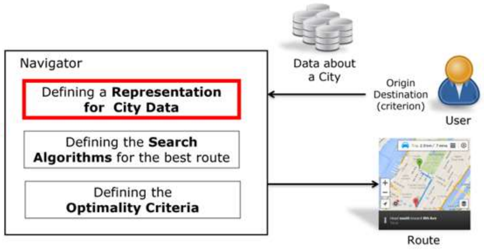
	Masséna	Charpennes	République	Le Tonkin	Collège Bellcombe	Thiers-Lafayette	Part-Dieu	Part-Dieu Serv.	Servient Brotteaux	Dauphiné Lacassagne
Masséna	0									
Charpennes	10	0								
République		10	0							
Le Tonkin		5		0						
Collège Bellecombe		5			0					
Thiers – La fayette					5	0				
Part-Dieu						5	0			
Part-Dieu Servient							5	0		
Brotteaux		20						20	0	
Dauphiné							15			0

	Masséna L1	Charpennes L1	République L1	Le Tonkin L2	Charpennes L2	Collège Bellecombe L2	Thiers Lafayette L2	Part-Dieu L2	Part-Dieu Servient L2	Charpennes L3	Brotteaux L3	Part-Dieu L3	Part-Dieu L4	Dauphiné L. L4
Masséna L1	0													
Charpennes L1	9	0												
République L1		4	0											
Le Tonkin L2				0										
Charpennes L2		20		5	0									
Collège Bellecombe L2					7	0								
Thiers Lafayette L2						4	0							
Part-Dieu L2							6	0						
Part-Dieu Servient L2								2	0					
Charpennes L3		15			18					0				
Brotteaux L3										2	0			
Part-Dieu L3								12			2	0		
Part-Dieu L4								6				15	0	
Dauphiné L. L4													21	0

Result: Move from a 10x10 matrix to a 14x14 matrix

(Charpennes x 3) i (Part-Dieu x 3)

Project 1

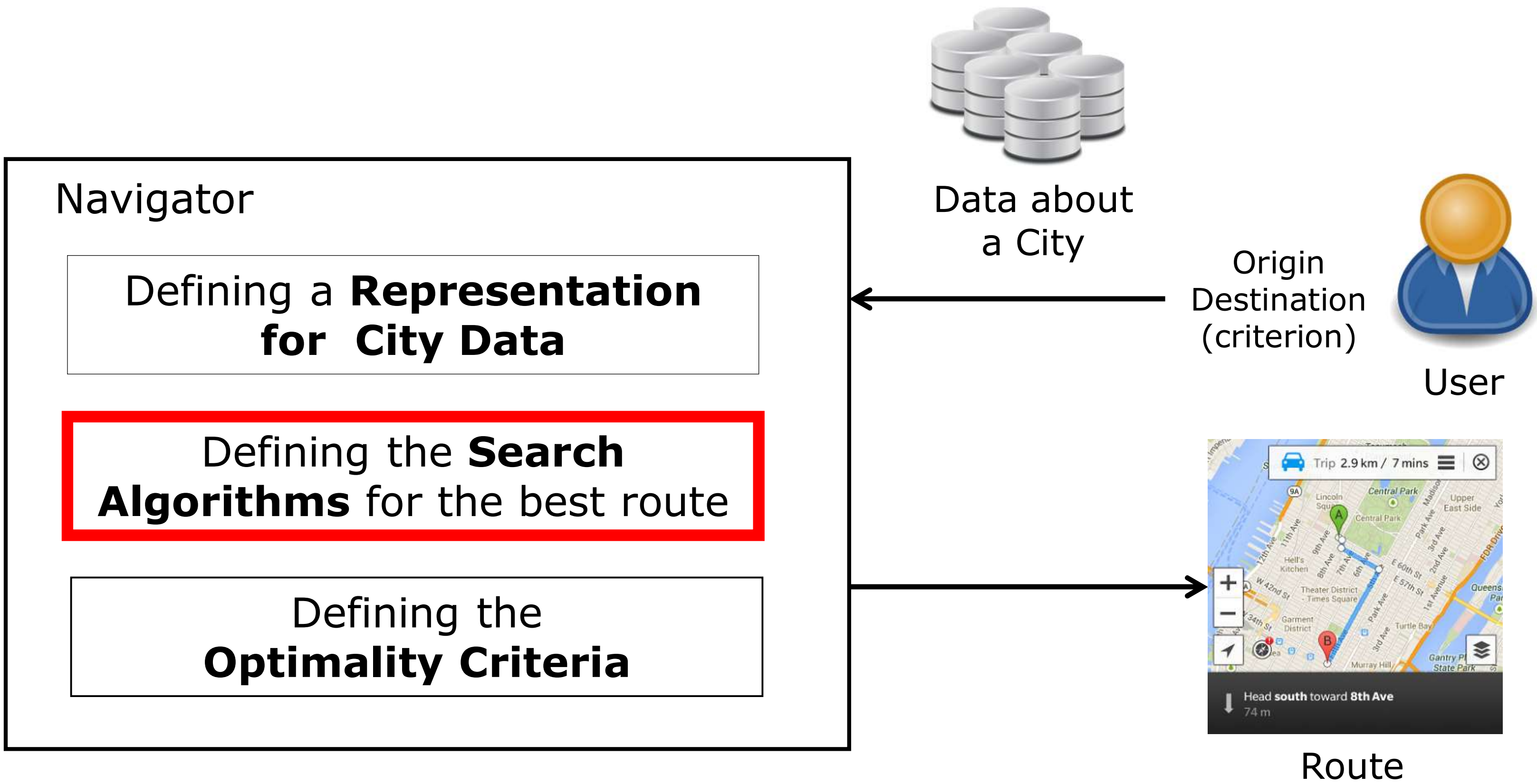


Important Note: the cost matrices we provide you have already duplicated the stations of different lines

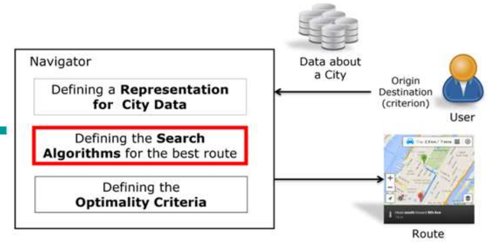
Folder: `CityInformation`
File: `Infovelocity.txt`

Project 1

Problems to be solved to implement a Navigator:



Project 1



Which algorithm do we have to apply, to implement a Navigator?

Search Algorithms, allow to find the path between an origin and a destination

Which are the differences between them?

	Non-Optimal Search	Optimal Search
Uninformed Search	Depth first Search Breadth first Search	Uniform Cost Search
Informed Search	Greedy-BFS Search	A* Search

Two questions:

- Do we want optimal routes in a given sense?
- Can we define heuristics on these searches?

Project 1

Problems to be solved to implement a Navigator:

Navigator

Defining a **Representation for City Data**

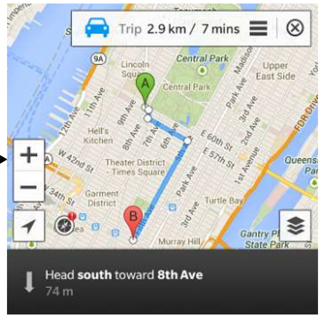
Defining the **Search Algorithms** for the best route

Defining the **Optimality Criteria**

Data about a City

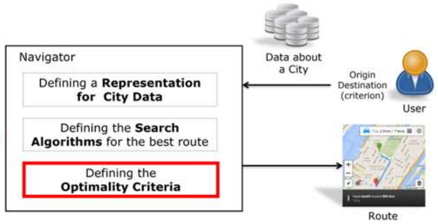
Origin
Destination
(criterion)

User



Route

Project 1

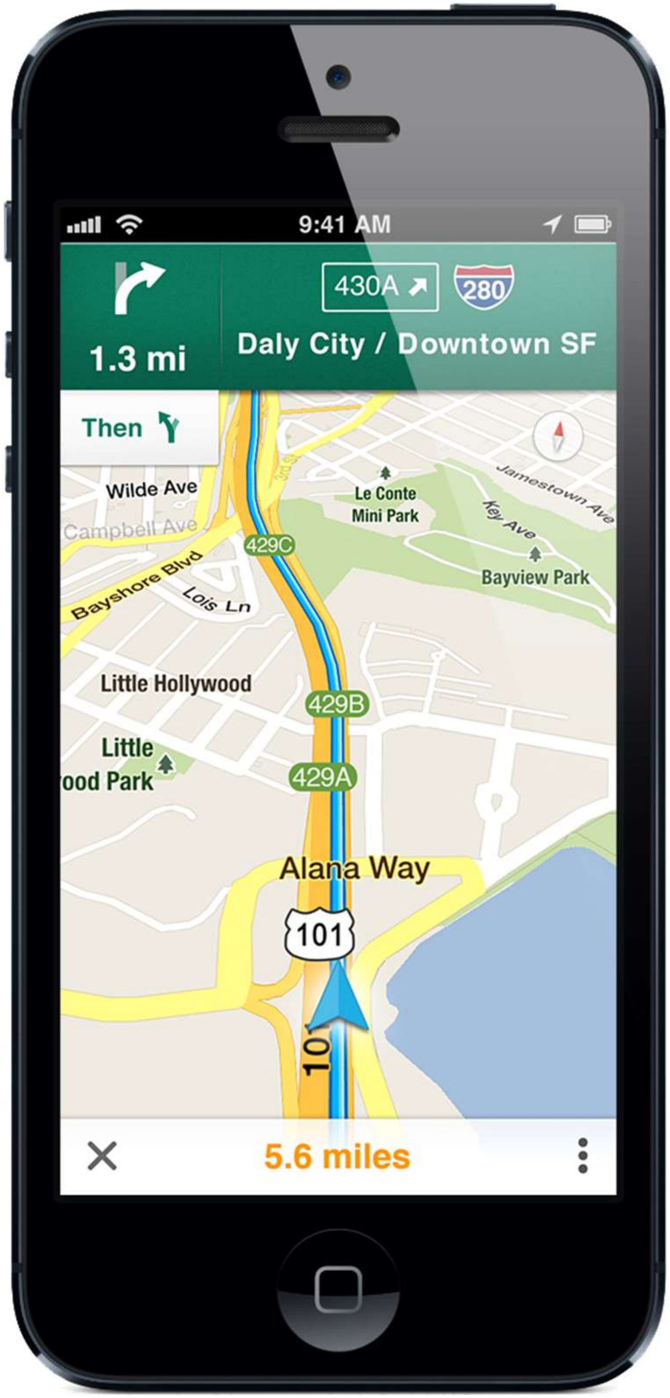


How do we apply each criterion?

- Time criterion
  - What the cost is?
  - Which heuristic?
- Distance criterion
  - What is the cost?
  - Which heuristic?
- Number of Line-Change criterion
  - What is the cost?
  - Which heuristic?
- Number of Stops criterion
  - What is the cost?
  - Which heuristic?

Remember:

- We know the time between all stops in all metro lines
- Each line has constant speed
- We know the position coordinates of all stations
- Railways between stations are not straight lines



PROJECT 1:

Navigator

Artificial Intelligence

Universitat Autònoma de Barcelona