ORCO
UGA & ENSIMAG

Decision Support System for carpooling to reduce car traffic in Grenoble area

Romain NAVARRO
June, 29th 2018

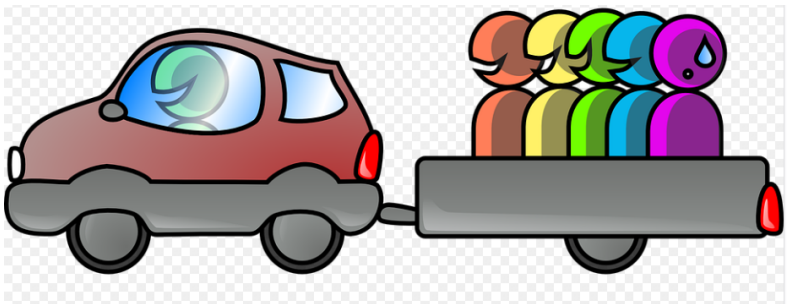
Supervisor: Prof. Van-Dat CUNG, G-SCOP & UGA
Jury members: Prof. Nadia BRAUNER
Prof. Van-Dat CUNG
Dr. Vassilissa LEHOUX
Prof. Matej STEHLIK

Outline

Context: Carpooling

Carpooling characteristics:

- Private vehicles
- Group of people sharing the same car, called pool
- Participation in the expenses generated by the trips



Context: Interests

Motivations:

- Users: Save money
- Communities:

  With 20% carpooling, there would be no traffic jams

- Companies: Create a stronger sense of community and improve productivity
- Operators: Make money

[1] Francois Bellot - fleeteurope.com

[2] How to Encourage Employees to Carpool - rideamigos.com

Context: Existing applications

- BlaBlaLines: Links users according to their schedule, allowing a detour of at most fifteen minutes for a trip
- Klaxit: Finds regular close carpoolers
- Karos: Fits with people who periodically do the same circuit

[1] Covoiturage domicile-travail BlaBlaLines arrive Paris et en Ile-de-France - 2017

[2] Sylvain Arnulf - Covoiturage domicile/travail : Klaxit (ex-Wayzup) embarque de nouveaux partenaires pour se detacher - 2018.

[3] Karos, comment a marche ? - Le Parisien - 2016

Context: Barriers to these systems

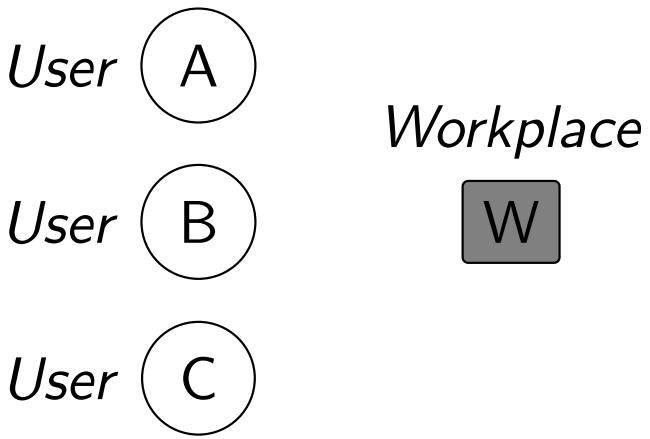
Three main barriers that emerge in the articles:

- Commitments: Users do not want to make a long-term commitment
- Punctuality: Users do not want to be too early or too late at work
- Detours: Users do not want to make too long detours

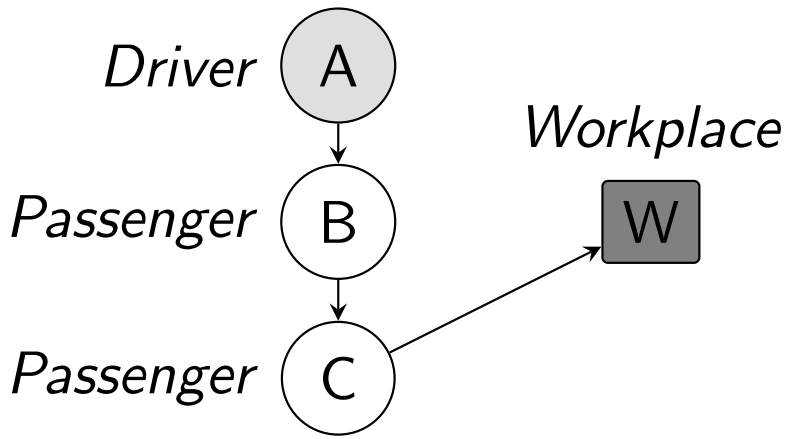
[1] Hai-Jun Huang, Hai Yang, and Michael G. H. Bell. 2000

Outline

Problem description: Same workplace for all



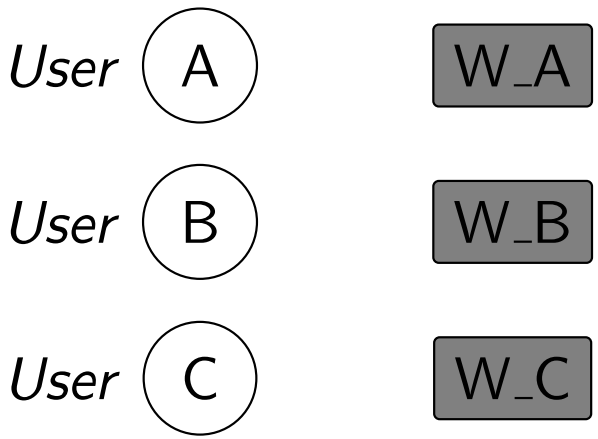
(a) User requests



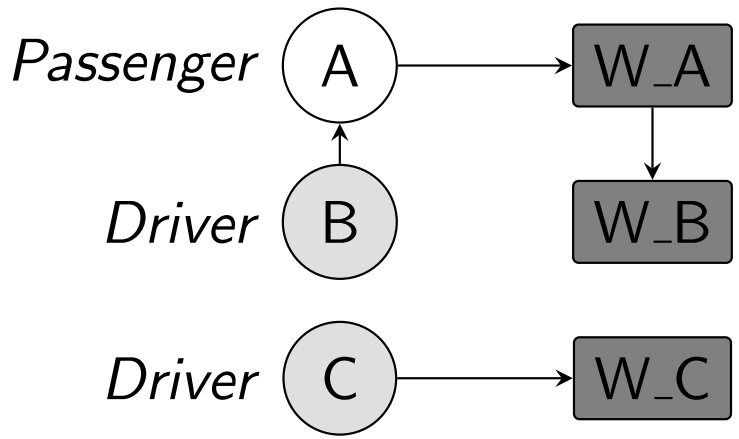
(b) A solution

[1] Yuhan Guo - 2012

Problem description: One workplace per user



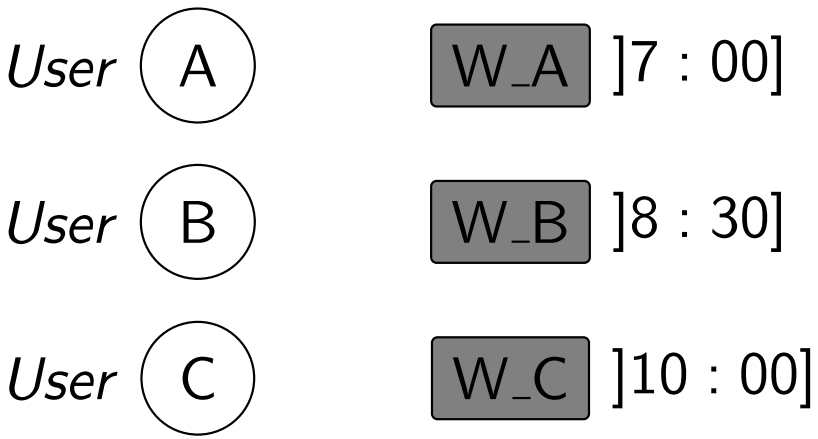
(a) User requests



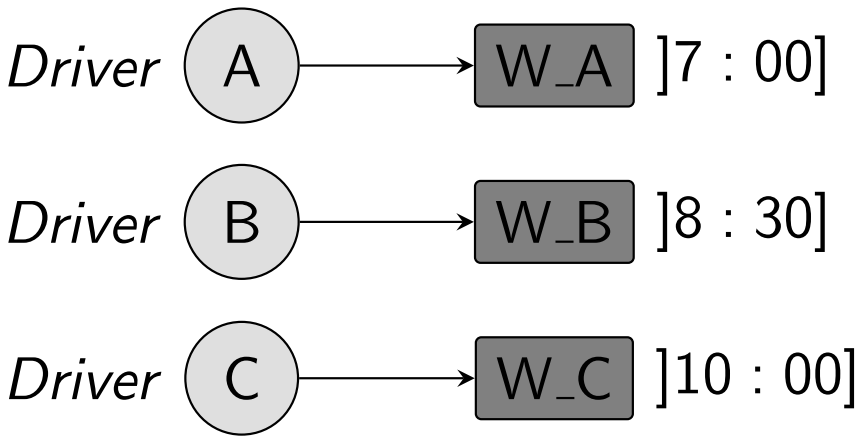
(b) A solution

[1] Yuhan Guo - 2012

Problem description: Work arrival time



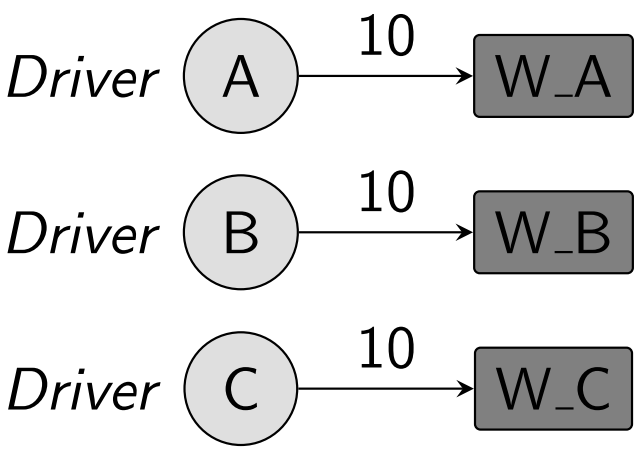
(a) User requests



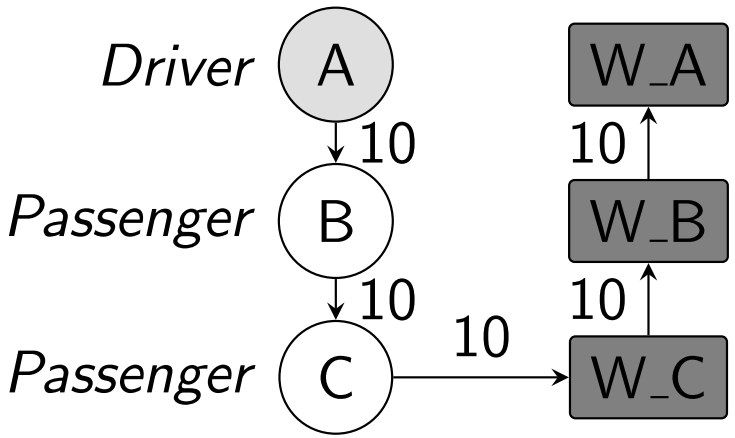
(b) A solution

[1] Shangyao Yan and Chun-Ying Chen - 2011

Problem description: Objective



(a) Total cost = 30



(b) Total cost = 50

Figure: Minimization of the total cost

[1] Jakub Nalepa - 2016

Problem description: Same pool

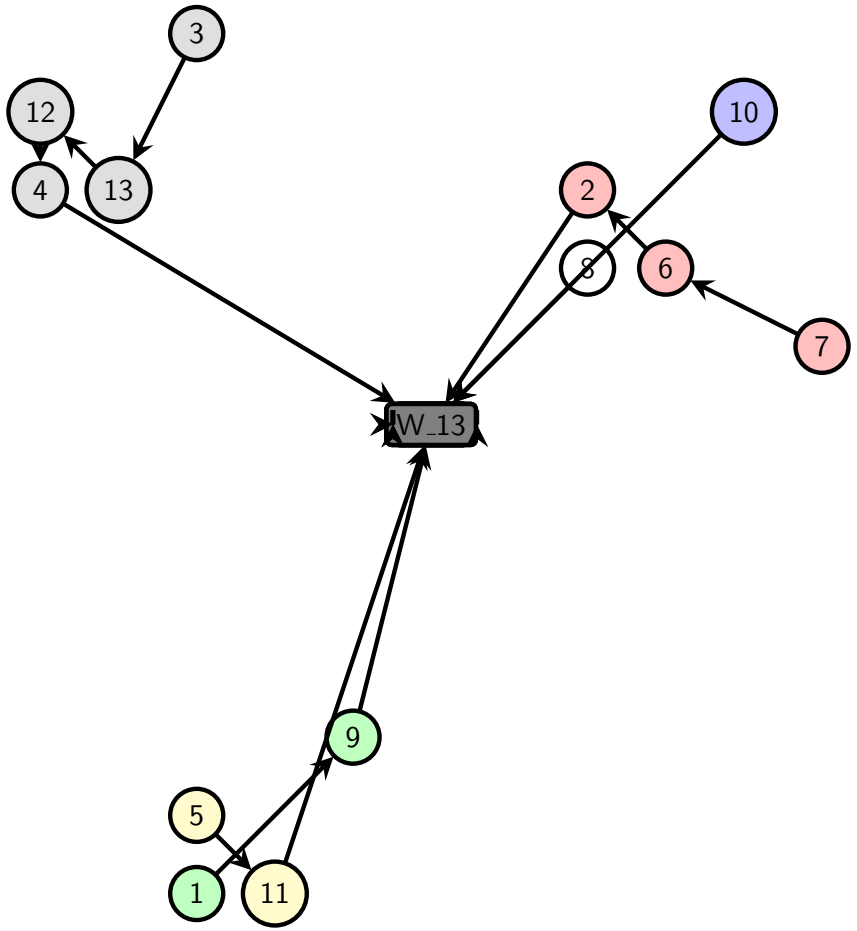


Figure: Home-to-work user pools

Problem description: Same pool

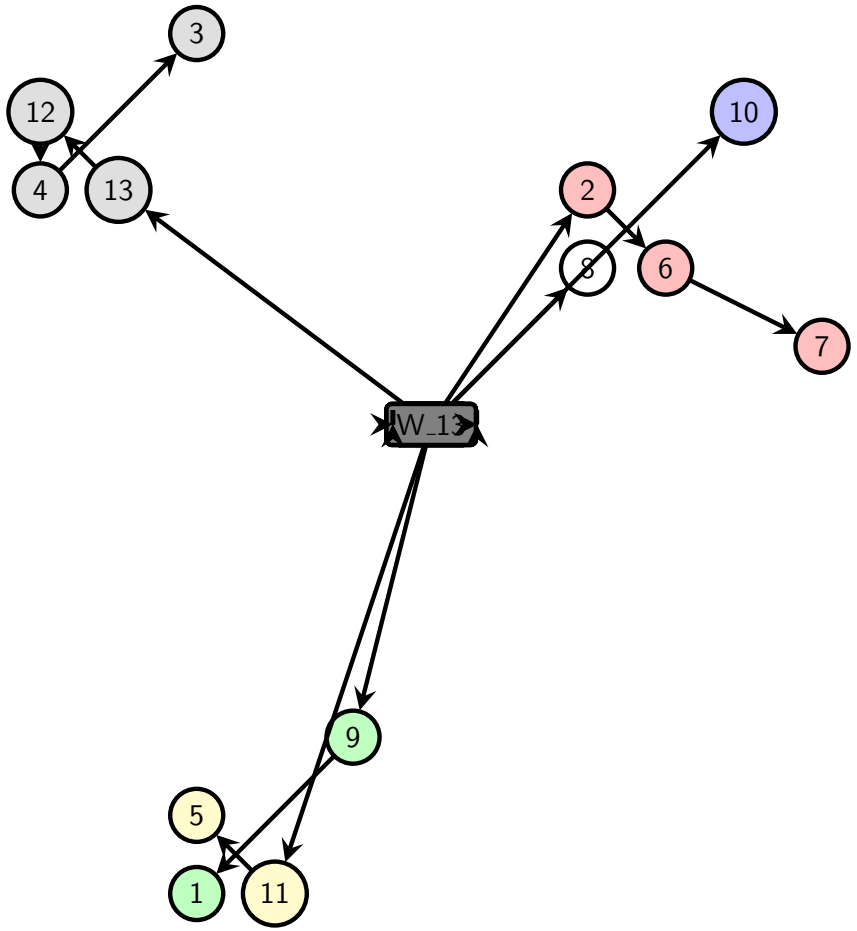
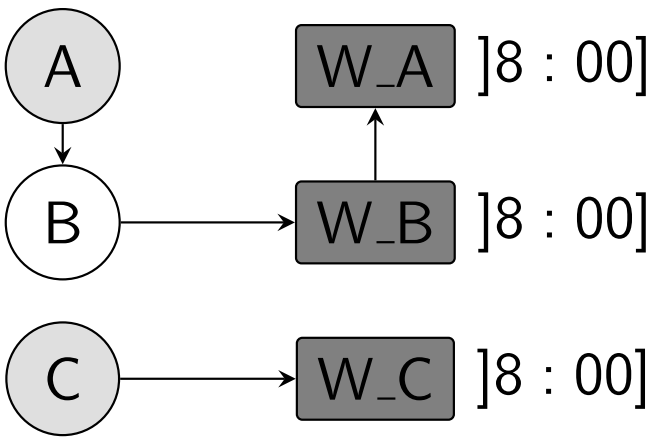
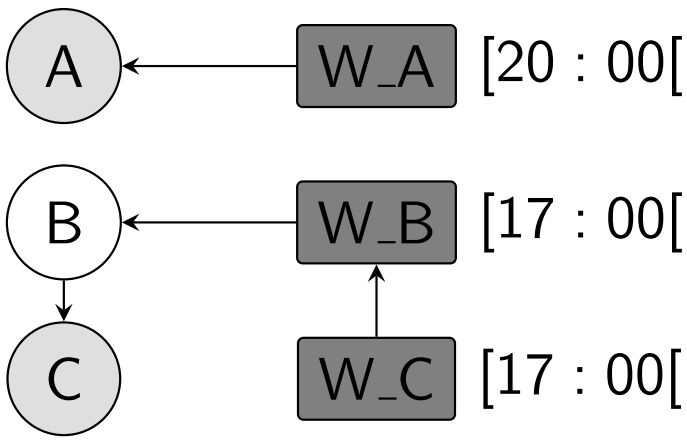


Figure: Way back user pools

Problem description: Return management



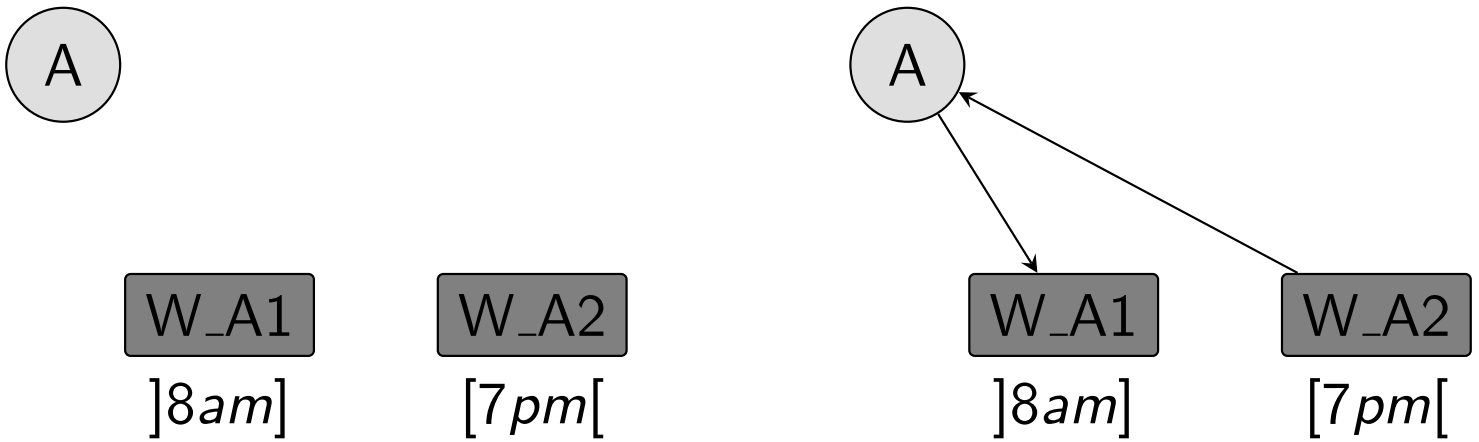
(a) Home-to-work trip



(b) Return trip

[1] M Bruglieri - 2011

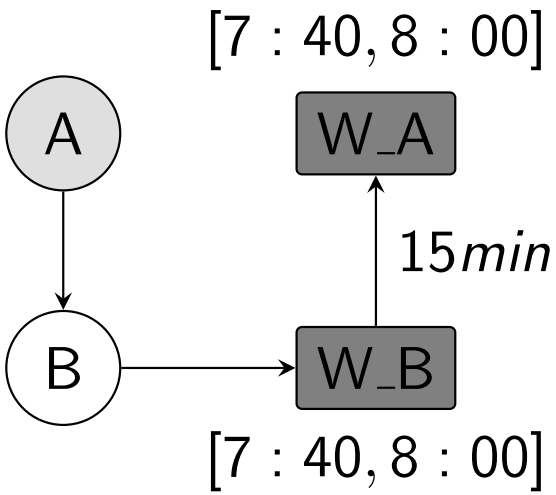
Problem description: One user several places



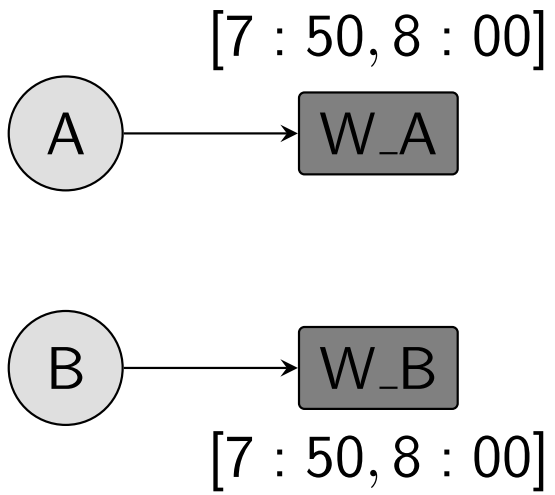
(a) Data (b) Solution

In the case the place of work is **not fixed**, or if the user planned an **external activity**.
The trip between the two workplaces is not managed by our system(company car, public transport, his car if he took it. . .).
Same thing with homes, even if it is less frequent.

Problem description: Latest arrival time



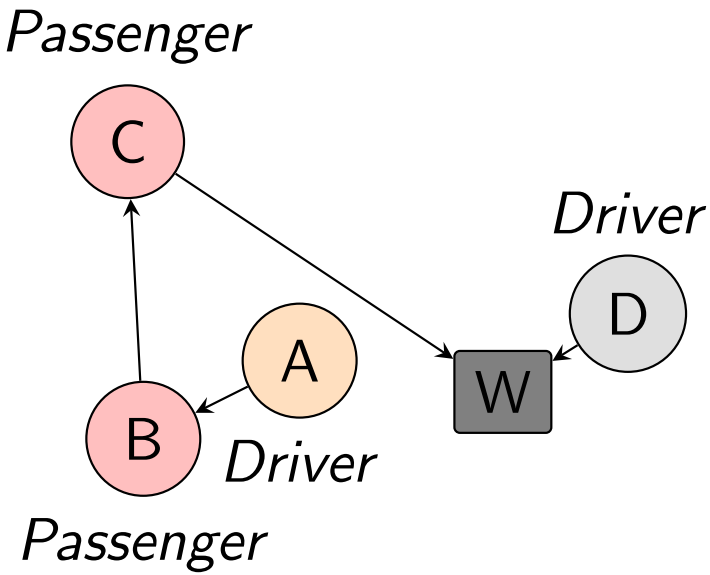
(a) Authorized advance = 20 min



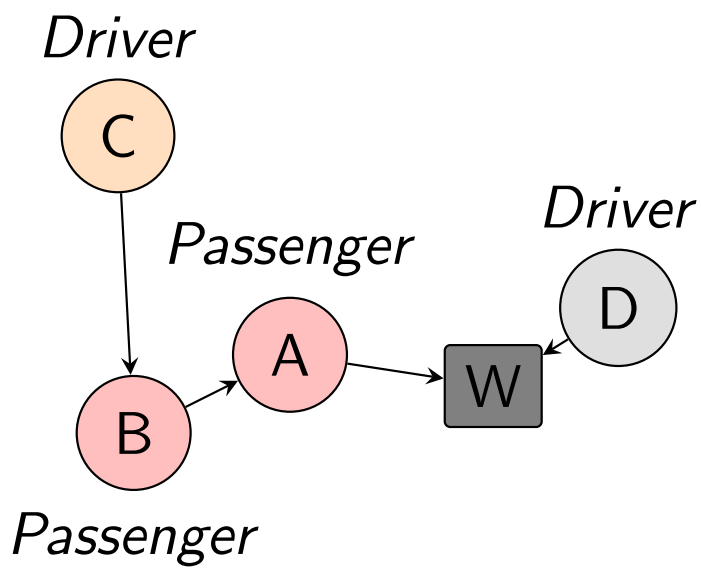
(b) Authorized advance = 10 min

The time window is of the form:
[(Latest arrival time - Authorized advance),Latest arrival time]
Similar thing after work, with the authorized wait.

Problem description: Problem class



(a) LCPP Day one



(b) LCPP Day two

LCPP must have regular users with a long-term commitment. We wanted a more flexible system, where users can change every day, and this class is called the DCPP.

[1] Vittorio Maniezzo, Roberto Wolfler Calvo - 2004

Problem description: State of the art

	Rus95	GLS96	LL03	PHDR04	BMM04	OB04	BB04	Kot04	MCH04	ML04	Cor06	BH06	HHJL08	PDH08	CV09	YC11	VCG+12	Guo12	HJL15
VRPPD																			
PDP																			
DARP																			
DCPP																			
LCPP																			

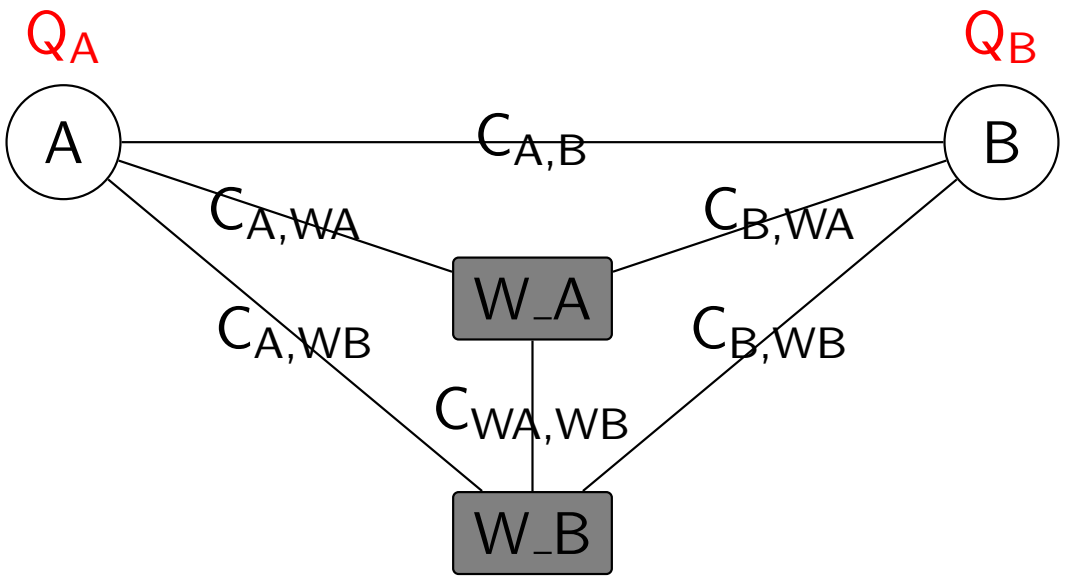
Exact
Heuristic
Both are developped
Hybrid

[1] All references in the report Romain NAVARRO - 2018

Outline

3 Modeling
- Data
- Decision variables
- Constraints summary
- Resolution process

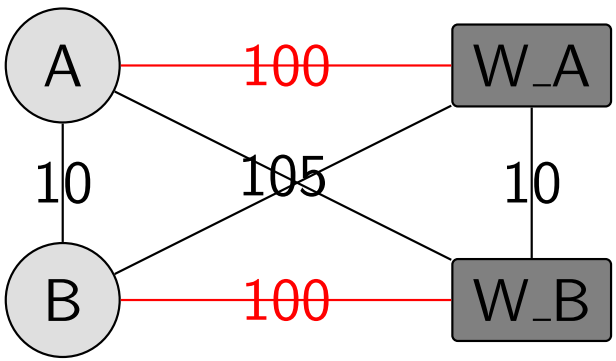
Modeling: Data



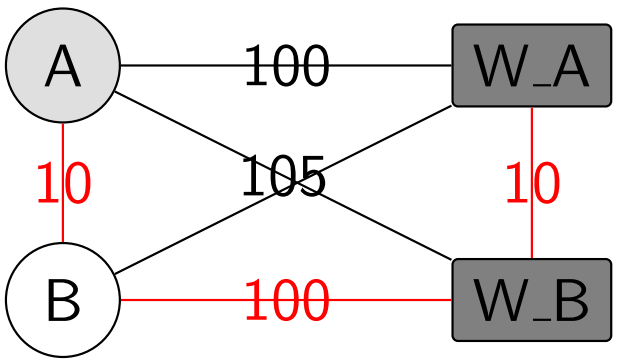
$$[(B_B - \alpha), B_B][E_B, (E_B + \beta)]$$

Modeling: Data

Max travel time of a vertex v = direct travel time$\times(1+\gamma)+\delta$

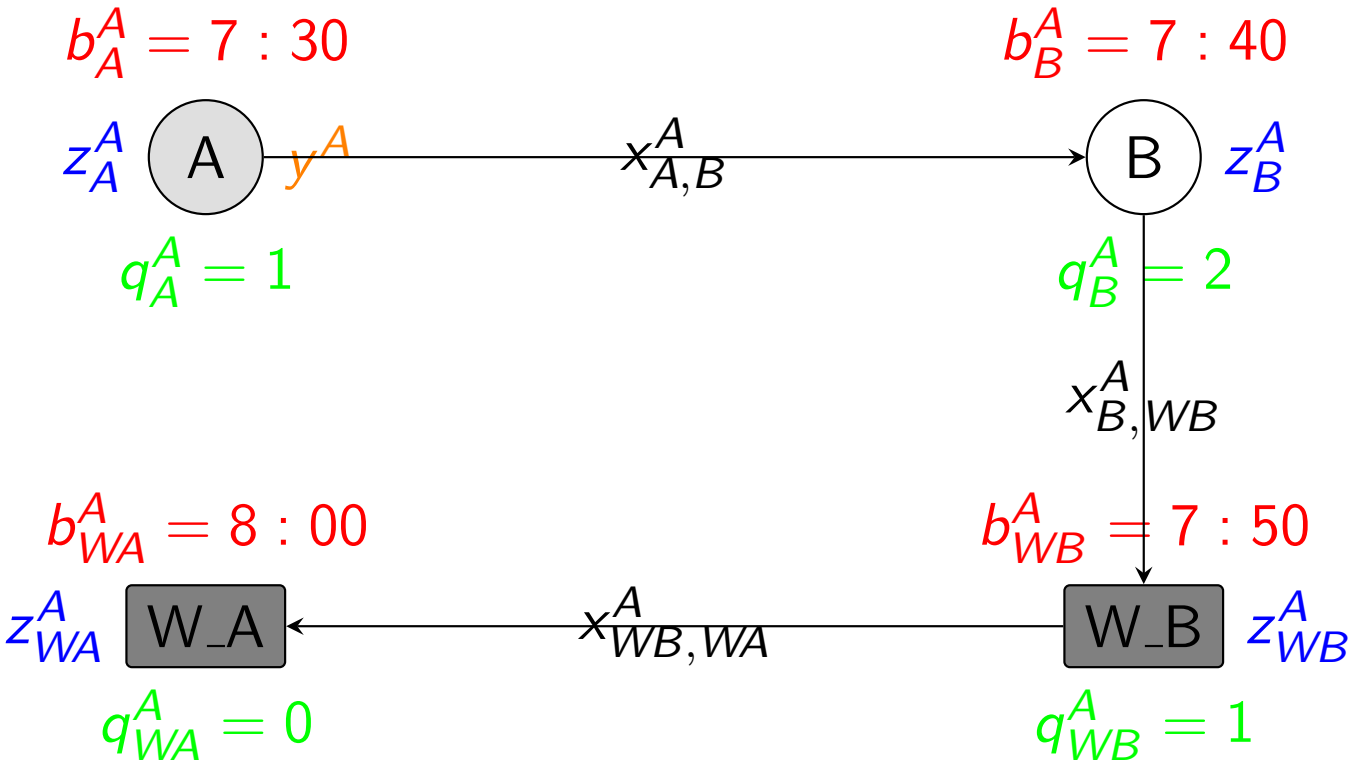


(a) Authorized deviation = 0%



(b) Authorized deviation = 20%

Modeling: Decision variables



Modeling: Constraints summary

Path constraints: (section 4.4.1 p32-33)

- Only a driver can pick-up passengers, and pick himself up
- A passenger picked up by a driver must be dropped by that driver
- An user never leaves his destination

Time constraints: (section 4.4.1 p33-34)

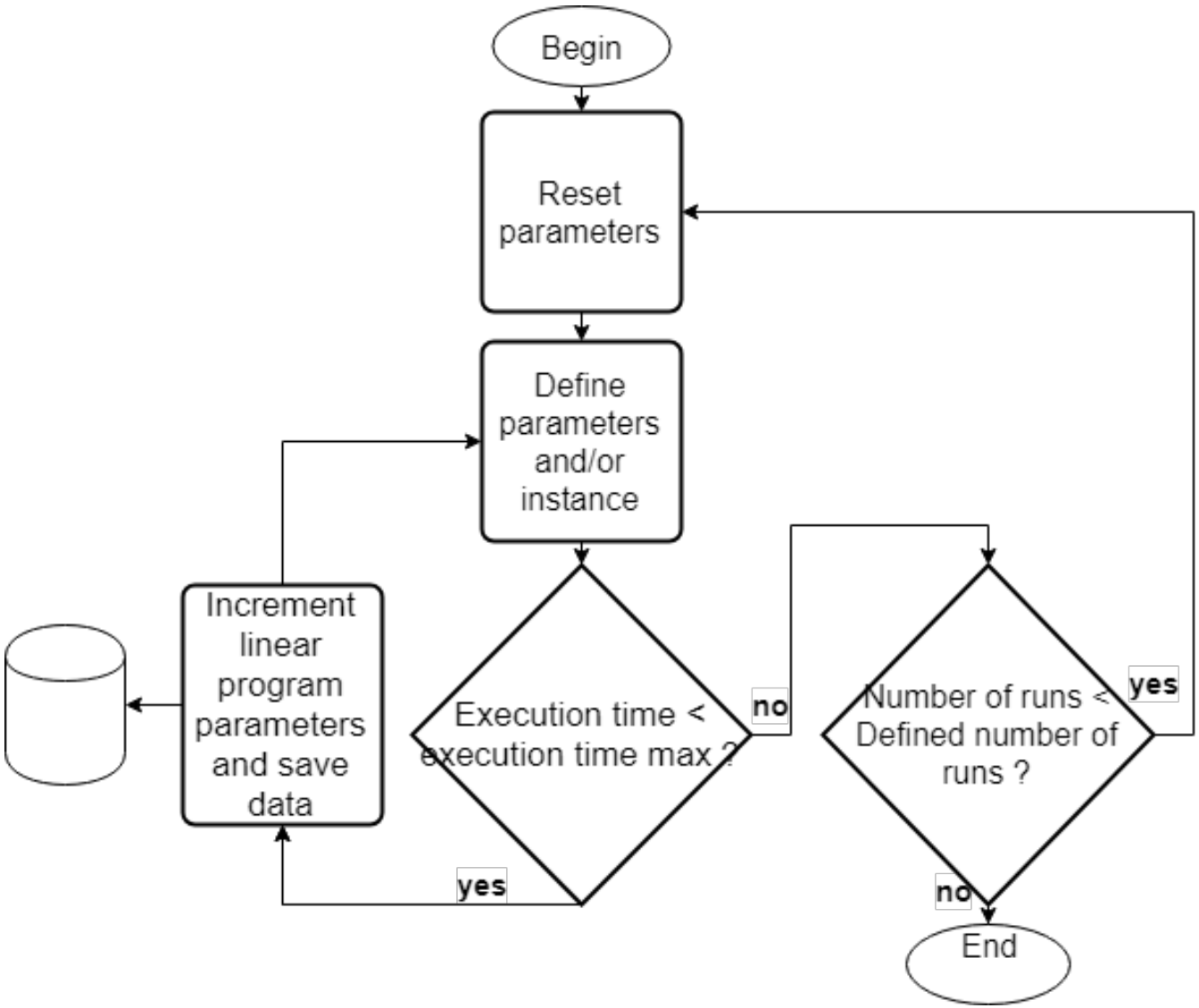
- The passage time at each vertex is precisely sequenced, respecting the time windows and max travel time constraints

Capacity constraints: (section 4.4.1 p34)

- The car's capacity at each vertex is precisely sequenced, and never exceeds its maximum capacity

[1] Hossein Karimi - 2018

Modeling: Resolution process



Outline

Experiments : Protocol

The PC used for the experiments:

- Operating System: **Windows 10 Professional 64-bit version**.
- Code language: **JAVA**
- Solver: **CPLEX**
- RAM quantity: **8GB**
- CPU: **Intel Core i5-4690 CPU 3.50 GHz**

All available at the following web address:
`https://github.com/NeoKa4ra/CarPoolingInternship`

Experiments: General parameters

- **Generator mode**: Associated Associated or dissociated program
- **Instances mode**: Change Does the instance have to change between each execution?
- **Number of runs** 30
- **Maximum execution time** 6 minutes
- **Maximum number of executions** 30

Experiments: Linear program parameters

- **Maximum advance time** 30 minutes
- **Maximum waiting time** 15 minutes
- **Percentage deviation** 20%
- **Fixed deviation value** 5

Experiments: Instances parameters

- **Instance mode**: 3 random cities and random workplaces
  Predefined cities, all random...
- **Number of users** 20
- **List of predefined cities and workplaces** None
- **Probability of having a second workplace** 20%
- **Probability of having a second home** 5%
- **Ranges in which the schedules will be generated**
  [8am,9am] and [4pm,9pm]

Experiments: Overall results

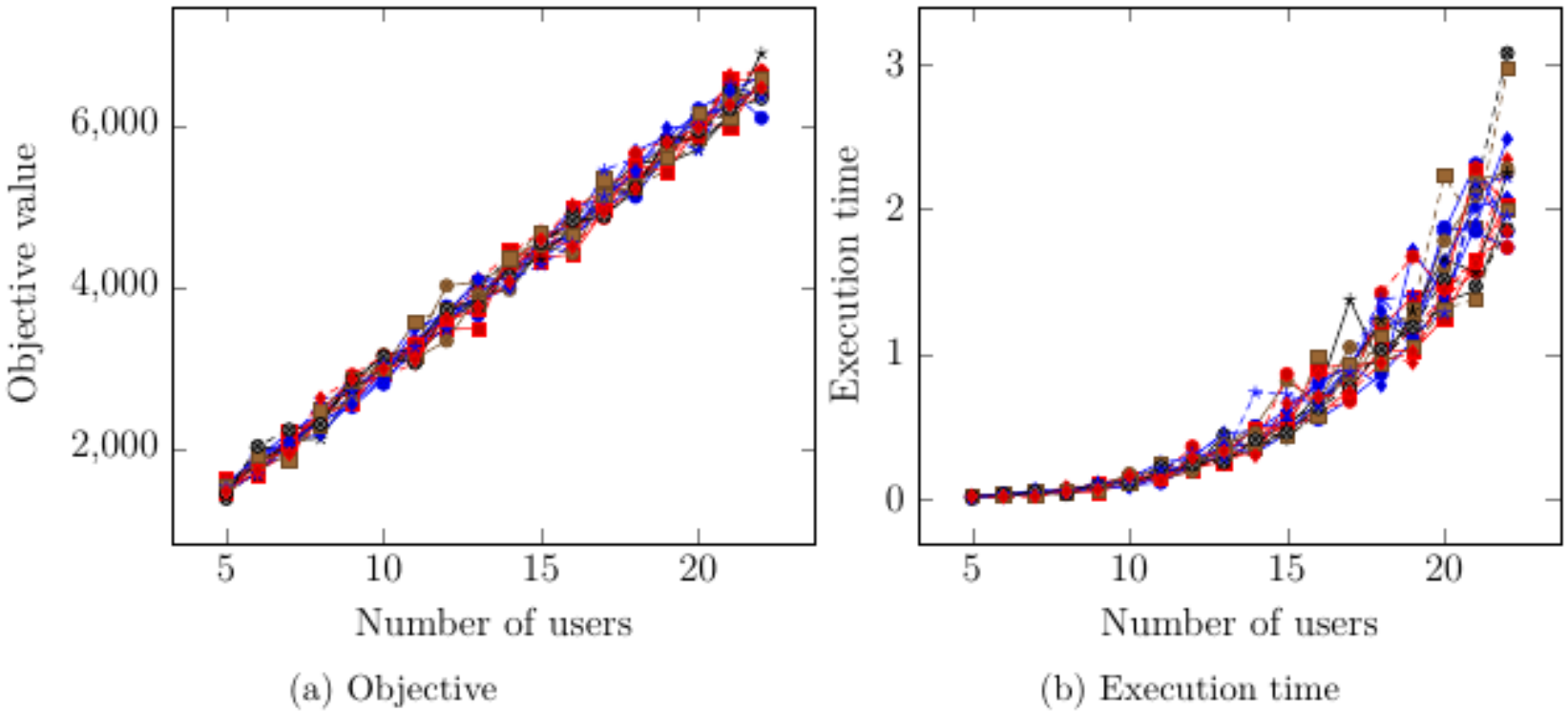


Figure: Vary users

Experiments: Overall results

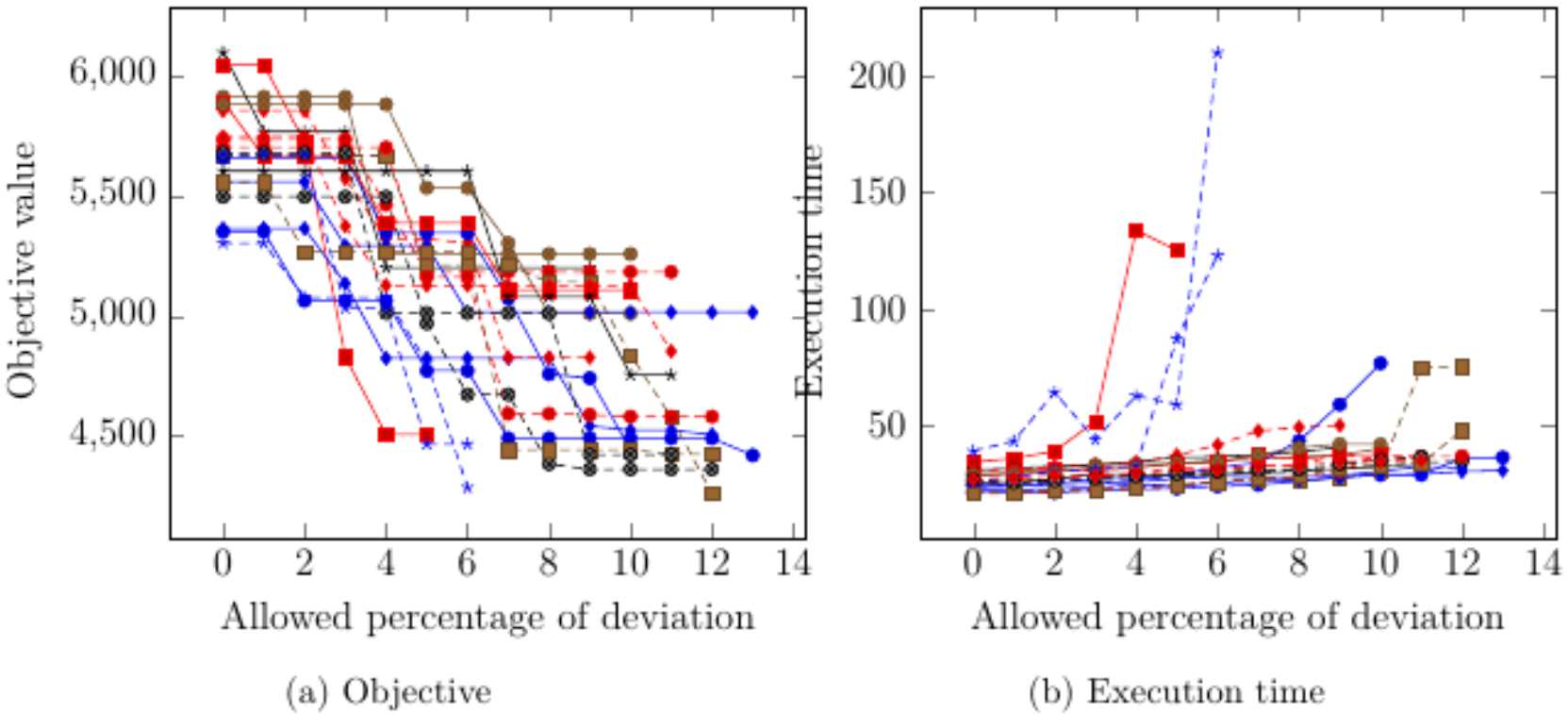


Figure: Vary the deviation percentage with 19 users

Experiments: Fill rate

Vehicle fill rate: Average number of people per car
Home-to-work daily commuting in France: from **1.1 to 1.2** people per car.

Hours generation range	5:00	1:00	0:00
Mean	1.14	1.38	1.81
Median	1.15	1.35	1.86
Standard deviation	0.09	0.12	0.21

The more users we have with close working hours, the higher the fill rate is .

[1] Quel est le taux doccupation d'une voiture ? - www.futura-sciences.com

Experiments : Same user pool

Same pool: much lower execution time

Table: Objective value with 5 users

Name of the data	LP	LPSP
Mean	48.96	50.04
Median	48.5	50.5
Standard deviation	15.26	15.32

Table: Objective value with 10 users

Name of the data	LP	LPSP
Mean	92.00	98.90
Median	88.00	95.5
Standard deviation	19.32	20.58

Objective difference with: 5 users: 2.20% ,10 users: 7.5%

Experiments: Limits of the model

We decided that having a maximum GAP of 2% on average was appropriate.
Less than 2% of GAP on 1 hour for 25 users.
Less than 10% of GAP on 1 hour for 30 users.
We can manage up to 25 people with the default configuration.

Experiments: The case of Grenoble

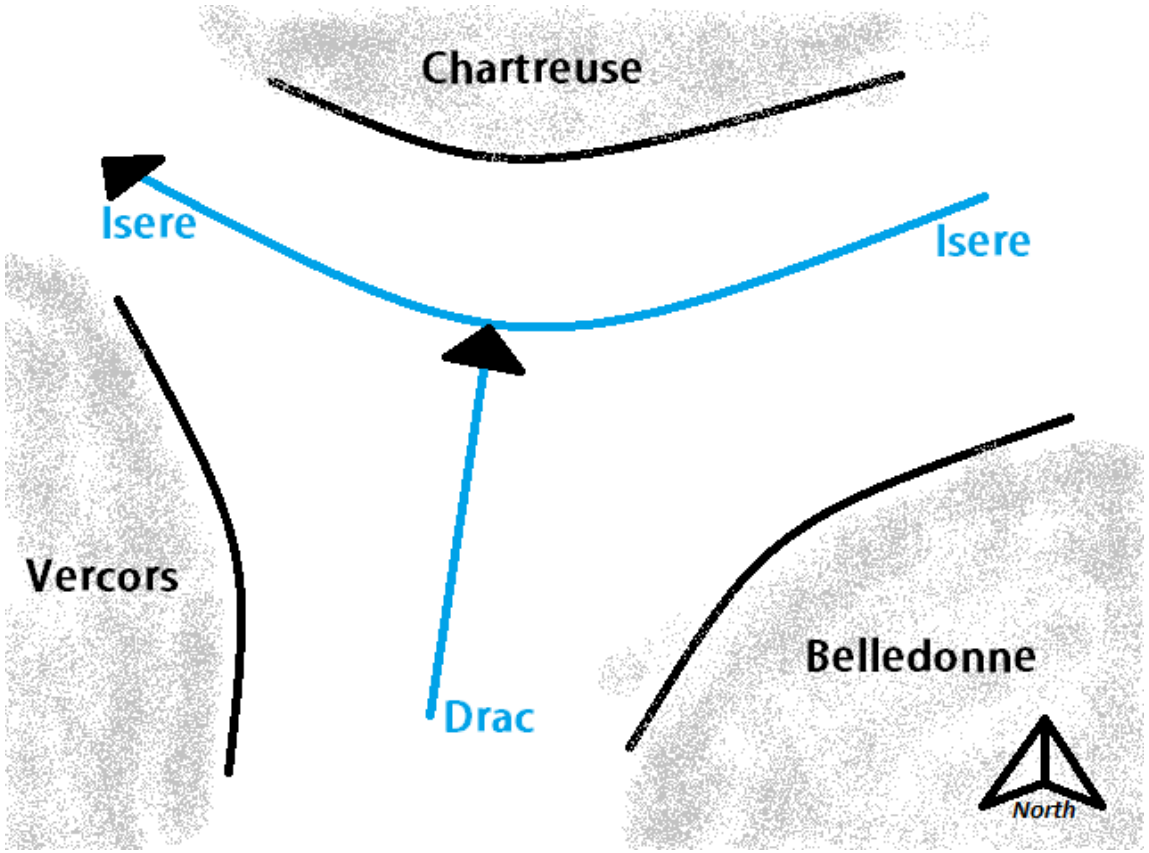


Figure: Mountains around Grenoble city

Experiments: The case of Grenoble

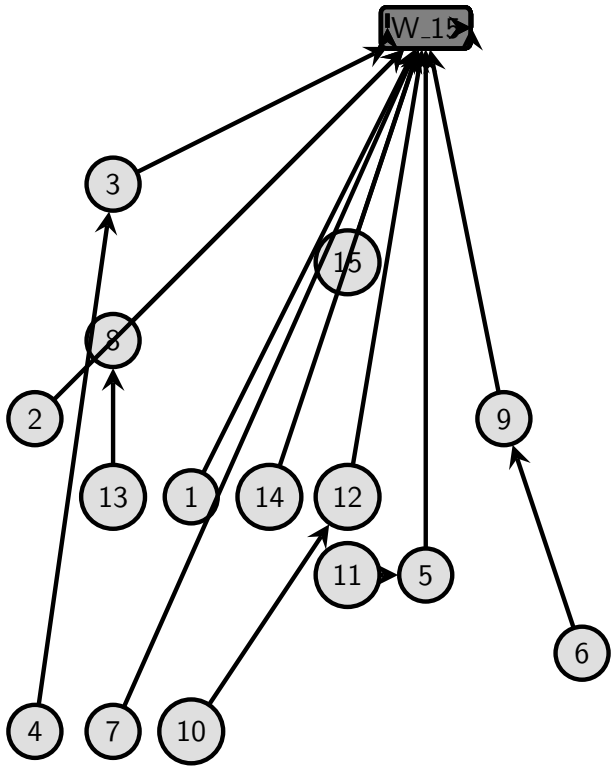


Figure: Home-to-work: VIZILLE PONT-DE-CLAIX VIF

Experiments: The case of Grenoble

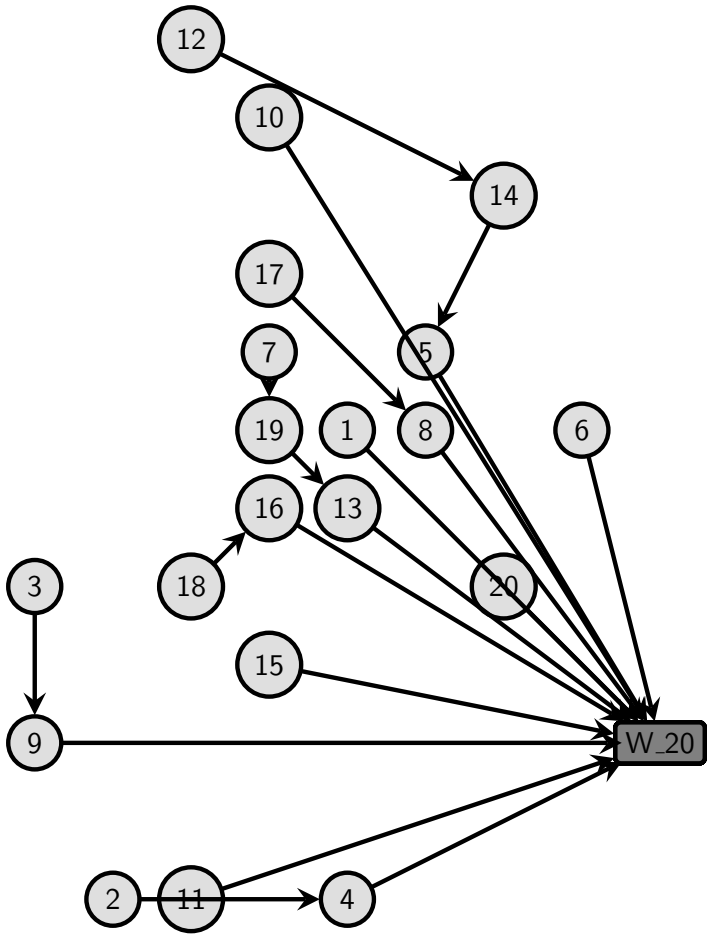


Figure: Home-to-work: VOIRON VINAY SAINT-LAURENT-DU-PONT

Experiments: The case of Grenoble

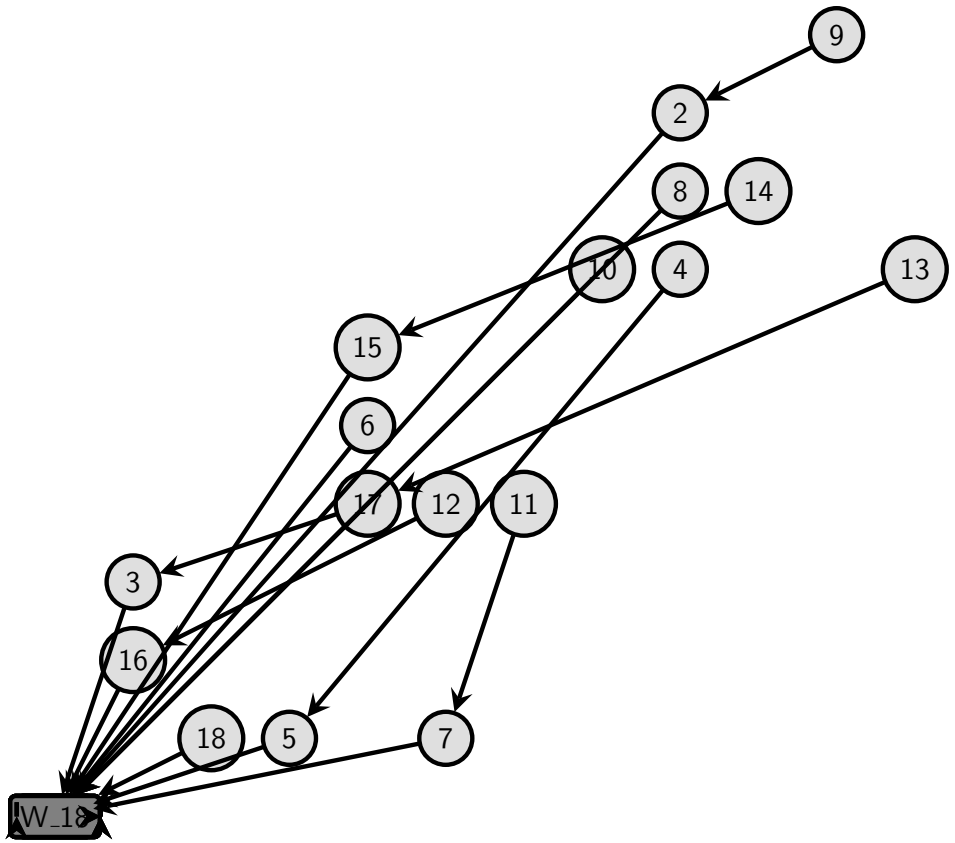


Figure: Home-to-work: PONTCHARRA LE-TOUVET CROLLES

Conclusion

Is not more complex than common CPP:

- Return Management
- One user with multiple workplaces
- Have respected and respectable schedules

Set up prospects:

- Parking relay before entering the valleys

Resolution prospects:

- Manage more users with a heuristic
  - Find the heuristics most appropriate to the particularities of Grenoble