Planificateur de trajet aérien

POLYTECH®
TOURS

Sommaire

01 → Gestion de Projet

02 → Travelling Salesman Problem (TSP)

03 → Coupe Breitling

04 → Interface

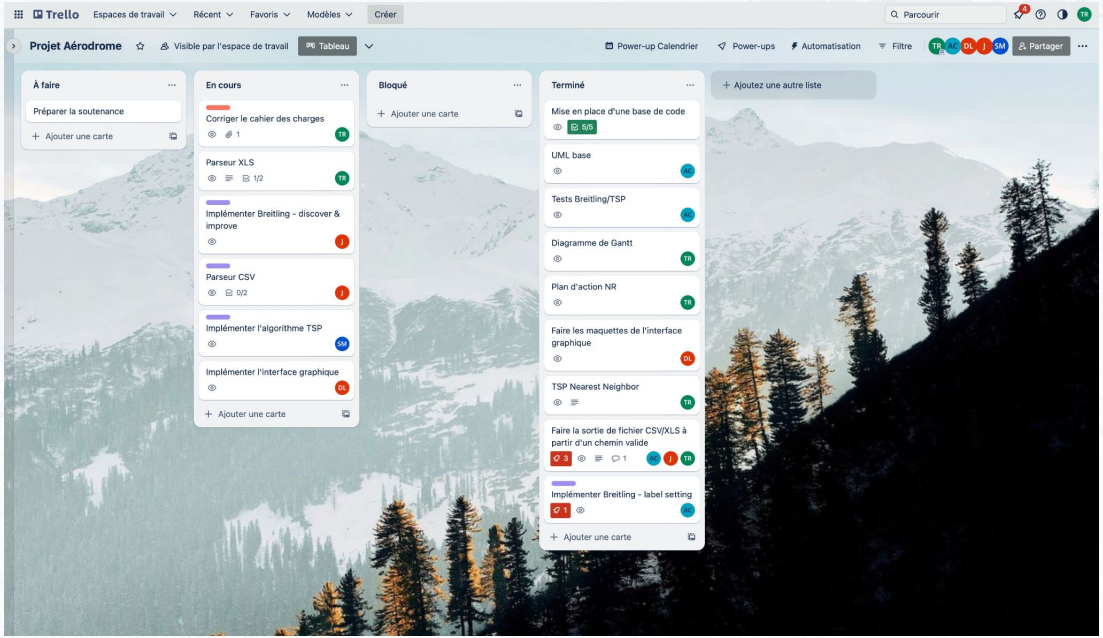
05 → Conclusion

01 →

Gestion de projet

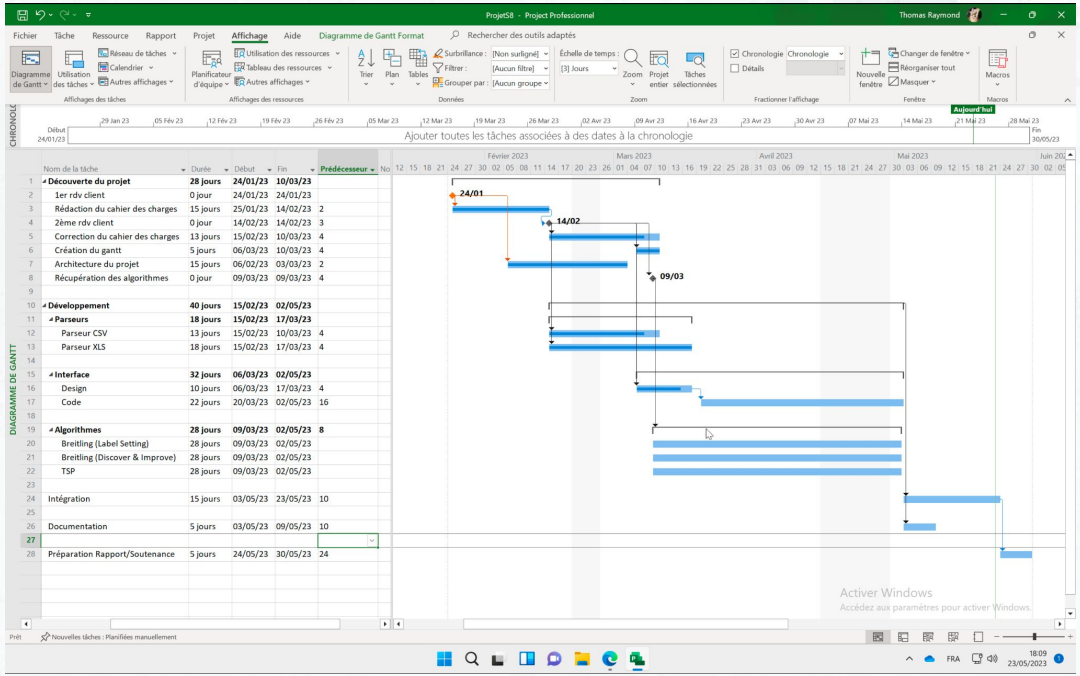
Gestion de projet

Trello

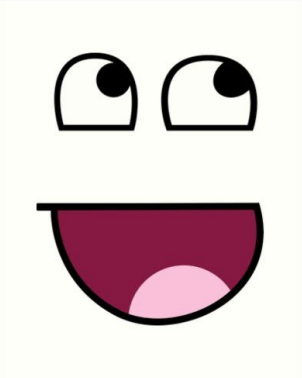


Gestion de projet

MS Project



Avant



Après

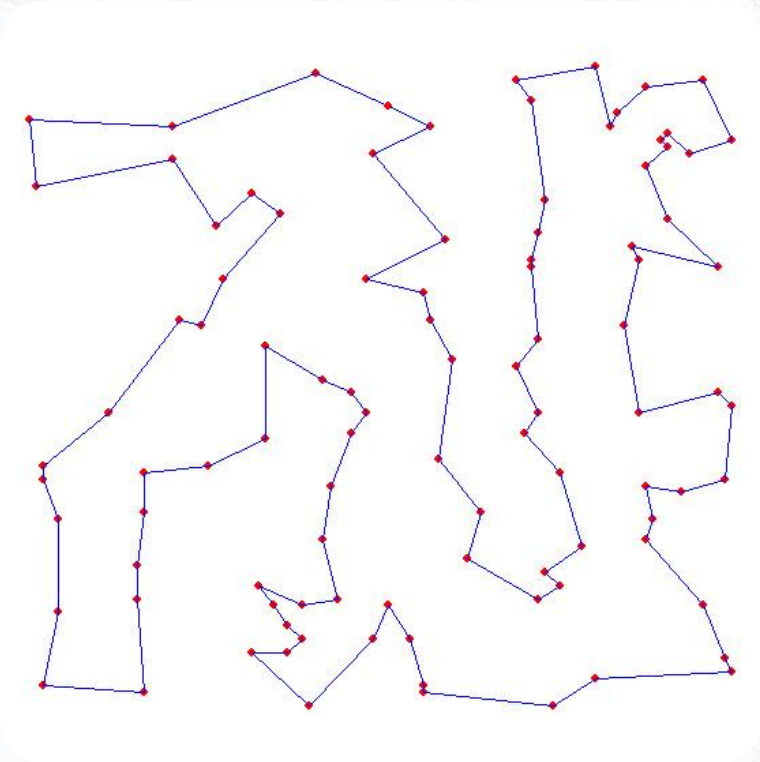
02 →

Travelling Salesman Problem (TSP)

Traveling Salesman Problem (TSP)

Problème NP-difficile

Aucun algorithme en temps polynomial



Traveling Salesman Problem (TSP)

Complexité algorithmique

Force brute : O(n!)

Nombre d'aérodromes	5	10	15	20
Nombre de solutions possibles	120	3'628'800	1'307'674'368'000	2'432'902'008'176'640'000
Temps de résolution (estimation)	60 µs	1.82 s	7j 13h	38'573 ans

Traveling Salesman Problem (TSP)

400! = 10^{868} =

6403452284662389526234797031950300585070258302600295945868444594280239716918683143627847864746326467629435057503585681084829816288351743522896198864680299793734165415083816242646194235230704624432501511444867089066277391491817331955996440709549671345290477020322434911210797593280795101545372667251627877890009349763765710326350331533965349868386831339352024373788157786791506311858702618270169819740062983025308591298346162272304558339520759611505302236086810433297255194852674432232438669948422404232599805551610635942376961399231917134063858996537970147827206606320217379472010321356624613809077942304597360699567595836096158715129913822286578579549361617654480453222007825818400848436415591229454275384803558374518022675900061399560145595206127211192918105032491008000000000

Traveling Salesman Problem (TSP)

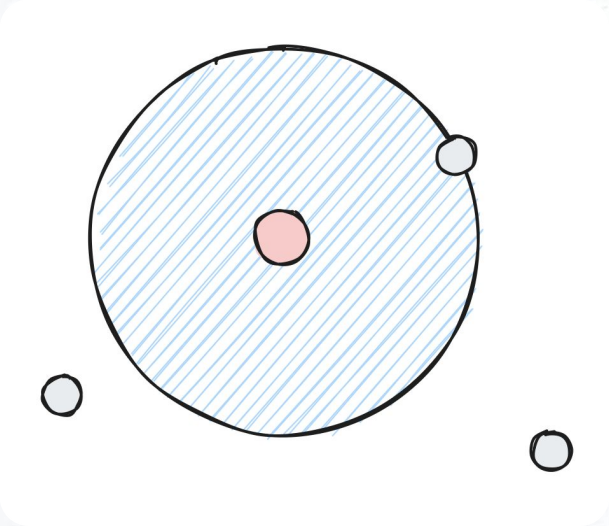
Complexité algorithmique

Programmation dynamique : $O(n^2 2^n)$

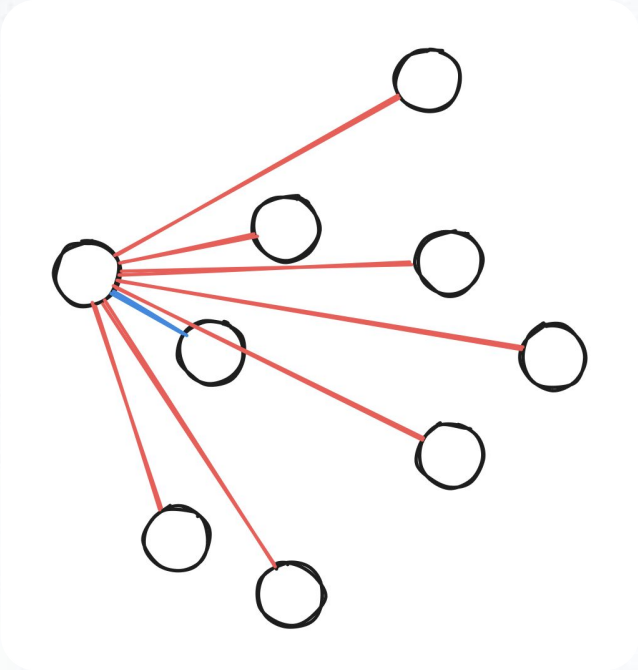
Nombre d'aérodromes	10	15	20	25
Nombre de solutions possibles	102'400	7'372'800	419'430'400	20'971'520'000
Temps de résolution (estimation)	51 ms	3.6 s	3.5 min	2.9 h

PPV

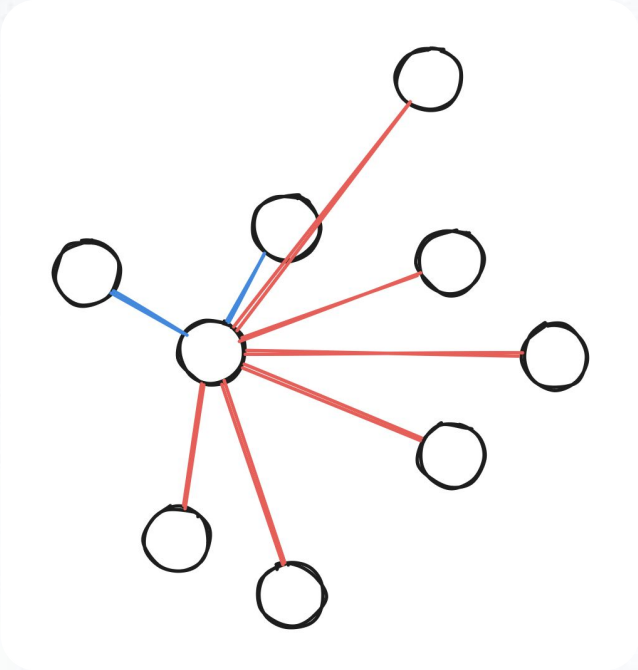
Plus proche voisin



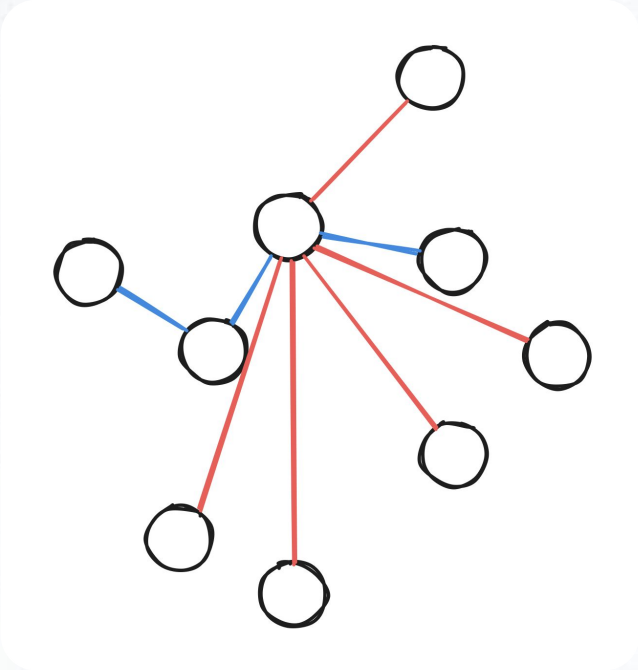
TSP - Plus proche voisin (PPV)



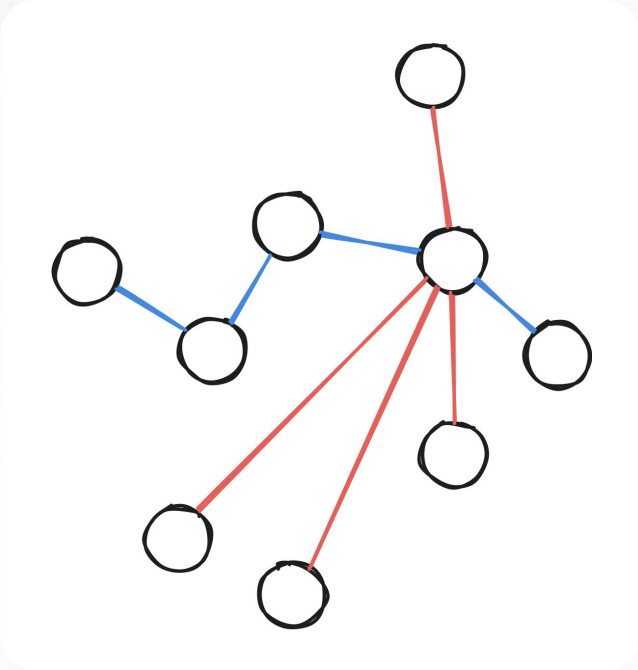
TSP - Plus proche voisin (PPV)



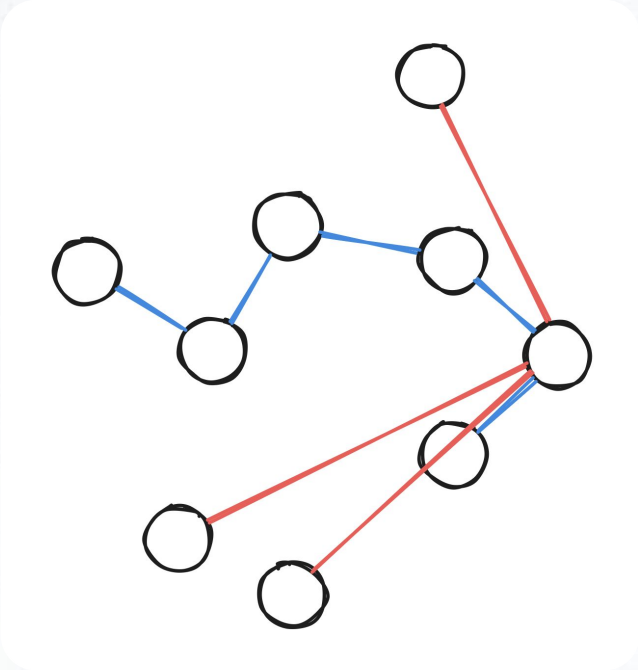
TSP - Plus proche voisin (PPV)



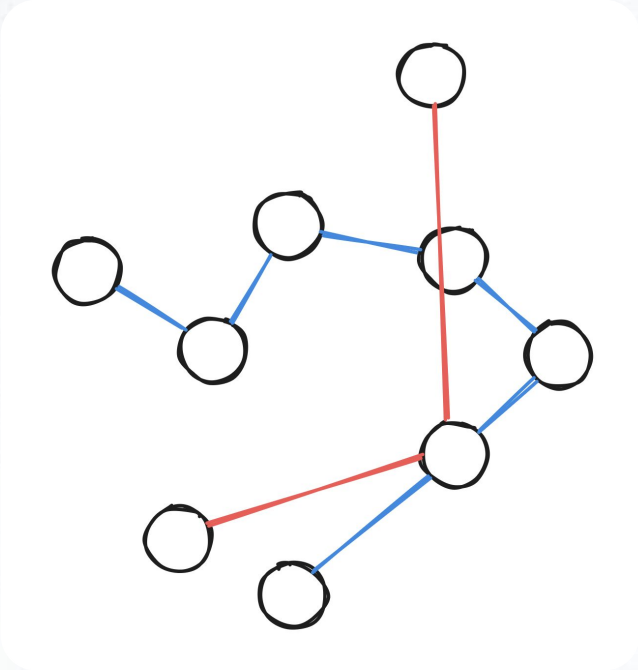
TSP - Plus proche voisin (PPV)



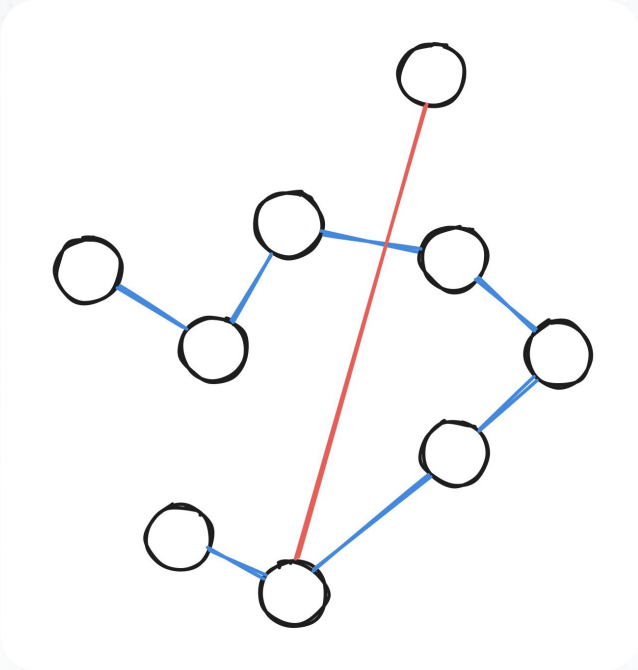
TSP - Plus proche voisin (PPV)



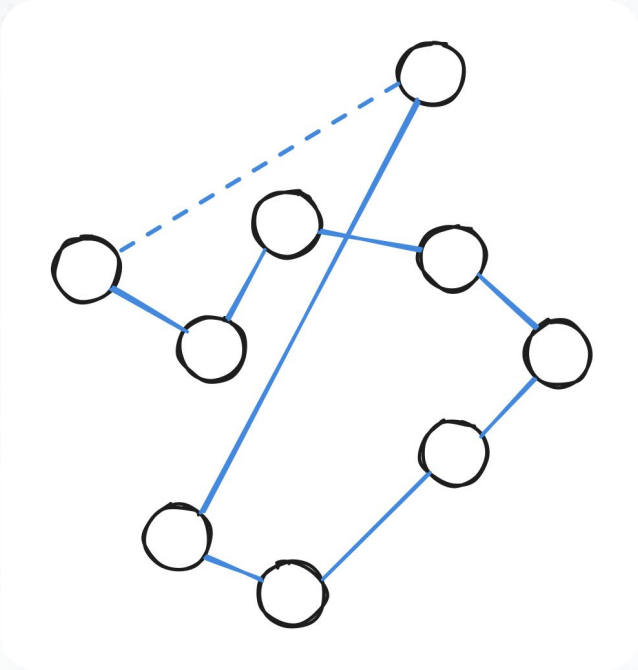
TSP - Plus proche voisin (PPV)



TSP - Plus proche voisin (PPV)



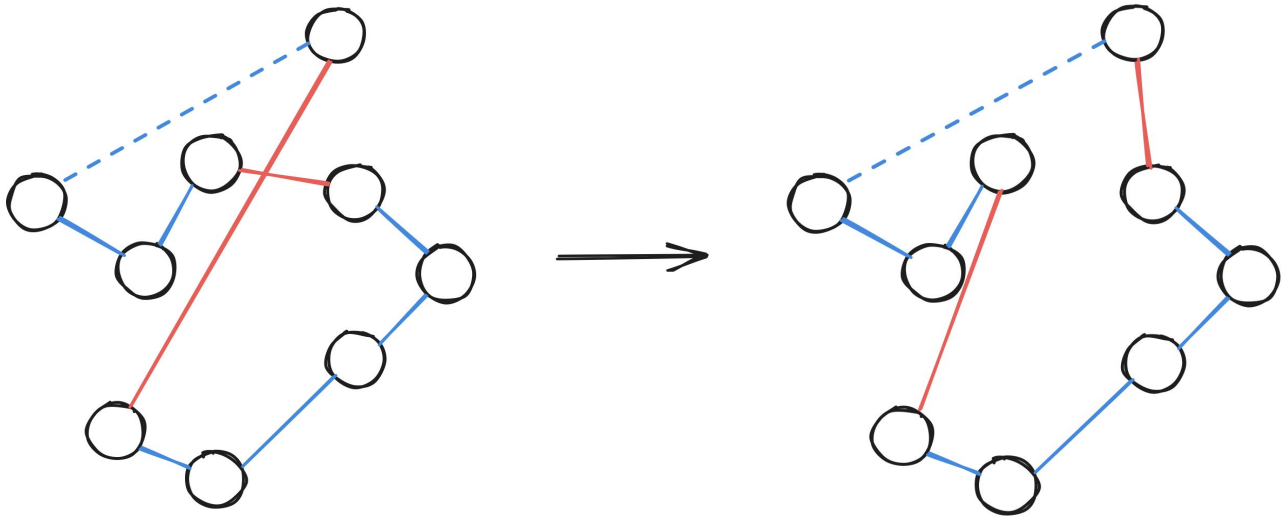
TSP - Plus proche voisin (PPV)



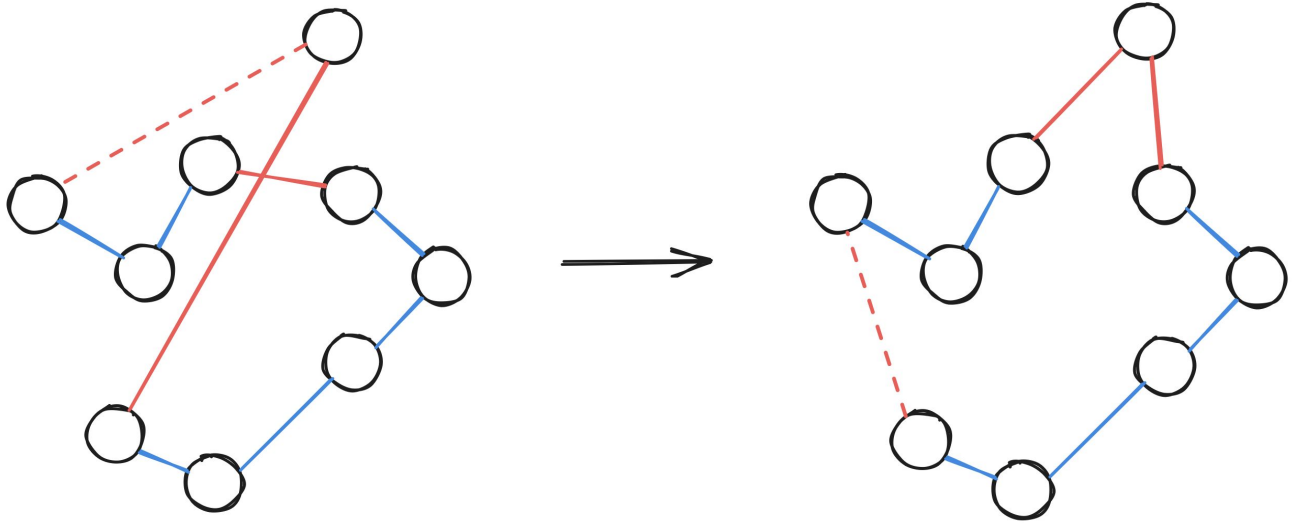
k-opt

Algorithme de recherche locale

2-opt



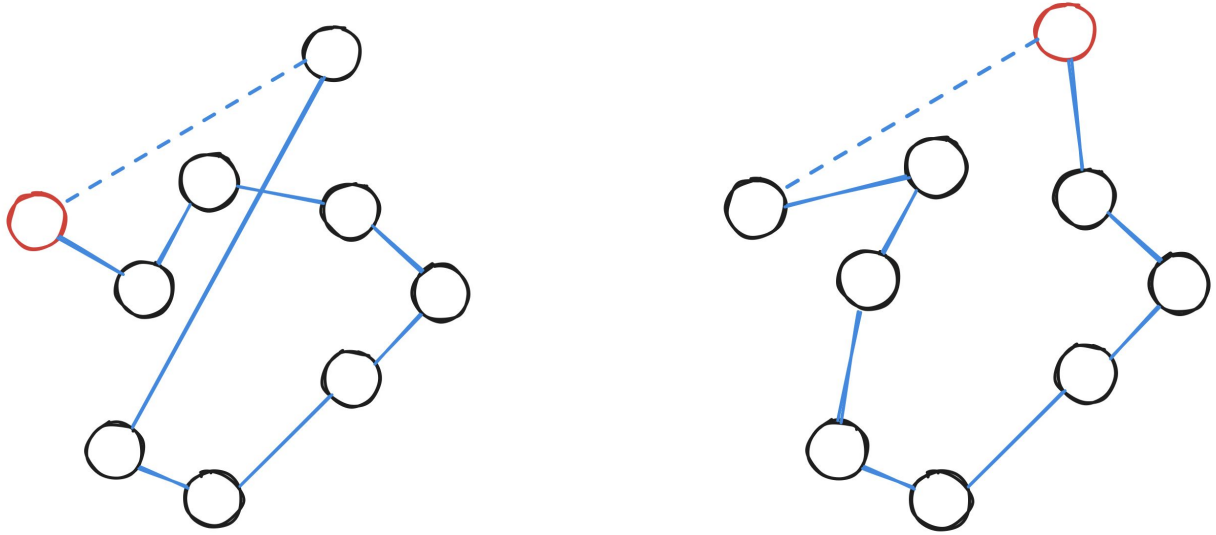
3-opt



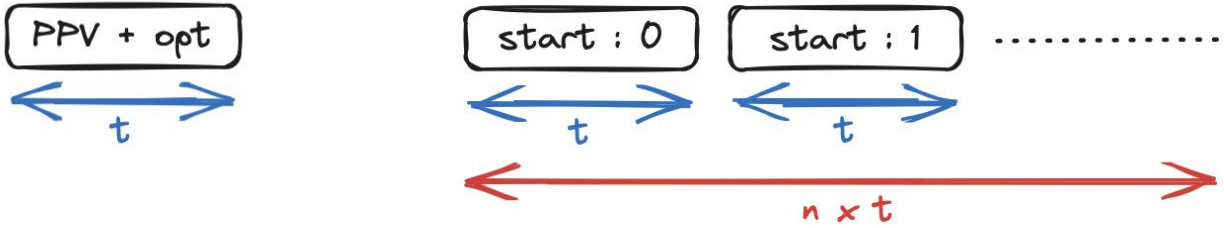
Multistart

Métaheuristique

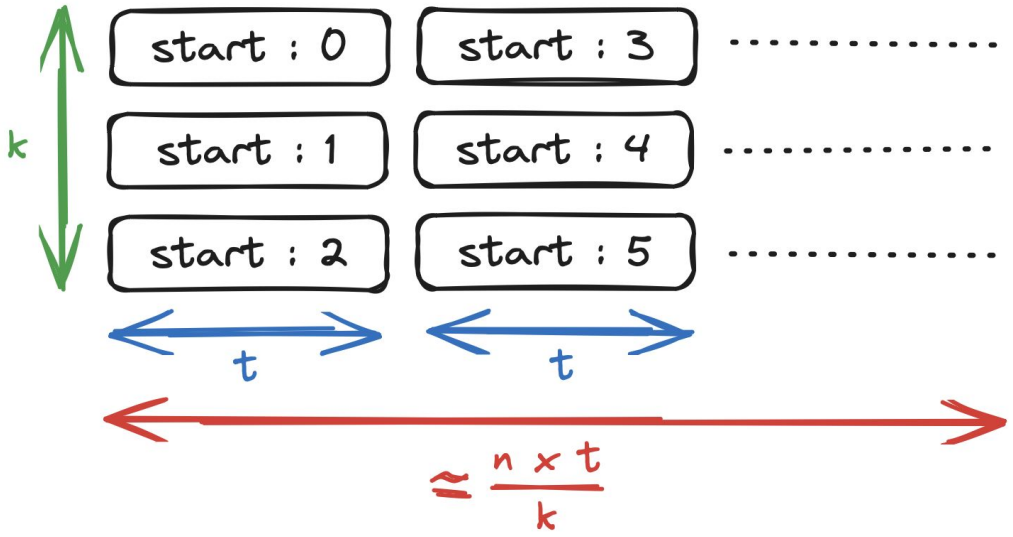
Multistart



Multistart

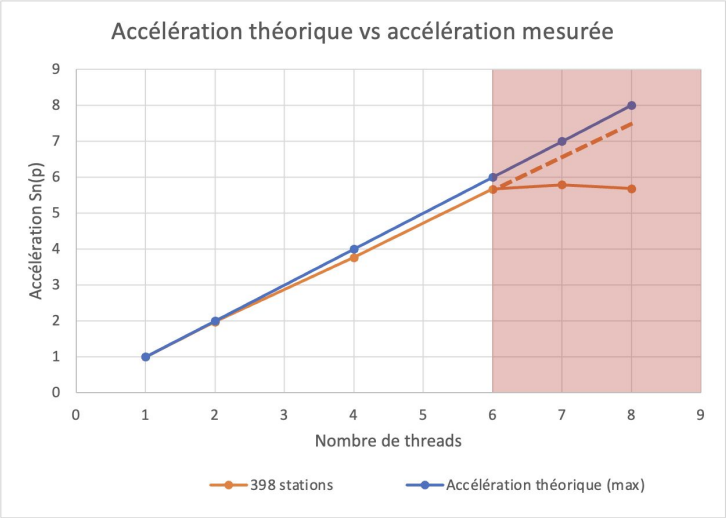


Multistart - Parallélisation



Multistart - Parallélisation

nbThread (p)	T(p)	S(p)	E(p)
1	45438	1	100%
2	23075	1,969	98%
4	12054	3,770	94%
6	8021	5,665	94%
7	7851	5,788	83%
8	7992	5,685	71%



TSP

Améliorations

TSP - Améliorations

- Concorde

85’600 villes

- Recherche locale

Autres algorithmes de recherche locale

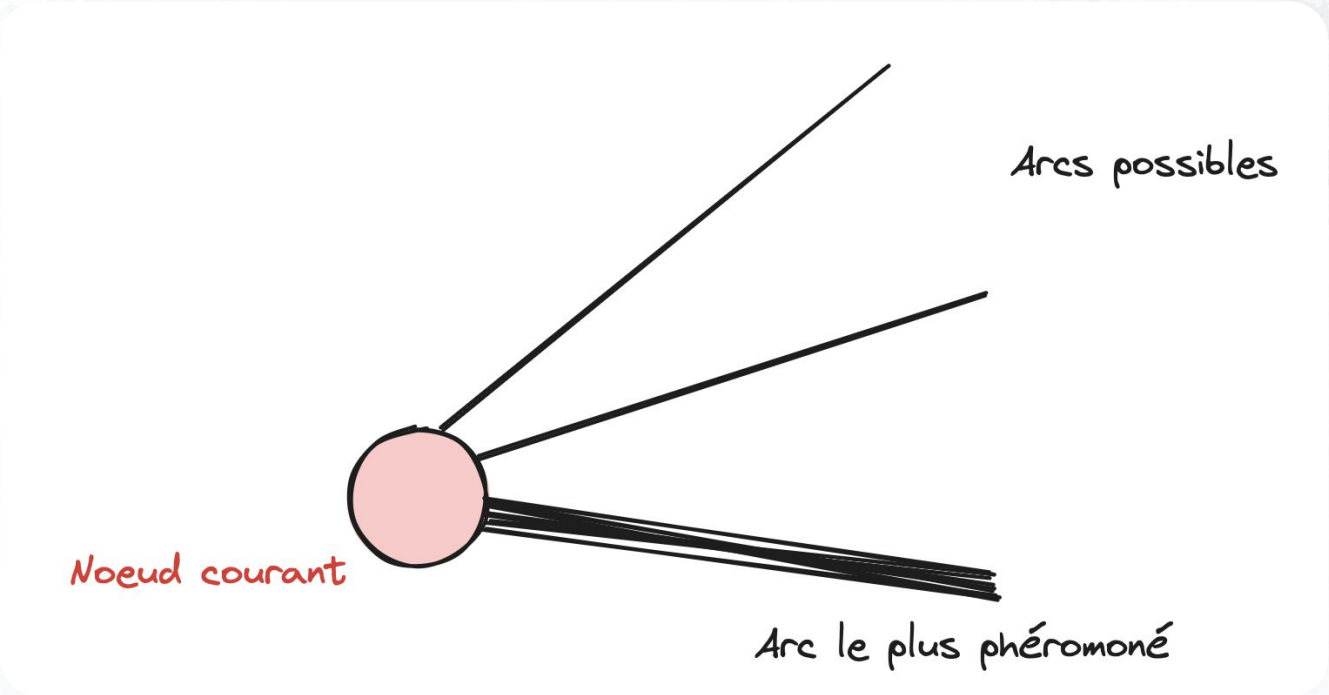
- Performances

Modèle (GeoMap/ProblemMap)

TSP

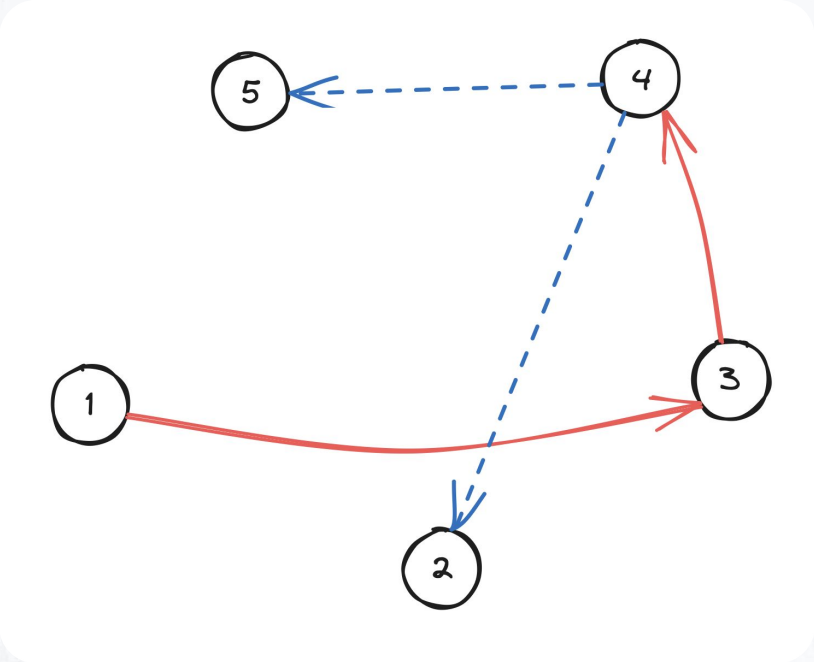
Algorithme de colonies de fourmis

TSP - Algorithme de colonies de fourmis

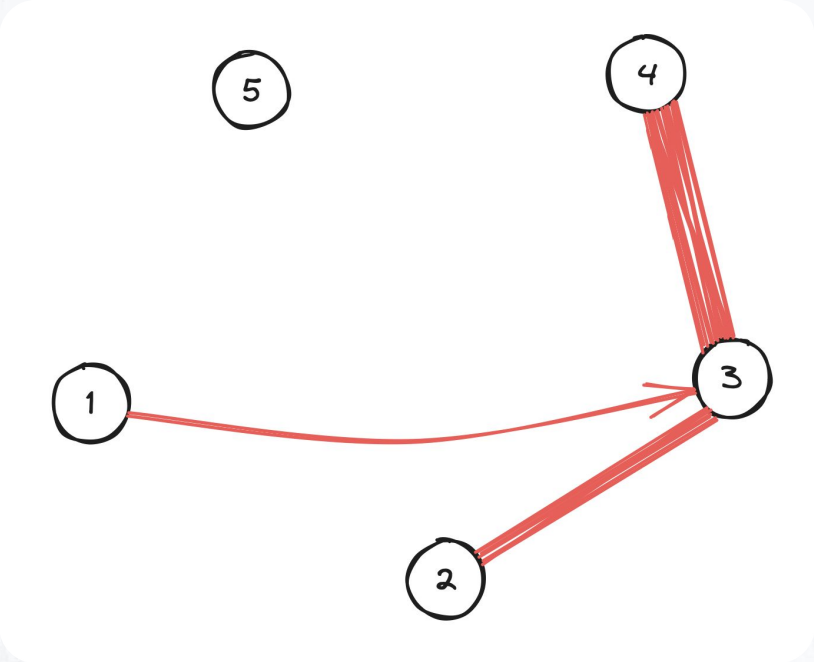


Algorithme de colonies de fourmis

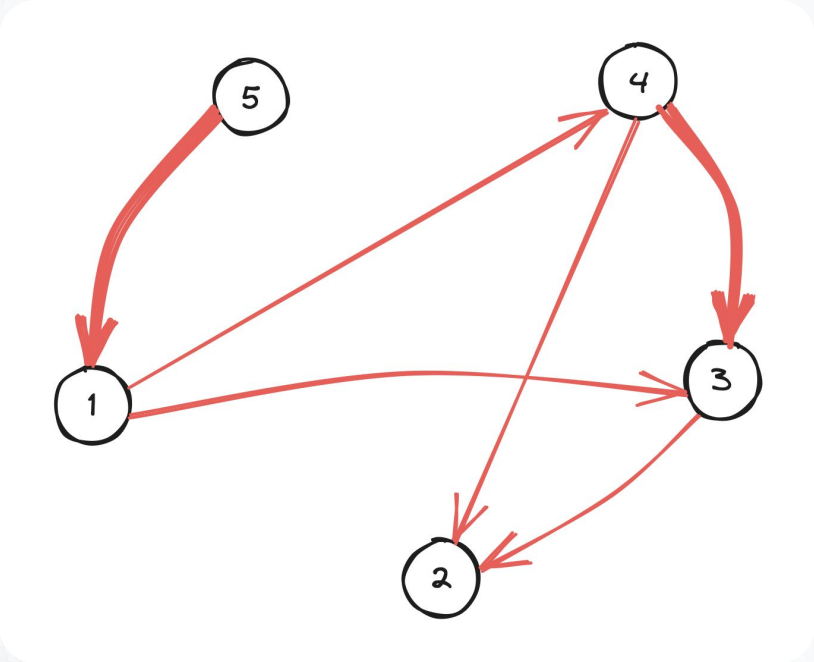
Choix pondéré des arcs



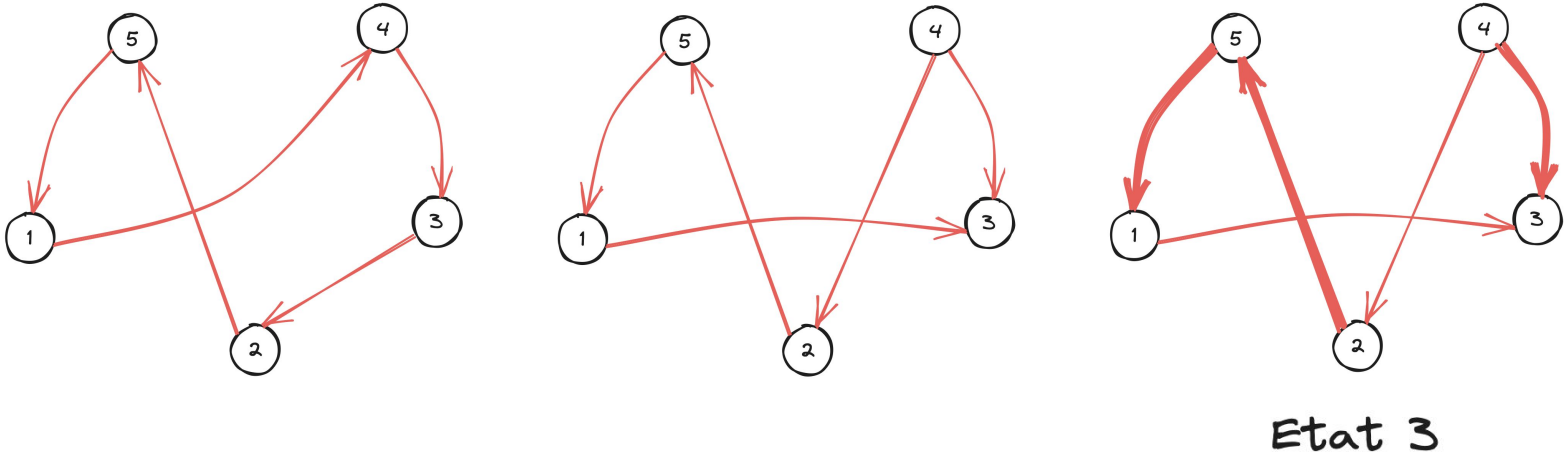
Algorithme de colonies de fourmis



Algorithme de colonies de fourmis



Algorithme de colonies de fourmis



Algorithme de colonies de fourmis

- Évaporation des phéromones

Diminution du taux de phéromones par un simple calcul de pourcentage

- Critère d’arrêt

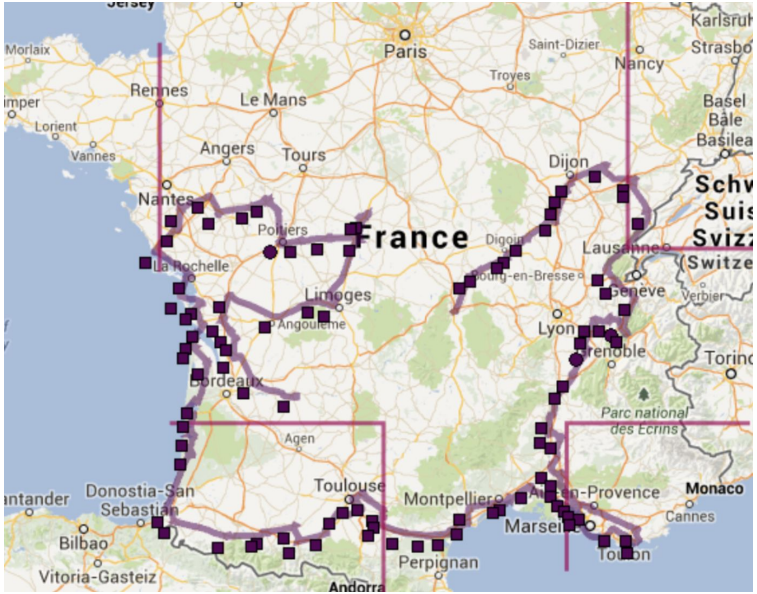
Fixer un nombre d’itérations

03 →

Coupe Breitling 100/24

Le défi Breitling

- 100 villes
- 24h
- 4 zones
- Fuel
- Gestion d’accessibilité



Coupe Breitling

Complexité algorithmique

Force brute : $N \times (N-1) \times (N-2) \ldots (N-100) = \binom{N}{100}$

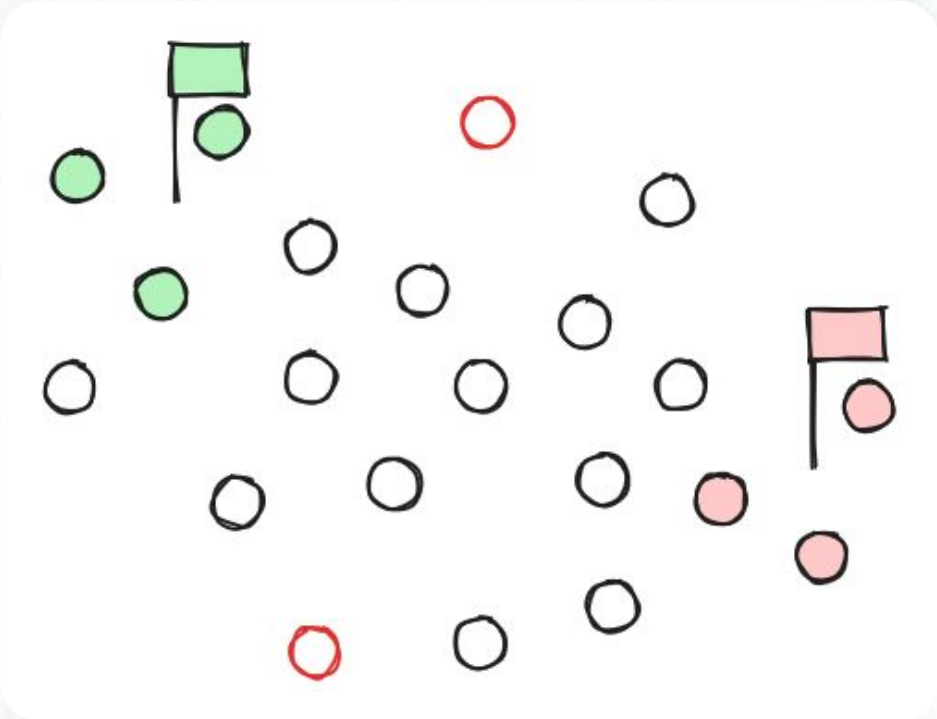
Choix d'arrêt : $2N \times 2(N-1) \times 2(N-2) \ldots 2(N-100) = \binom{N}{100} 2^{100}$

$$\binom{400}{100} 2^{100} \simeq 10^{126}$$

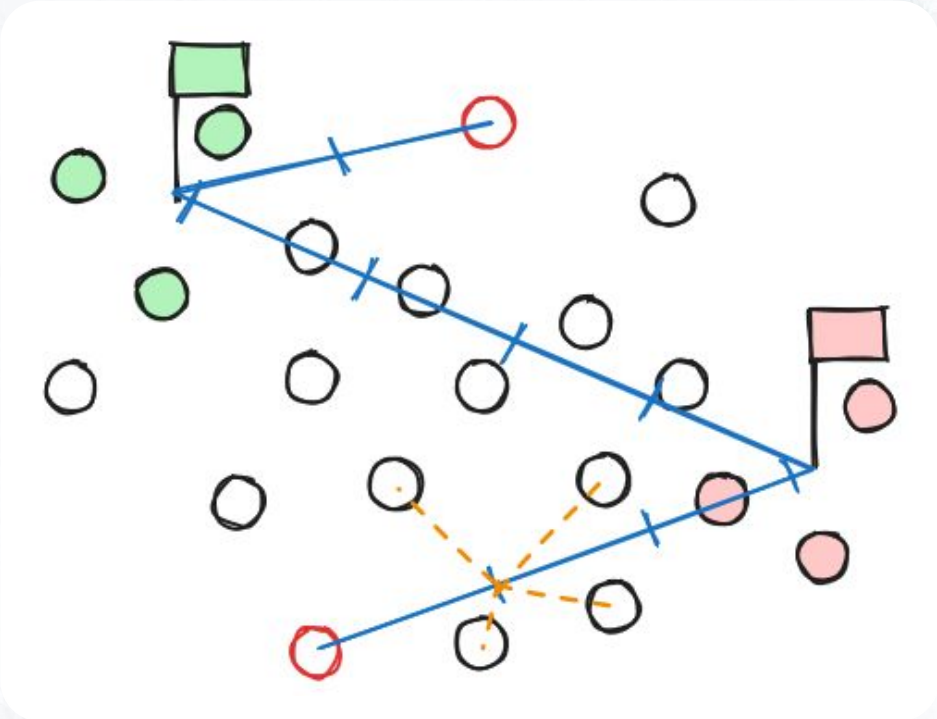
Coupe Breitling

Solution naturelle

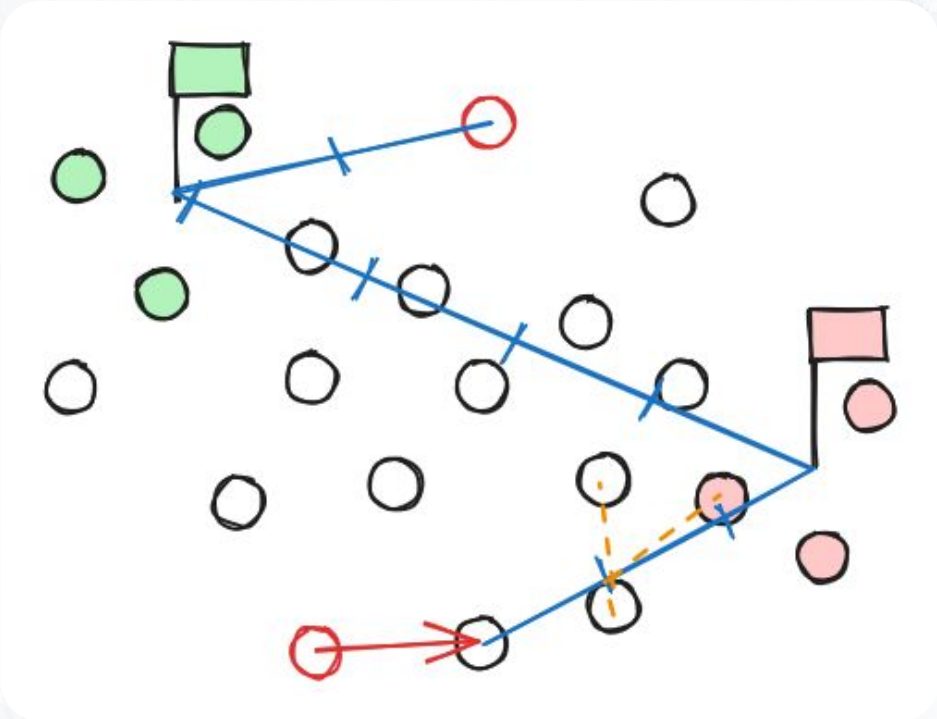
Coupe Breitling - Solution naturelle



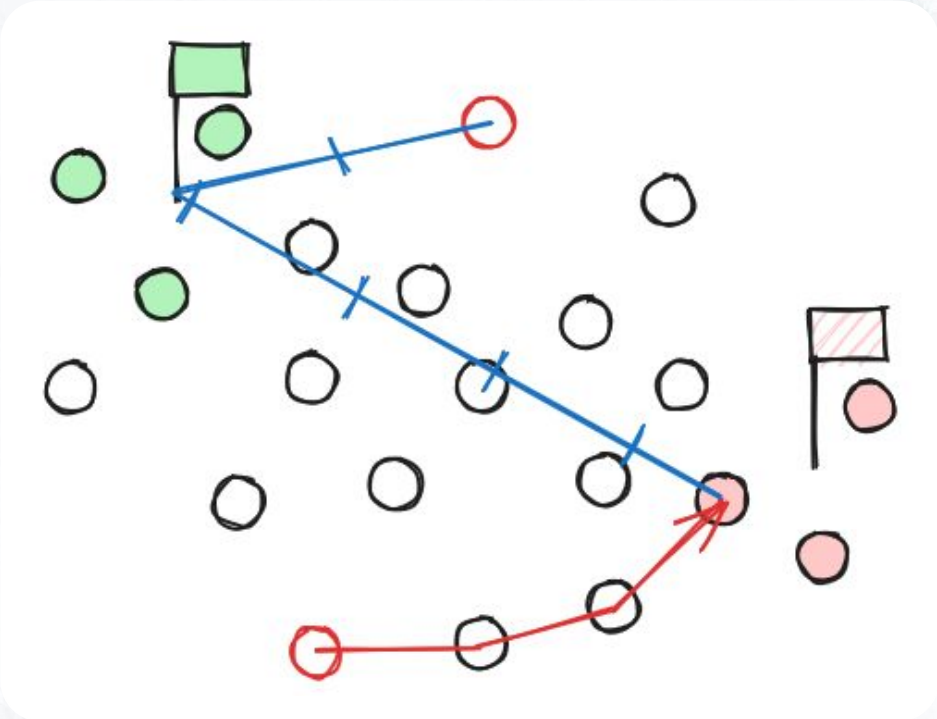
Coupe Breitling - Solution naturelle



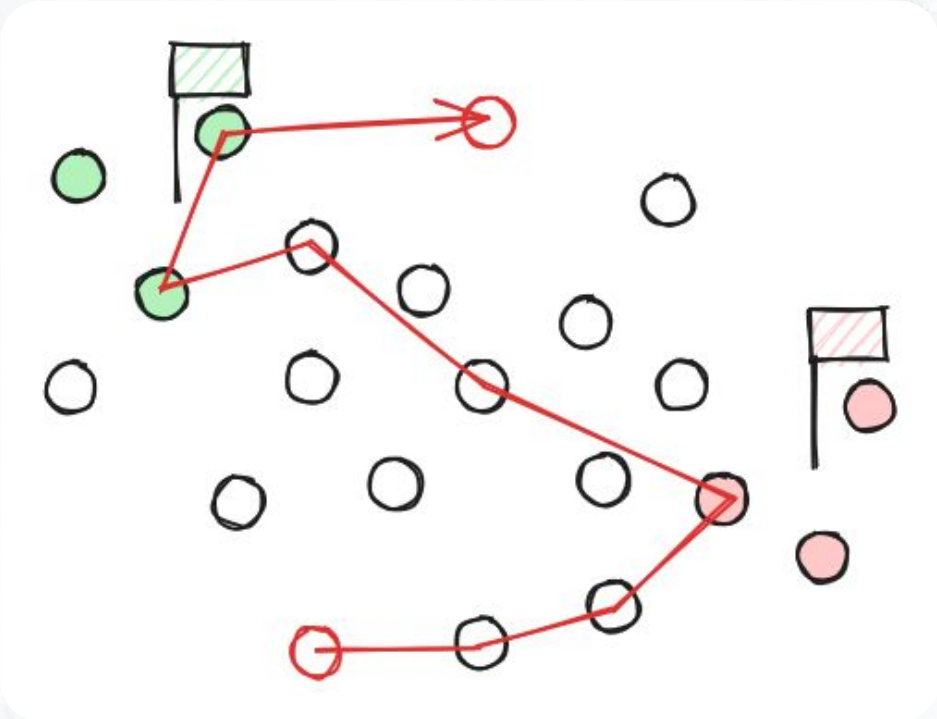
Coupe Breitling - Solution naturelle



Coupe Breitling - Solution naturelle



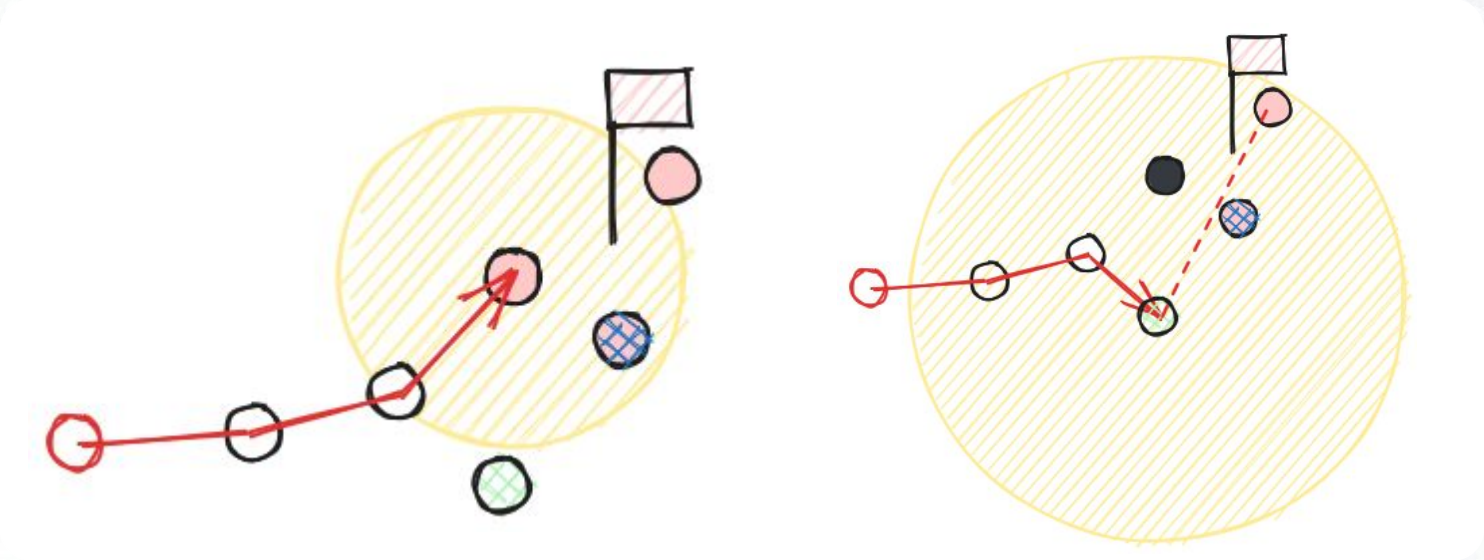
Coupe Breitling - Solution naturelle



Coupe Breitling - Solution naturelle

- Contraintes d’autonomie
- Contraintes sur les aérodromes de nuit

Retour en arrière



Coupe Breitling

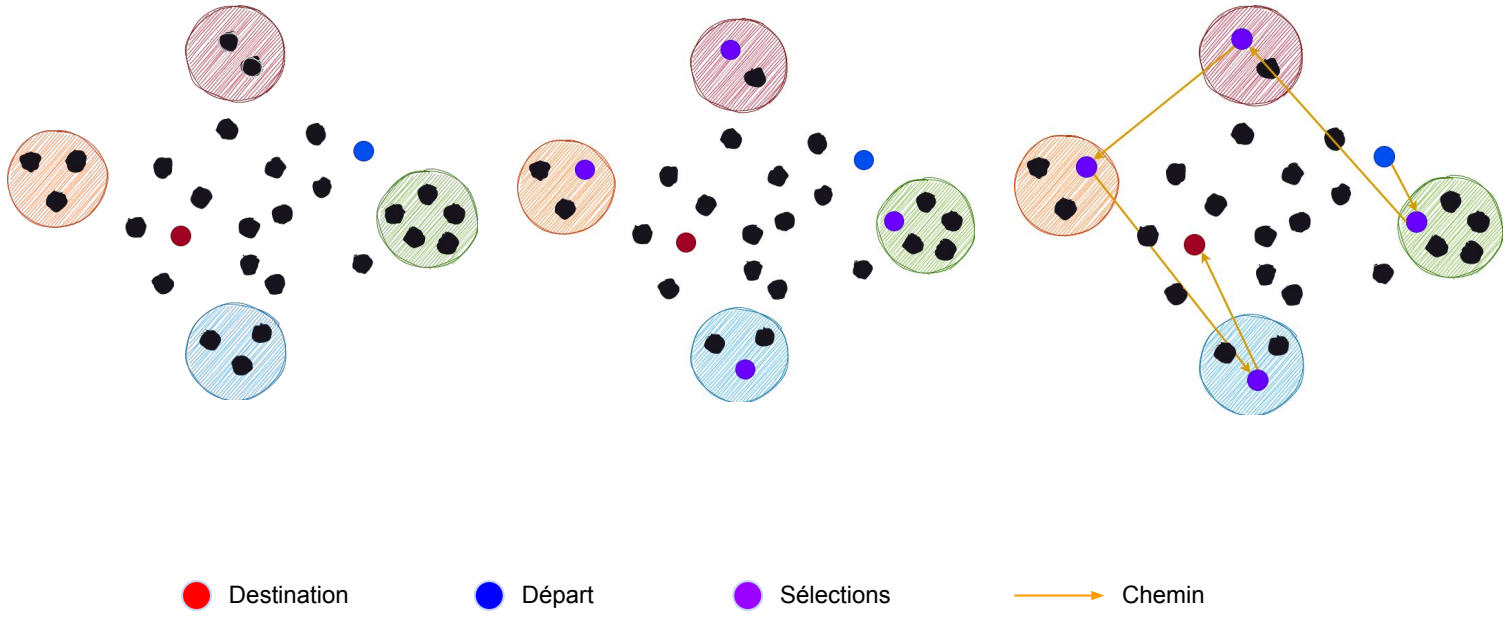
Construction Par Optimisation (CPO)

CPO – Etapes

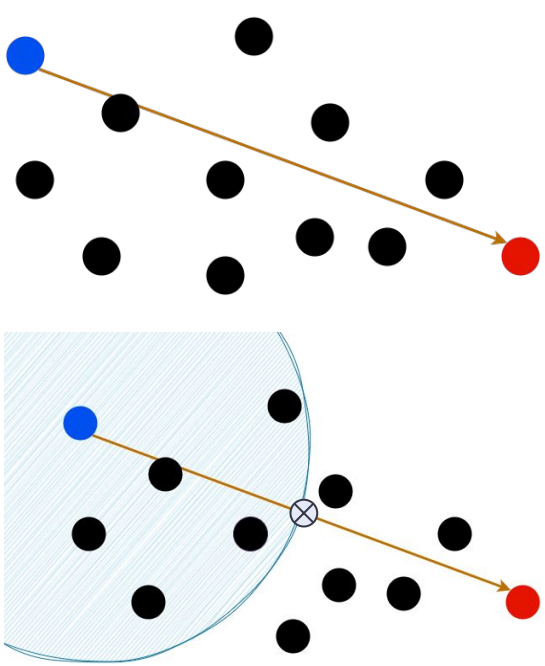
- Sélection des régions

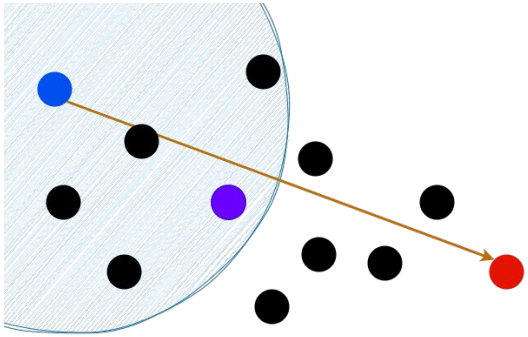
- Sélection des stations

CPO - Sélection des régions



CPO - Sélection des stations





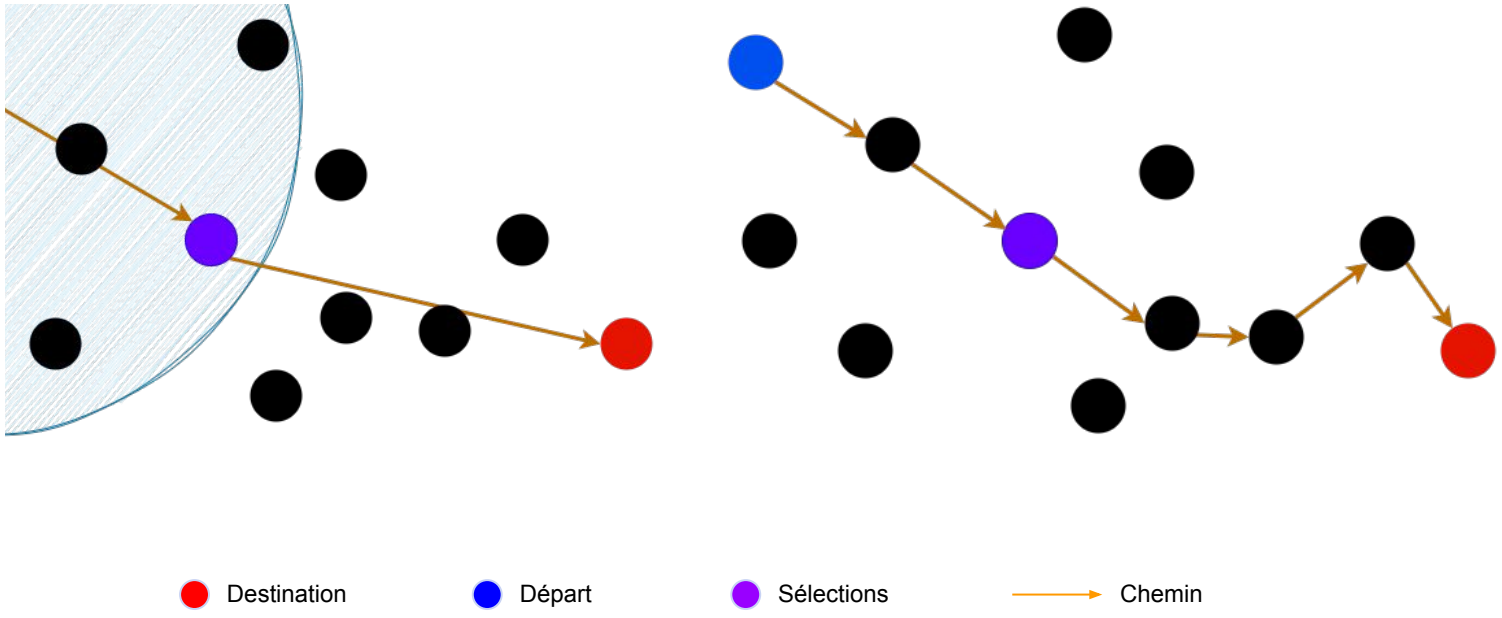
Destination

Départ

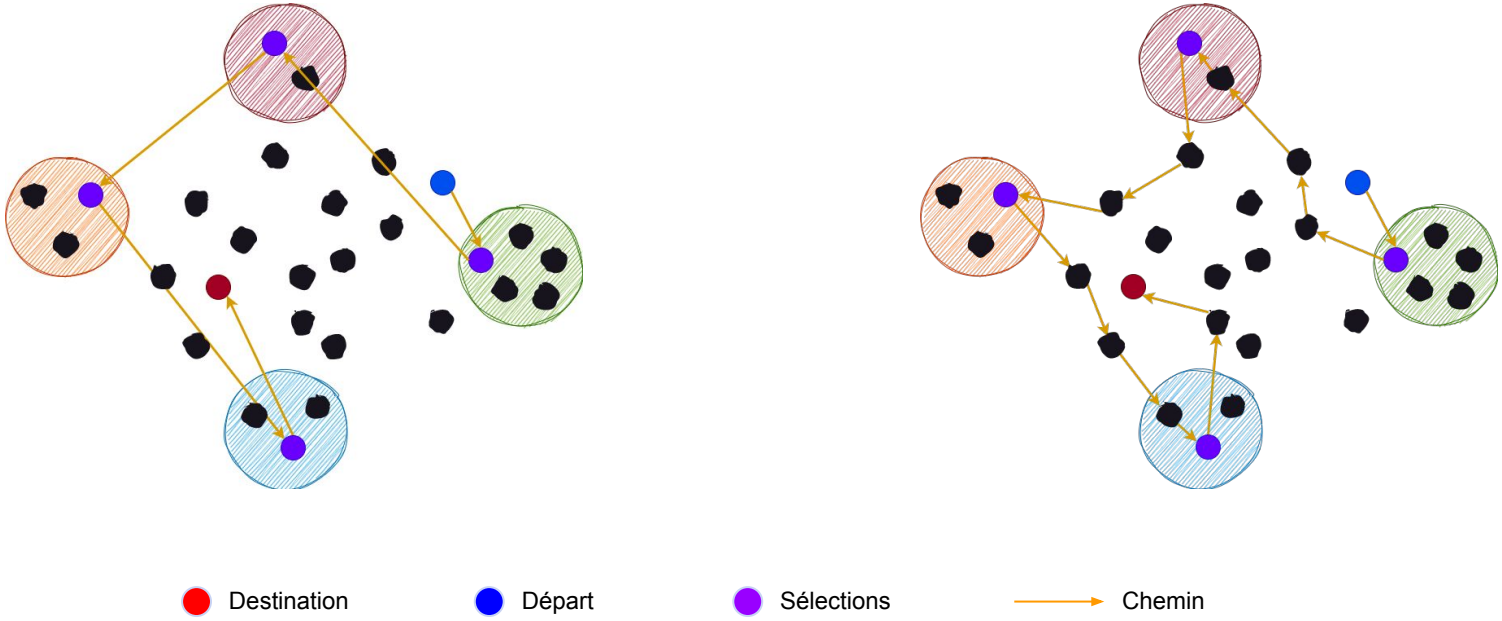
Sélections

Chemin

CPO - Sélection des stations



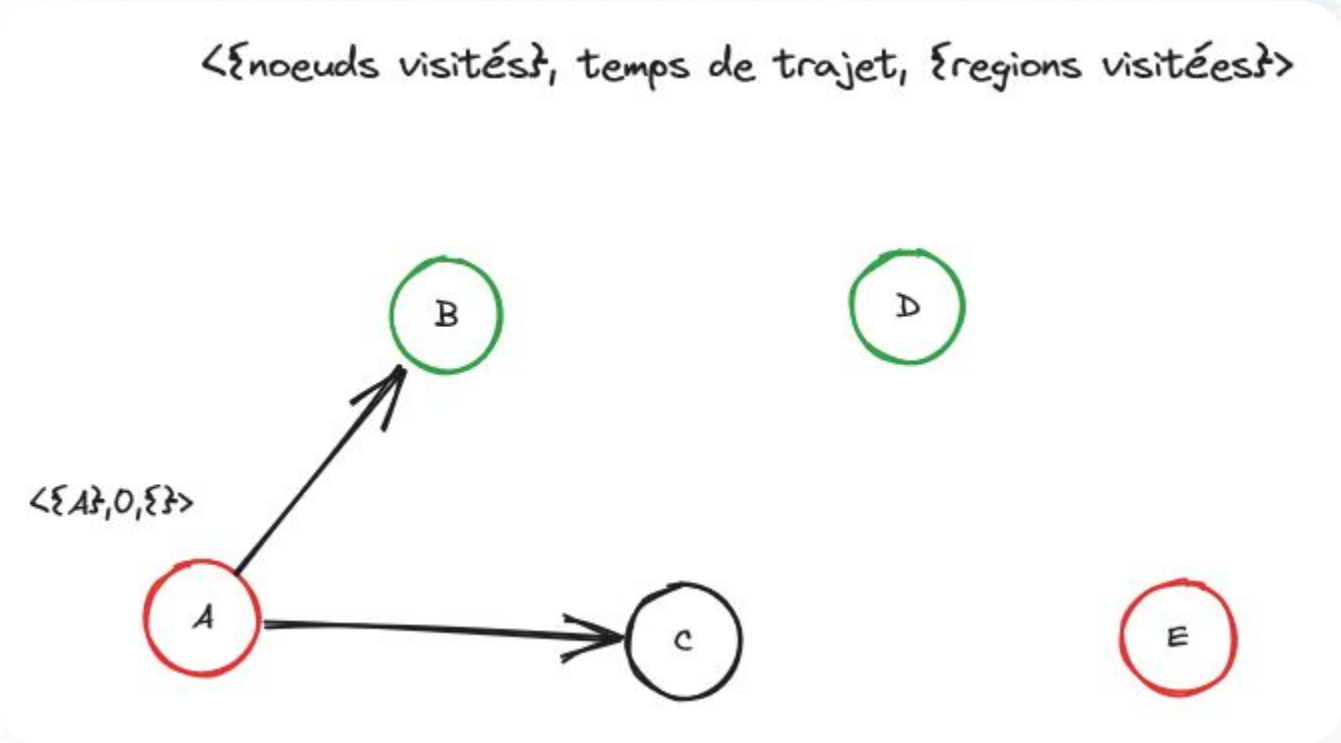
CPO - Sélection des stations



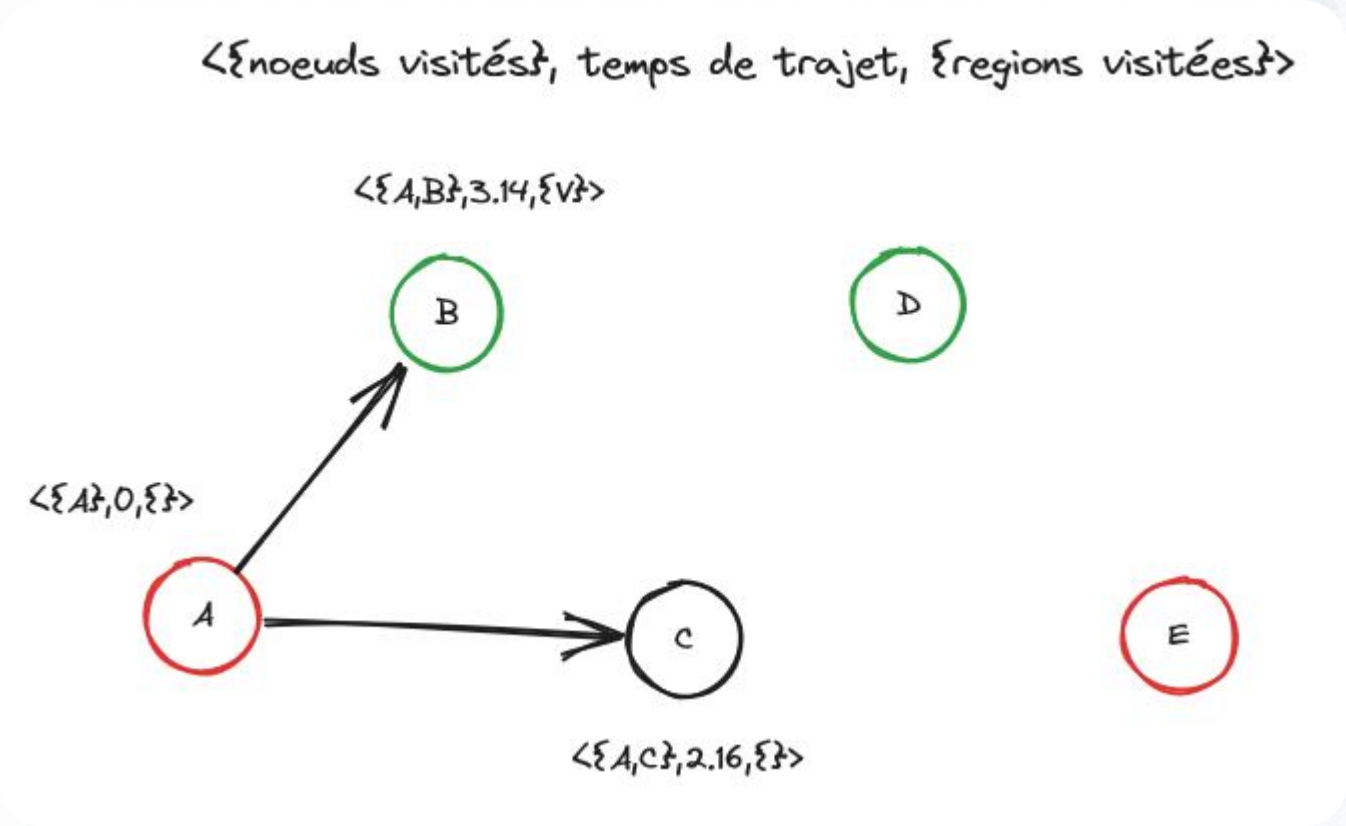
Coupe Breitling

Label Setting

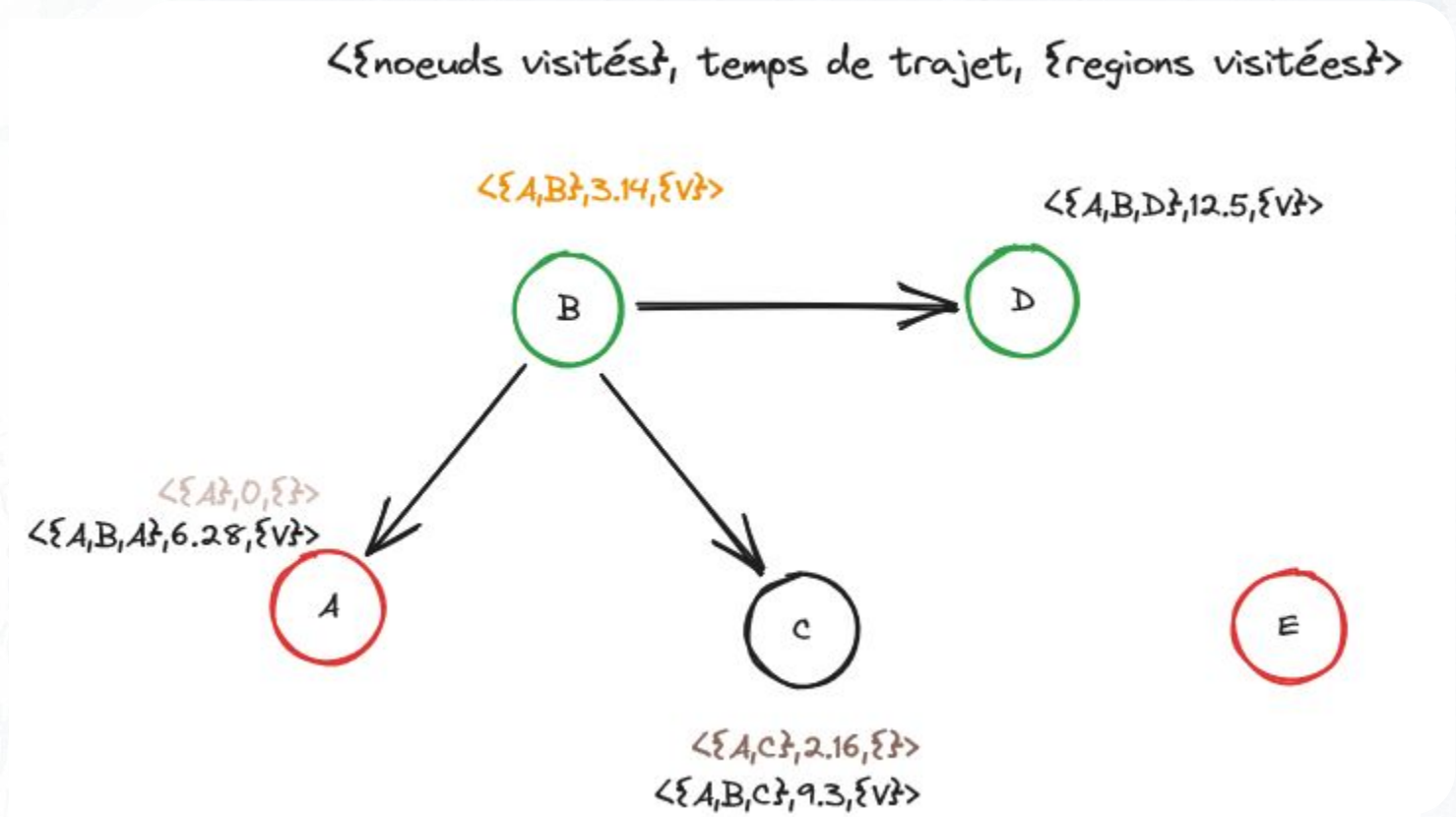
Coupe Breitling - Label Setting



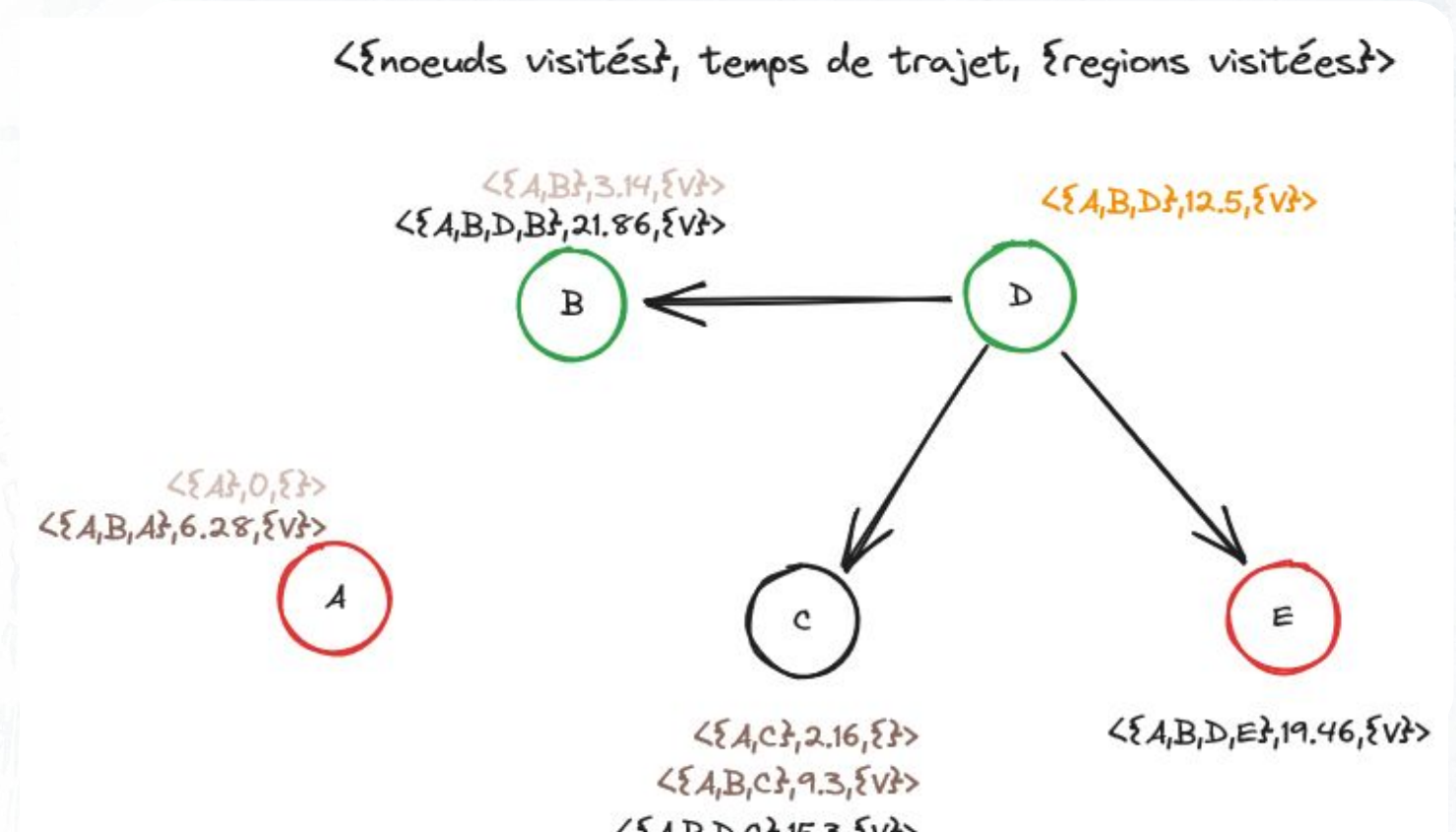
Coupe Breitling - Label Setting



Coupe Breitling - Label Setting

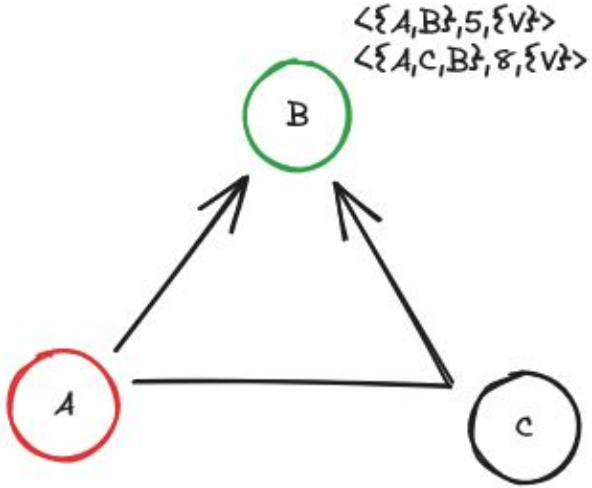


Coupe Breitling - Label Setting

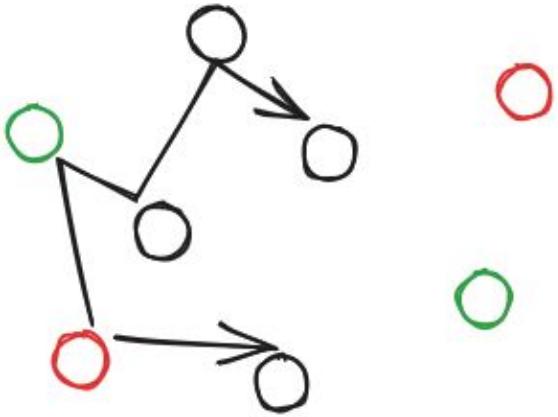


Coupe Breitling - Label Setting

- Comment retirer les labels innutiles ?

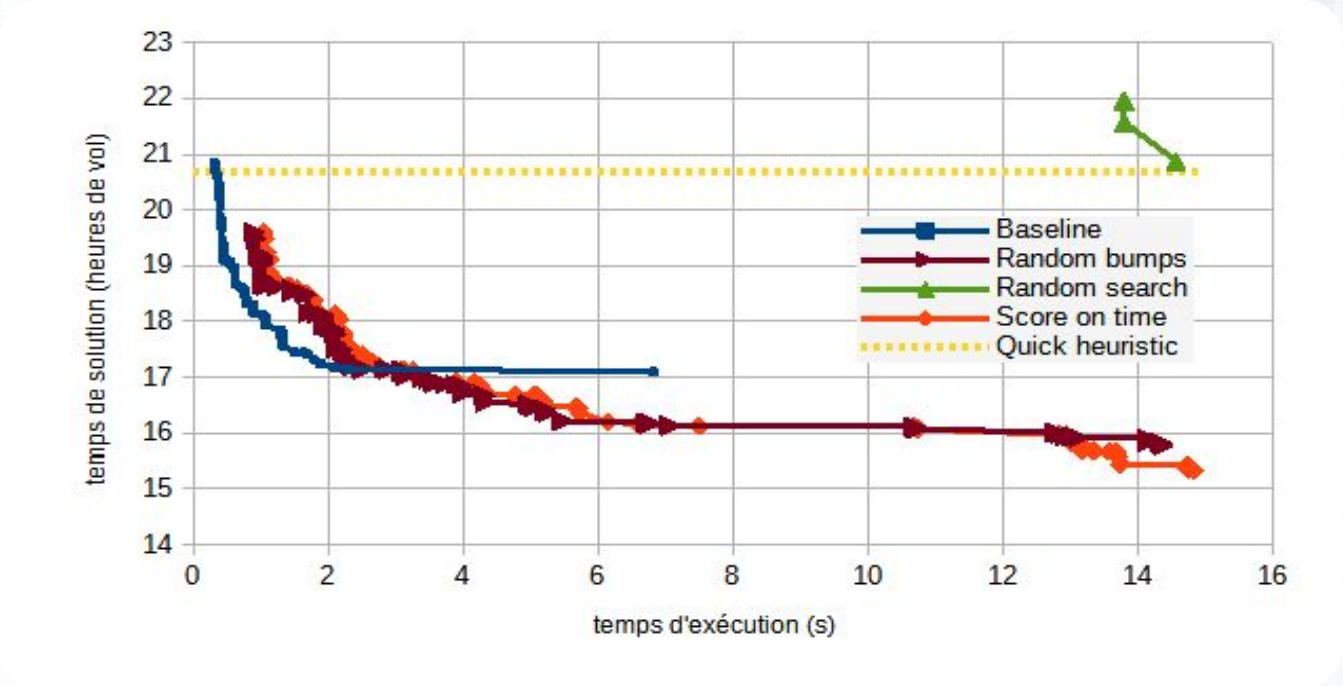


- Comment choisir les meilleurs labels ?



Coupe Breitling - Label Setting - Résultats

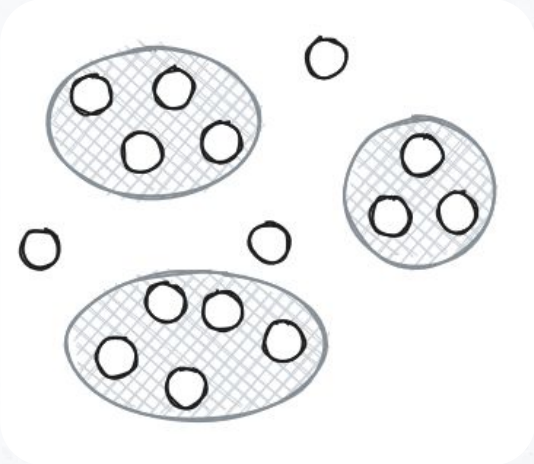
- Relation de domination
- Affectation de score

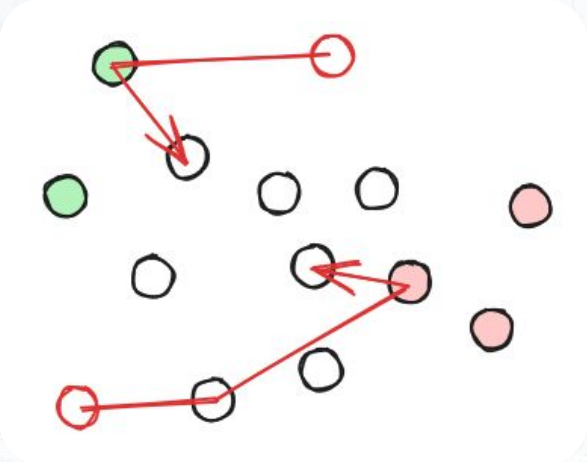


Coupe Breitling - Label Setting

- Scores dynamiques
- Parallélisation

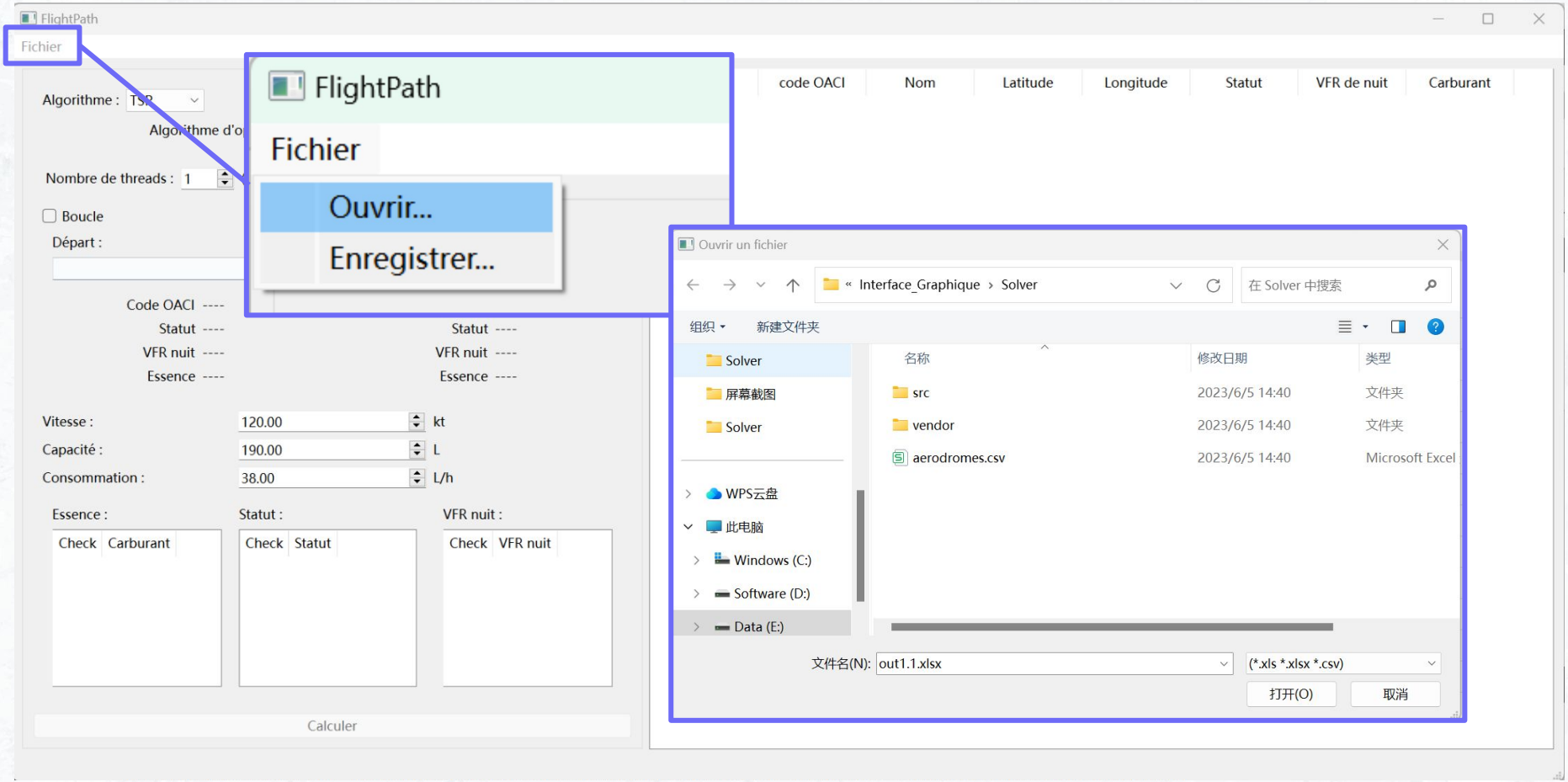
- Clustering
- Meet in the middle
- Approche génétique & amélioration de solution

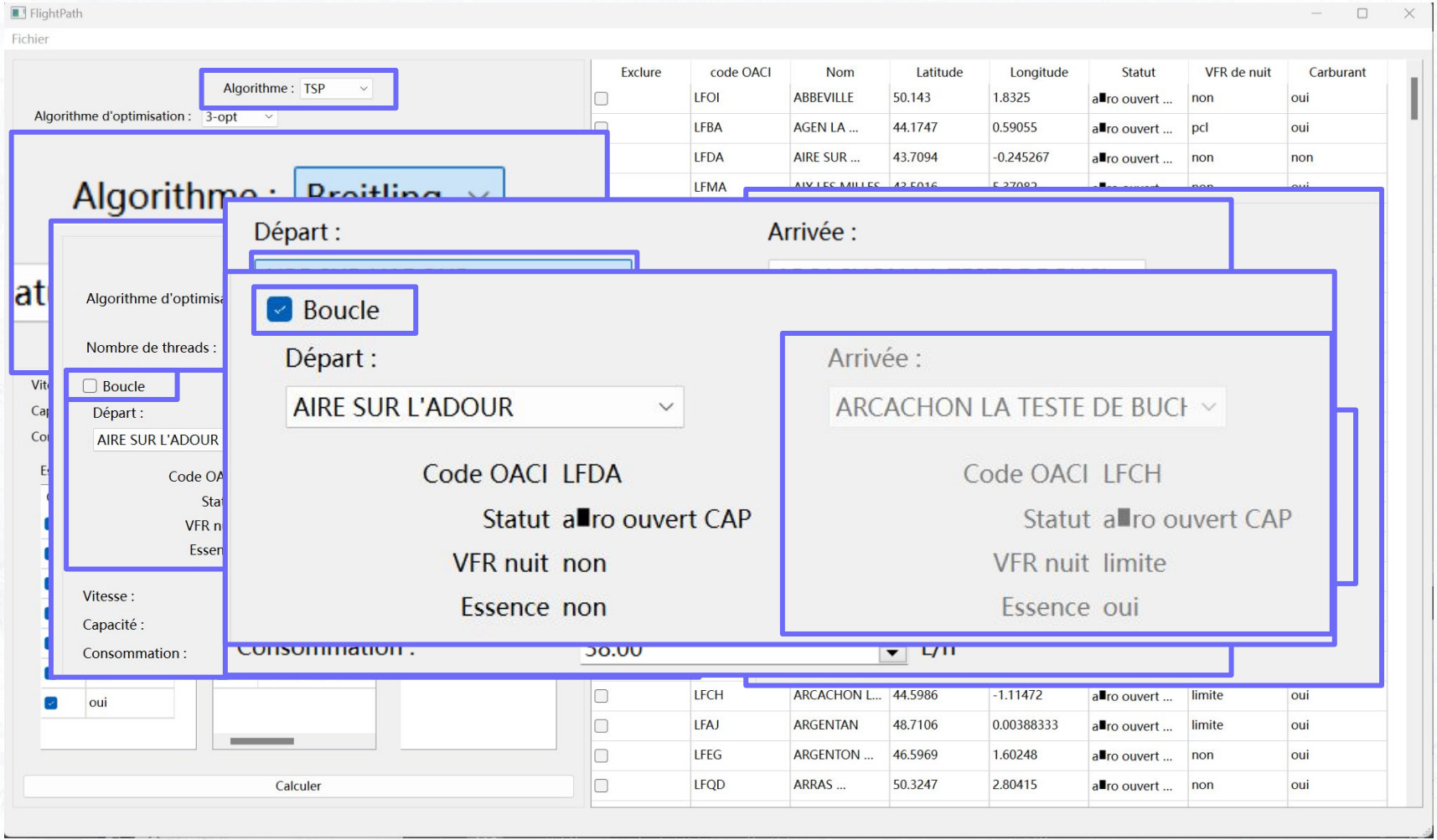


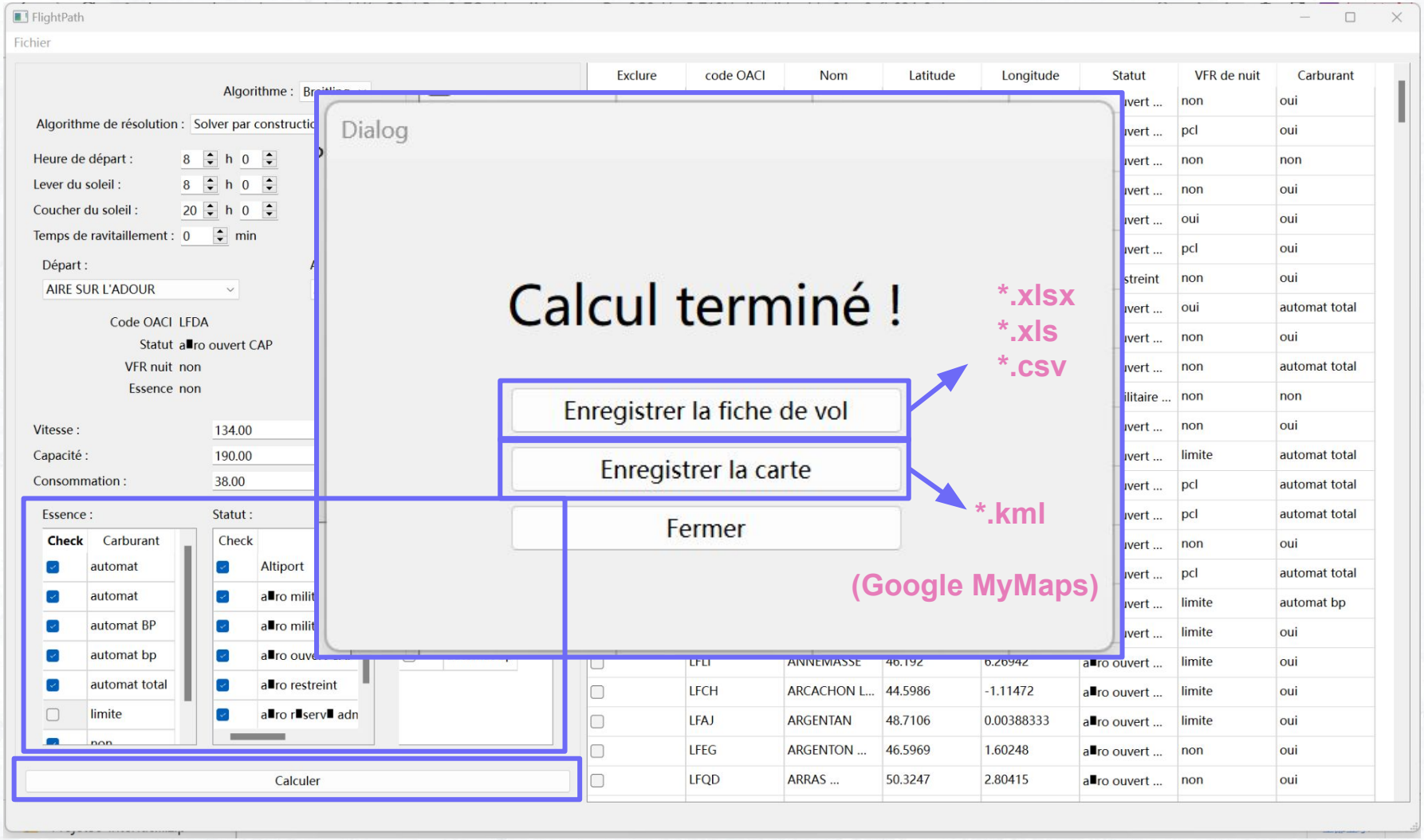


04 →

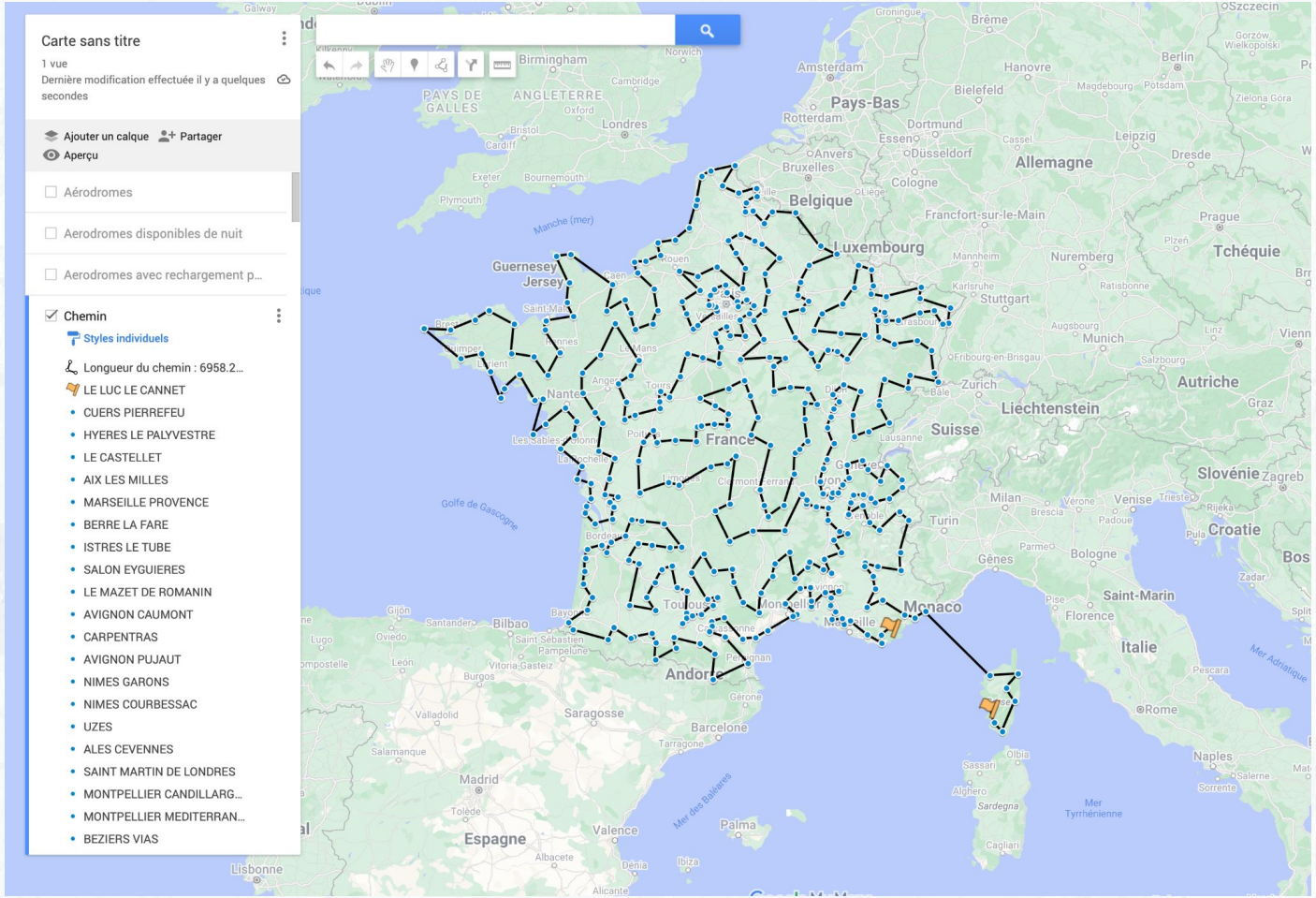
Interface


FlightPath
Fichier
Algorithme : TSP
Nombre de threads : 1
Boucle
Départ :
Code OACI ----
Statut ----
VFR nuit ----
Essence ----
Vitesse : 120.00 kt
Capacité : 190.00 L
Consommation : 38.00 L/h
Essence :
Check Carburant
Statut :
Check Statut
VFR nuit :
Check VFR nuit
Calculer
code OACI
Nom
Latitude
Longitude
Statut
VFR de nuit
Carburant
FlightPath
Fichier
Ouvrir...
Enregistrer...
Ouvrir un fichier
« Interface_Graphique › Solver
在 Solver 中搜索
组织
新建文件夹
Solver
屏幕截图
Solver
WPS云盘
此电脑
Windows (C:)
Software (D:)
Data (E:)
名称
修改日期
类型
src
2023/6/5 14:40
文件夹
vendor
2023/6/5 14:40
文件夹
aerodromes.csv
2023/6/5 14:40
Microsoft Excel
文件名(N): out1.1.xlsx
(*.xls *.xlsx *.csv)
打开(O)
取消


FlightPath
Fichier
Algorithme : TSP
Algorithme d'optimisation : 3-opt
Algorithme : Breitling
Départ :
Arrivée :
Boucle
Départ :
AIRE SUR L'ADOUR
Code OACI LFDA
Statut a■ro ouvert CAP
VFR nuit non
Essence non
Arrivée :
ARCACHON LA TESTE DE BUCH
Code OACI LFCH
Statut a■ro ouvert CAP
VFR nuit limite
Essence oui
Nombre de threads :
Boucle
Départ :
AIRE SUR L'ADOUR
Vitesse :
Capacité :
Consommation :
Calculer
Exclure | code OACI | Nom | Latitude | Longitude | Statut | VFR de nuit | Carburant
LFOI | ABBEVILLE | 50.143 | 1.8325 | a■ro ouvert ... | non | oui
LFBA | AGEN LA ... | 44.1747 | 0.59055 | a■ro ouvert ... | pcl | oui
LFDA | AIRE SUR ... | 43.7094 | -0.245267 | a■ro ouvert ... | non | non
LFCH | ARCACHON L... | 44.5986 | -1.11472 | a■ro ouvert ... | limite | oui
LFAJ | ARGENTAN | 48.7106 | 0.00388333 | a■ro ouvert ... | limite | oui
LFEG | ARGENTON ... | 46.5969 | 1.60248 | a■ro ouvert ... | non | oui
LFQD | ARRAS ... | 50.3247 | 2.80415 | a■ro ouvert ... | non | oui


FlightPath
Fichier
Algorithme :
Algorithme de résolution : Solver par constructio
Heure de départ : 8 h 0
Lever du soleil : 8 h 0
Coucher du soleil : 20 h 0
Temps de ravitaillement : 0 min
Départ :
AIRE SUR L'ADOUR
Code OACI LFDA
Statut aéro ouvert CAP
VFR nuit non
Essence non
Vitesse : 134.00
Capacité : 190.00
Consommation : 38.00
Essence :
Check Carburant
automat
automat
automat BP
automat bp
automat total
limite
Statut :
Check
Altiport
aéro milit
aéro milit
aéro ouve
aéro restreint
aéro réserv adn
Calculer
Dialog
Calcul terminé !
Enregistrer la fiche de vol
Enregistrer la carte
Fermer
*.xlsx
*.xls
*.csv
*.kml
(Google MyMaps)
Exclure
code OACI
Nom
Latitude
Longitude
Statut
VFR de nuit
Carburant
LFCH ARCACHON L... 44.5986 -1.11472 aéro ouvert ... limite oui
LFAJ ARGENTAN 48.7106 0.00388333 aéro ouvert ... limite oui
LFEG ARGENTON ... 46.5969 1.60248 aéro ouvert ... non oui
LFQD ARRAS ... 50.3247 2.80415 aéro ouvert ... non oui

Google MyMaps



05 →

Conclusion

Conclusion

- 1+1 algorithme de résolution du TSP
- 2 algorithmes d’optimisation
- 3 algorithmes de résolution pour la coupe Breitling
- 1 interface

Merci de nous avoir écouté