Project 2 Kick-Off and Guest Lecture

IT3708 Bio-Inspired Artificial Intelligence
February 6th 2025

Camilla Dybdal and Espen Grødem

Resolve

VISMA

Camilla Dybdal

Kyb 2023

AI Tech Lead in Resolve

Espen Grødem

I&IKT 2022

AI Developer in Resolve

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Our involvement in IT3708

We are guest hosts of project 2. This involves...

- Providing the optimization case that you will solve in the project
- Hosting a competition that you can participate in during the project

Schedule

- Today, February 6th (12:15 - 14:00): Kick-off with Visma Resolve @ F2.
- February 6th to March 10th: Work on the project.
- Friday, March 10th: Demo day.

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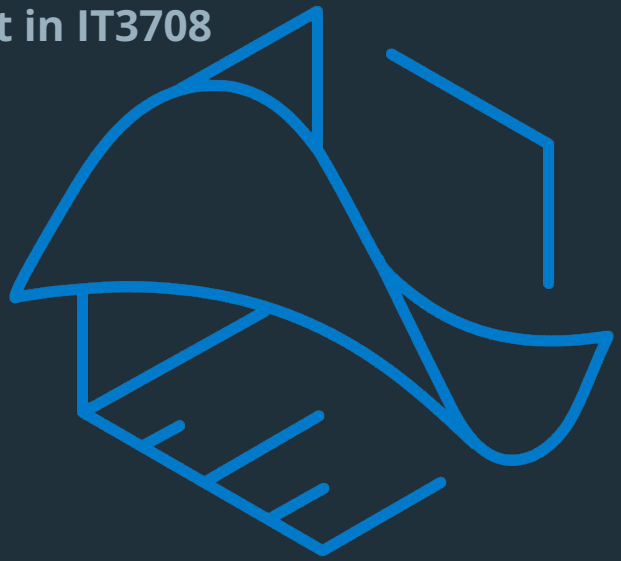
Agenda

Introduction to Visma, Resolve, and our involvement in IT3708
Introduction to route planning in the home health care
Deep dive into our Operational Route Planner (ORP)

15-minute break

Introduction to IT3708 project 2
Implementation tips & tricks
The competition web page




We are shaping the future of society through technology
Empowering people by simplifying and automating complex processes
VISMA


VISMA

Visma in numbers

16 400
Engaged employees with nearly **6 400** developers

Top 5%
We have among the most engaged employees in the software industry

200+
Companies make up the Visma Group today

2 000 000
Customers

€2.804B
Revenue LTM Q4 2024

33 countries
Visma entered Italy and Croatia in 2024

VISMA

Dagens Næringsliv

Teknologi

Fersk transaksjon priser Visma til 215 mrd. – Øystein Moan og de ansatte har aksjer for 12 mrd.

Visma kunne med den nye prisingen nesten vært Børsens tredje største selskap. Og de ansattes andel: 12 milliarder kroner.

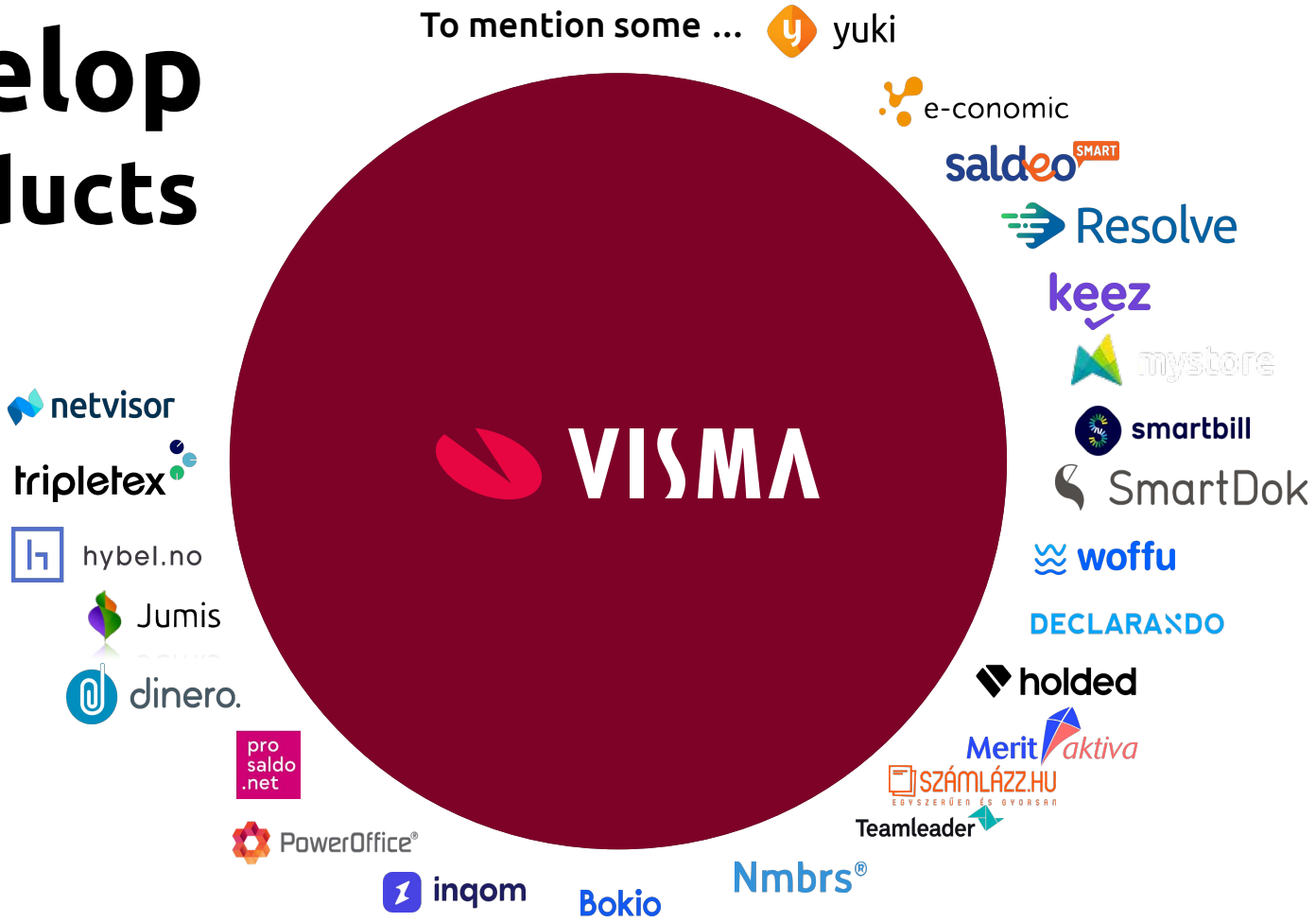
Konsernsjef Merete Hverven (foran) og styreleder Øystein Moan i Visma. Her fra da Hverven i 2019 tok over sjefsstolen Moan hadde hatt. (Foto: Aleksander Nordahl)

Visma valued at EUR 19 billion

Visma would have been the 3rd largest company on Oslo stock exchange

VISMA

We develop
550+ products




Resolve
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AI as a service from Resolve

Route optimization

Determining the best route for each worker

Automatic rostering

Creating fair and efficient workforce schedules

Inventory optimization

Forecasting demand and providing optimal purchase order suggestions

Time detect

Detect irregularities in time registrations to improve time-registration and approval processes

Payroll detect

Managing payroll efficiently by detecting irregularities

Optimization

Route optimization

Determining the best route for each worker

Automatic rostering

Creating fair and efficient workforce schedules

Machine Learning

Time detect

Detect irregularities in time registrations to improve time-registration and approval processes

Payroll detect

Managing payroll efficiently by detecting irregularities

Inventory optimization

Forecasting demand and providing optimal purchase order suggestions

Resolve

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AI as a service from Resolve

AI algorithms

Complex and continuously improved models

Scalable APIs

Highly scalable and performant Rest APIs

Security

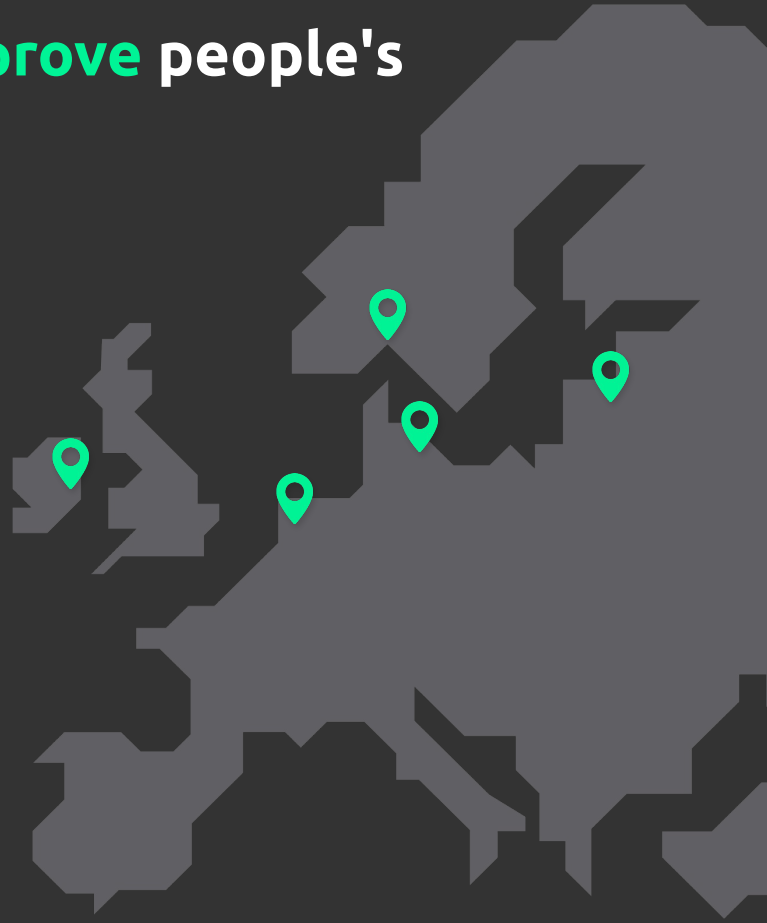
VASP-onboarded products and a strong security culture

Monitoring

Monitor API usage to effectively manage errors and address abnormalities

We deliver AI and ML solutions to improve people's work lives

Our team of **20 passionate employees** are dedicated to transforming the way work gets done using AI



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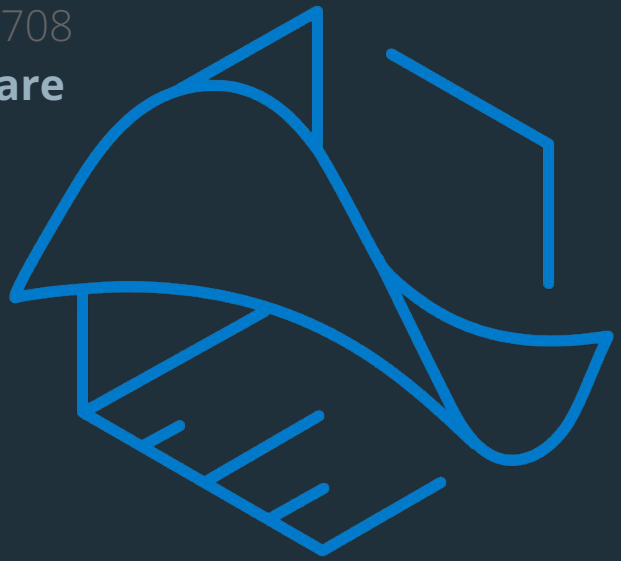

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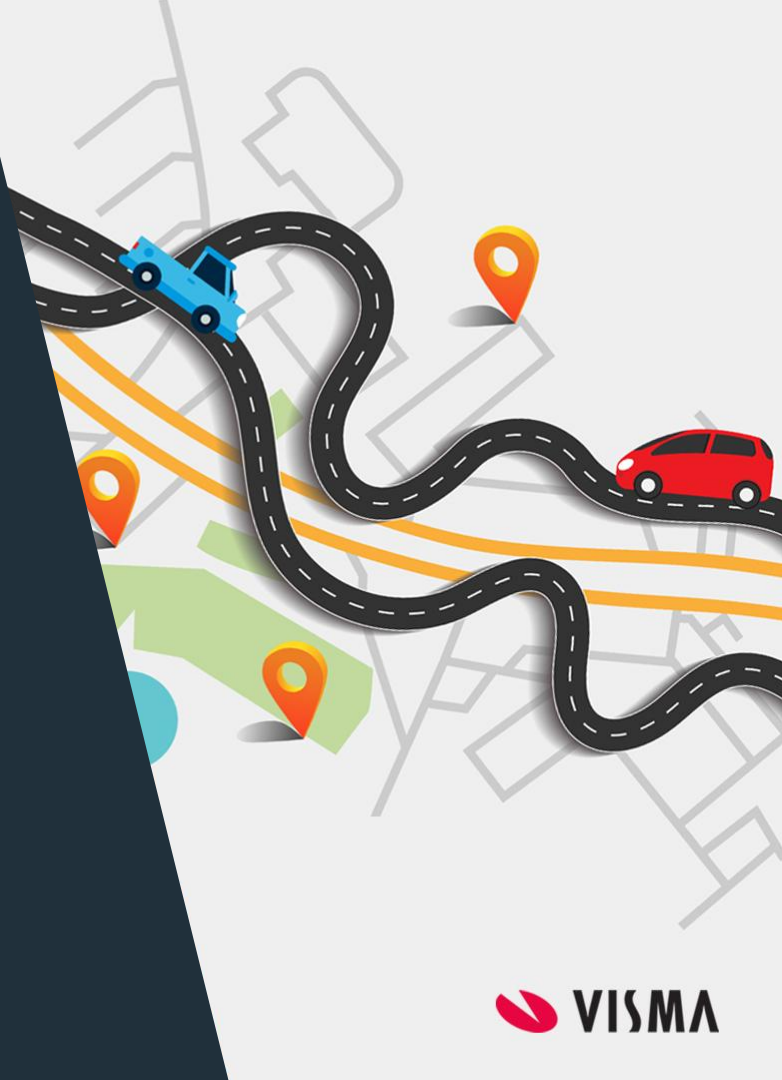
Resolve

Route Planning



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Route Planning Domains and Markets

Home Nursing Care

Craftsmen

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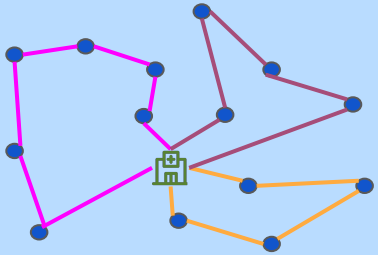
Home Health Care

Elderly people need health treatment

Lack of capacity to host everyone in nursing homes

Nurses give patients health treatment in the patients' homes



A need for efficient routes

Challenges in the Home Health Care

... for nurses

Stressful work

Routes are not efficient

Routes lack robustness

... for patients

Meets many different nurses

Unpredictable visiting times

Visits by nonpreferred nurses

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Route Planning Problem

- Competence
- Workshifts
- Synchronized tasks
- Max number of heavy task per work shift
- Balancing workload
- Time windows
- Employee visit history
- Overqualification
- Travel time & transport mode
- Ride-sharing

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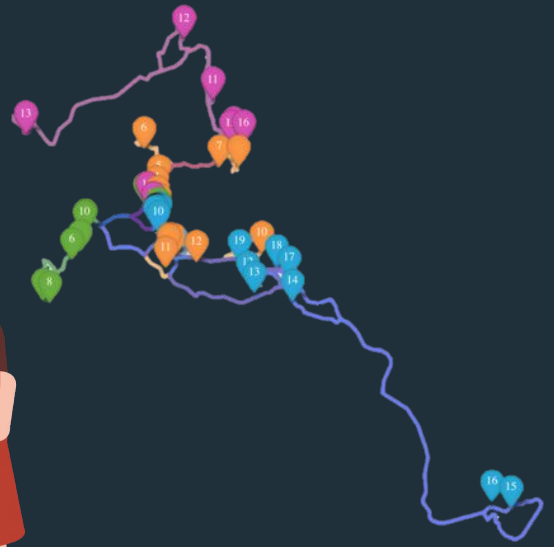
Route Planning Problem

Constraints

- Competence
- Workshifts
- Synchronized tasks
- Max number of heavy task per work shift

Objectives

- Balancing workload
- Time windows
- Employee visit history
- Overqualification
- Travel time & transport mode
- Ride-sharing



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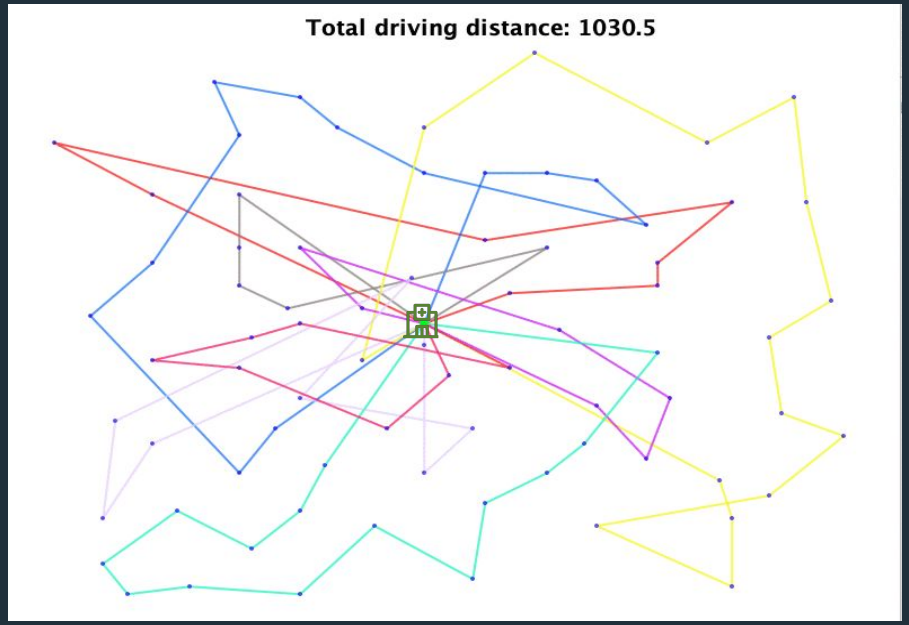
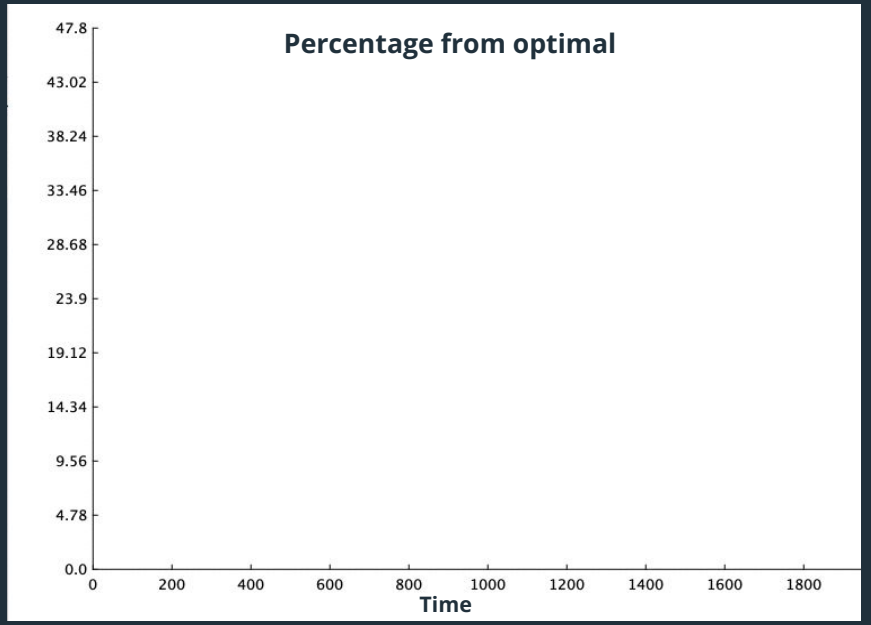
Meta heuristic finding close to optimal





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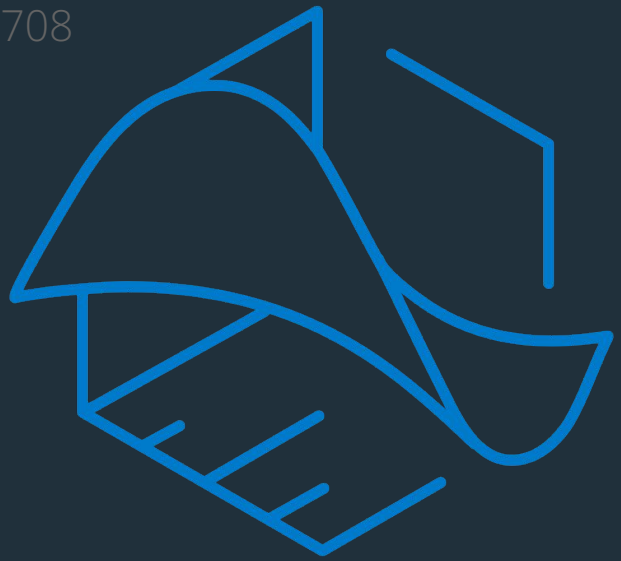

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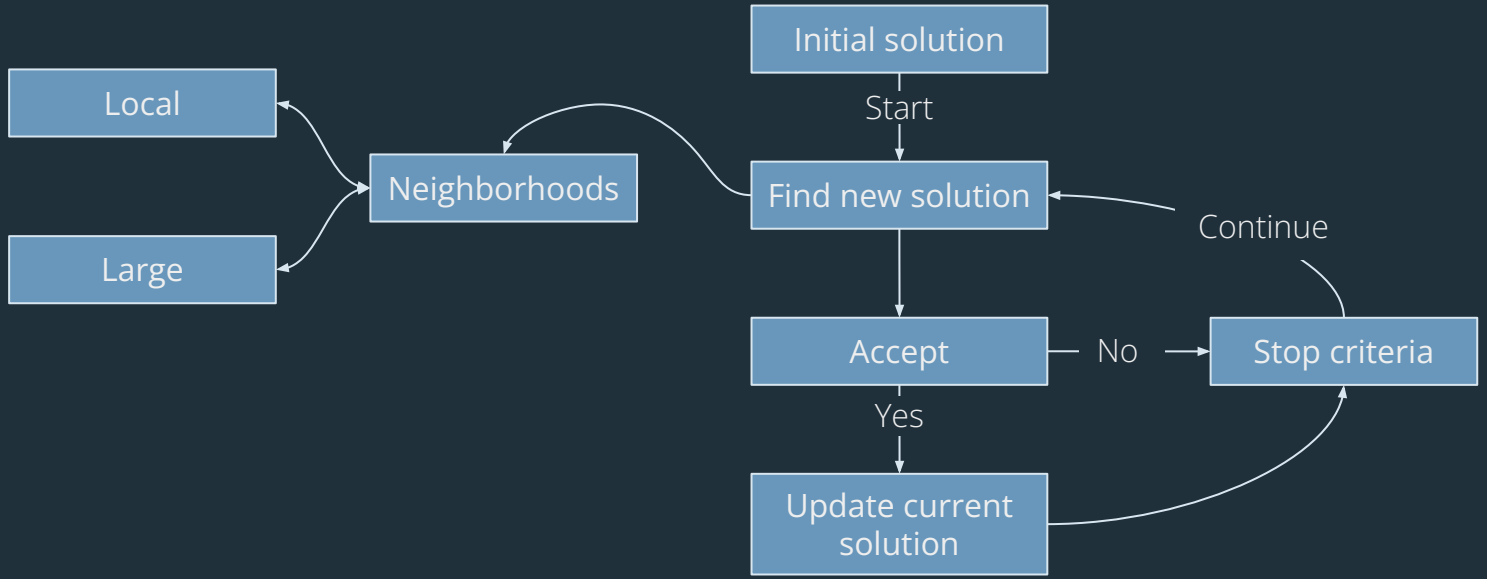
Large Neighborhood Search (LNS)



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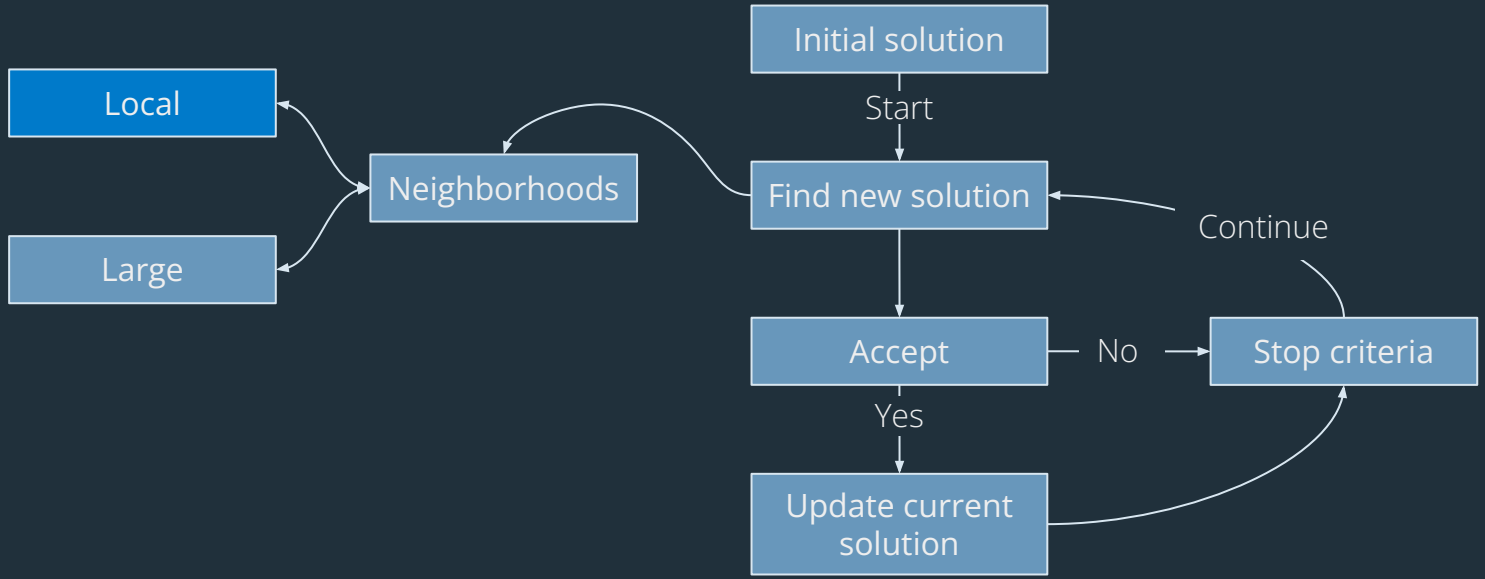

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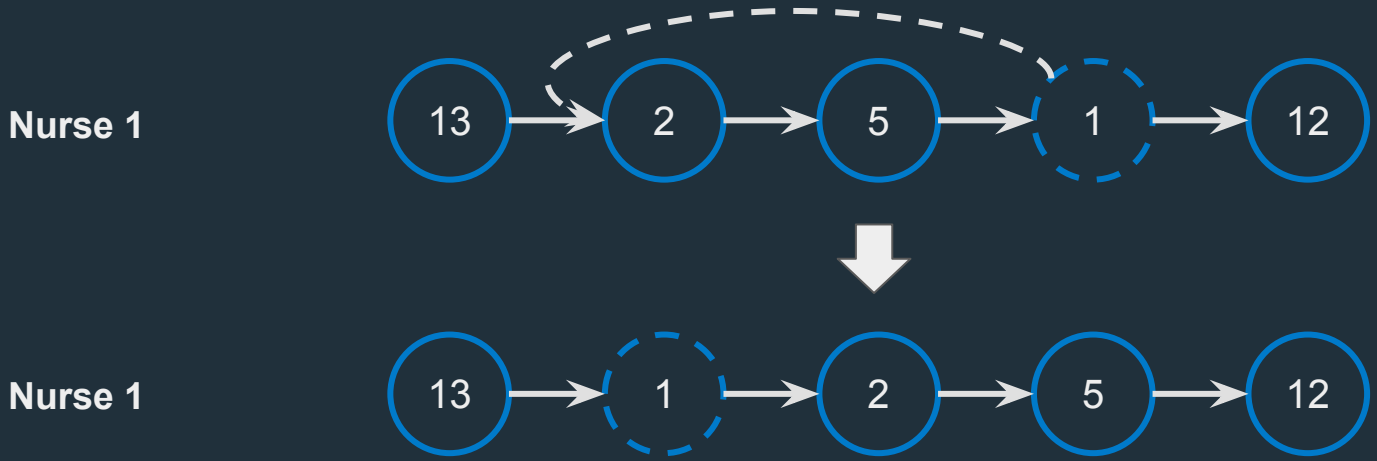
Local neighborhood

Intra move: Move one patient visit in one employee's route



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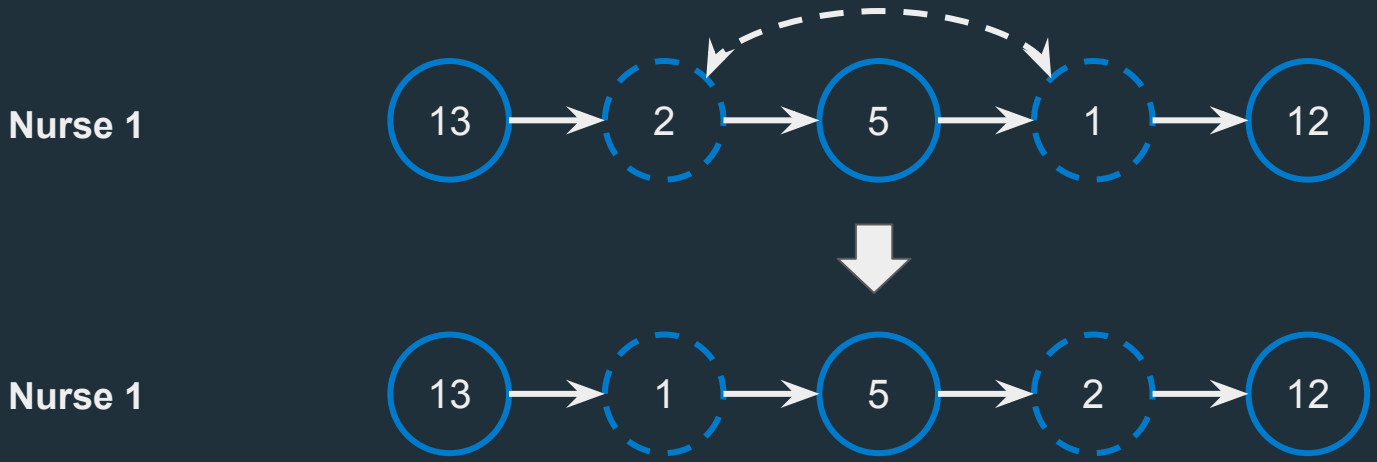
Local neighborhood

Intra swap: Swap two patient visits for one employee



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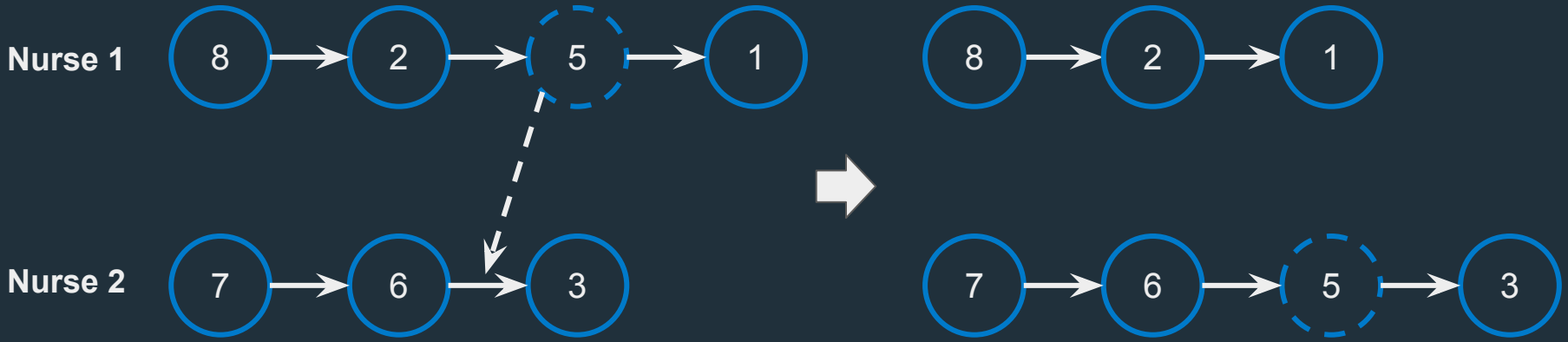
Local neighborhood

Inter move: Move one patient visit from one employee to another



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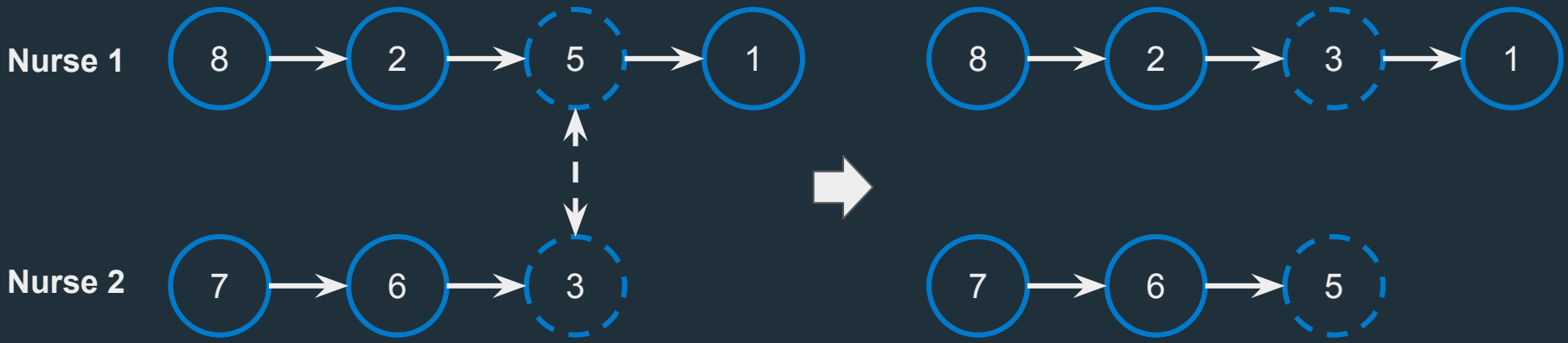
Local neighborhood

Inter swap: Swap two patient visits between employees



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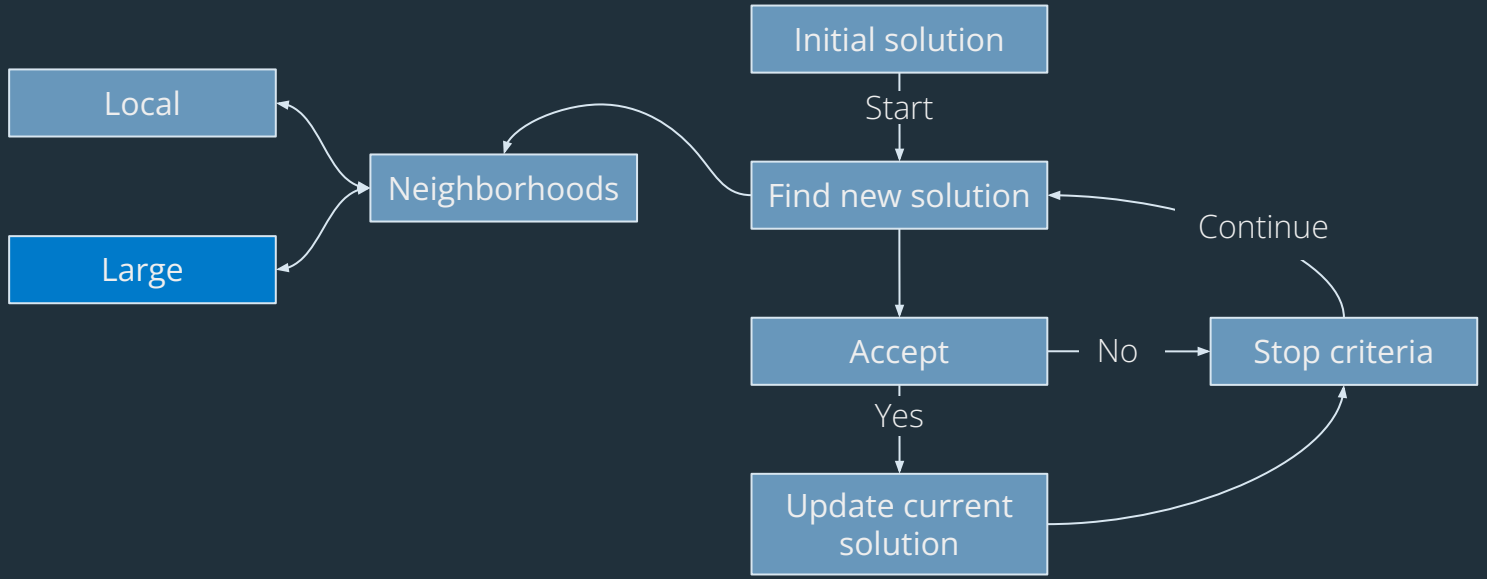

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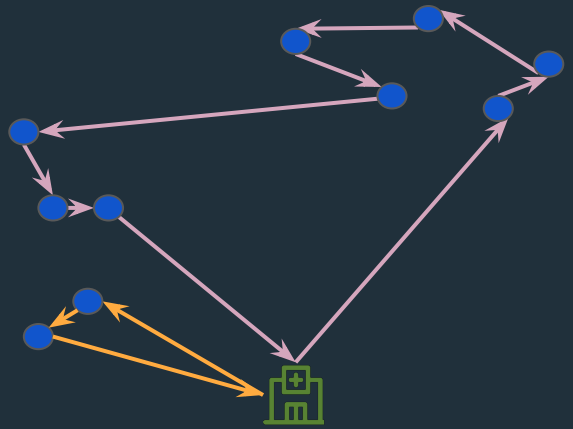
Large neighborhood

- Ruin and Recreate approach
  - Select a destroy and repair operator and apply them to get a new solution
- Set of destroy operators
  - Random removal
  - Greedy removal
  - Cluster removal
- Set of repair operators
  - Random insert
  - Greedy insert
  - Optimal insert

Large neighborhood

Remove clusters: Identify clusters of worsening visits.
Example: longest travel not connected with office



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Large neighborhood

Remove clusters: Identify clusters of worsening visits.
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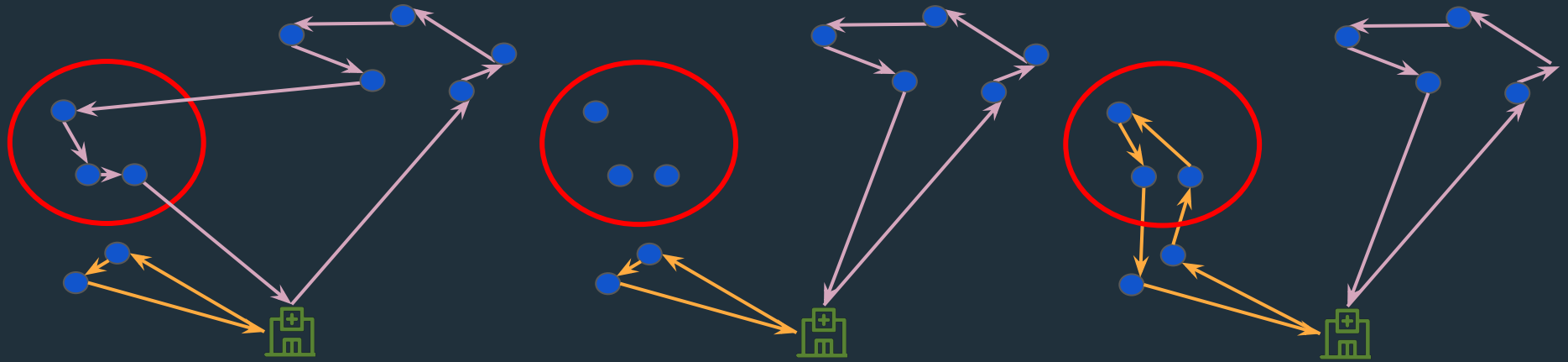

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Customer value of the Route Planner

- Better **resource allocation** and competence matching
- **Face-to-face** time with patients **increased with 14%**
- **Time saved** for planning routes

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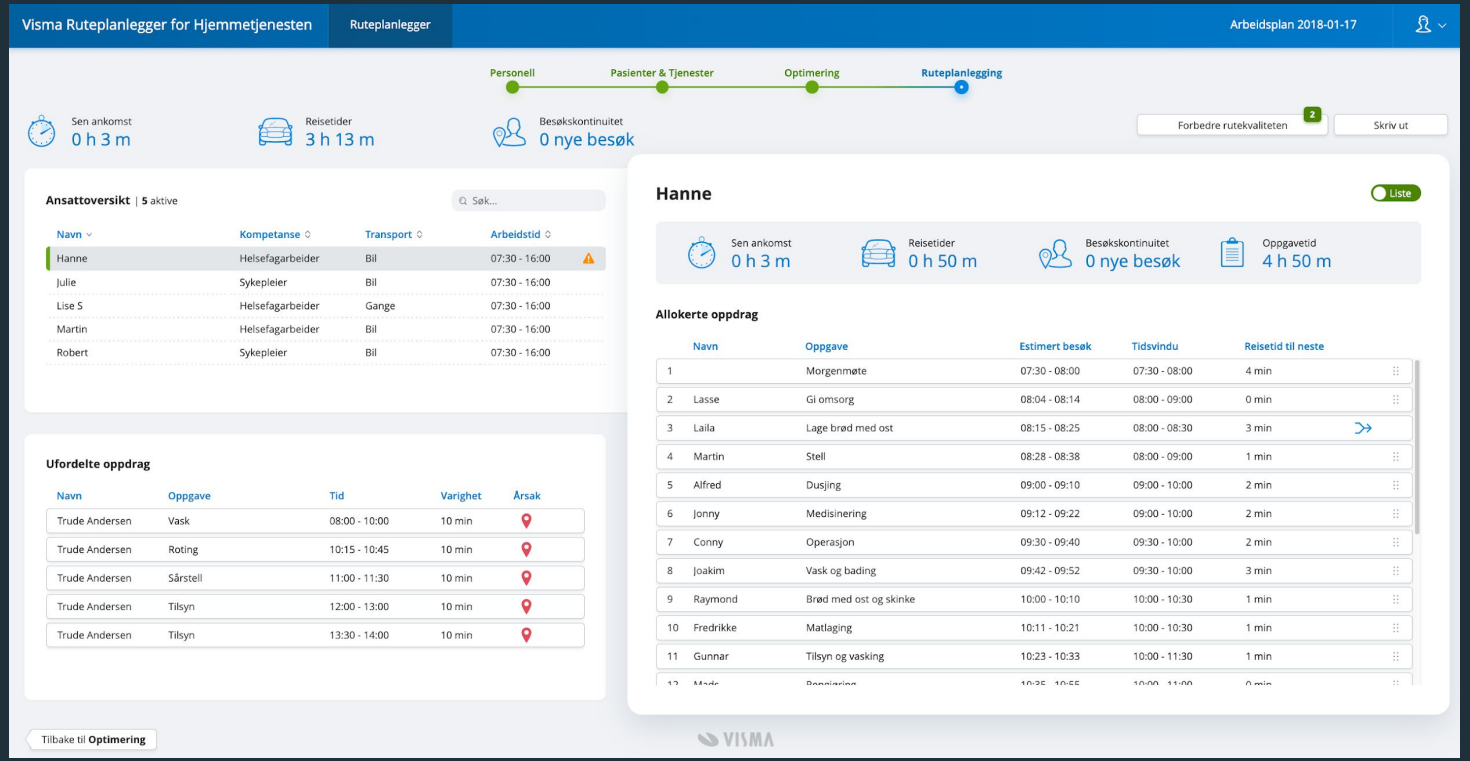
Partner Interface



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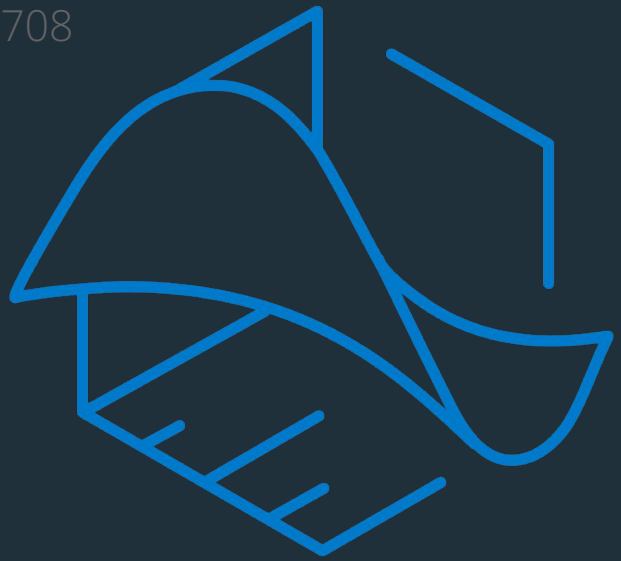

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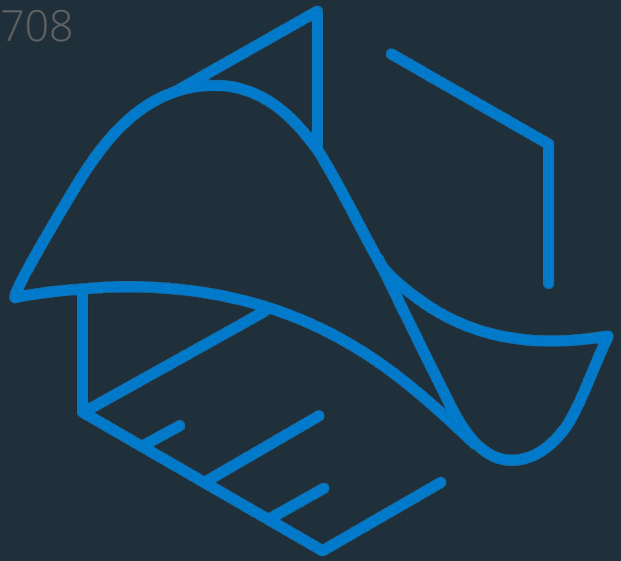

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Our involvement in IT3708

We are guest hosts of project 2. This involves...

1. Providing the optimization case that you will solve in the project
2. Assisting with a solution validator you can use when you implement the problem
3. Hosting a competition that you can participate in during the project

The case: Solving the simplified home health care optimization problem

Nurses 

Depot → patients → depot

Capacity (homogeneous)

Finish care within time window, wait if early

Be back within the return time

Patients 

Visited by exactly one nurse

Demand/strain (heterogeneous)

Time window and care time

The constraints

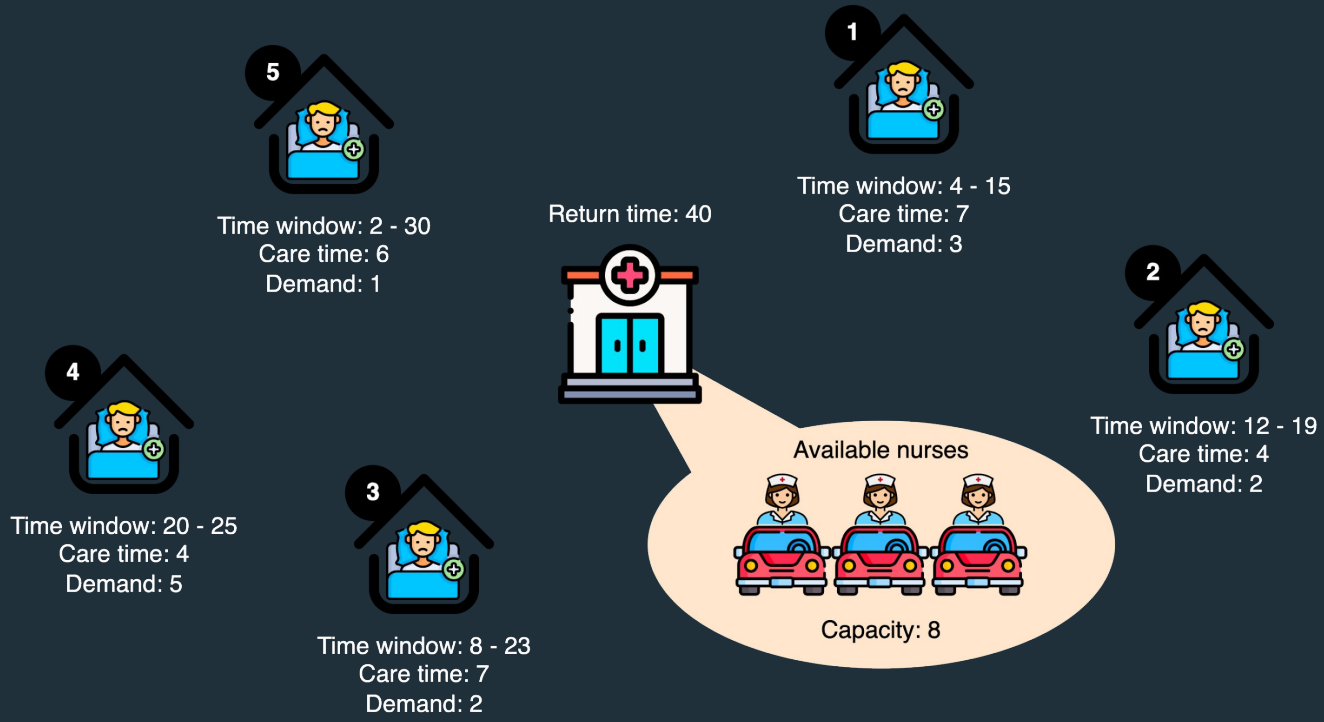
1. Each route starts at the depot on time 0.
2. Each route ends at the depot and must arrive before the given depot return time.
3. The total demand on a route must be less than or equal to the nurse's capacity.
4. Each patient visit on a route must be within the respective time windows.
5. Each patient is visited on exactly one route.

The objective

Make routes that satisfy the constraints and...
***minimize the total travel time**, i.e., the sum of the travel time of all routes.*

Note that the travel time does not include the care time or the potential waiting time!

Example of a problem instance



Your task

Implement a genetic algorithm (GA) solving the simplified home health care optimization problem.

The instances

Instance	Benchmark	5%	10%	20%	30%
train_0	827	868	910	992	1075
train_1	589	618	648	707	766
train_2	1258	1321	1384	1510	1635
train_3	1132	1189	1245	1358	1472
train_4	1261	1324	1387	1513	1639
train_5	1092	1147	1201	1310	1420
train_6	924	970	1016	1109	1201
train_7	870	914	957	1044	1131
train_8	731	768	804	877	950
train_9	855	898	941	1026	1112

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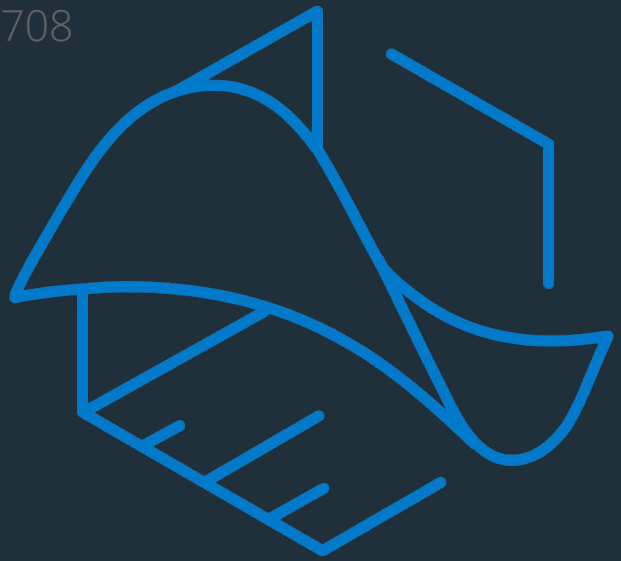

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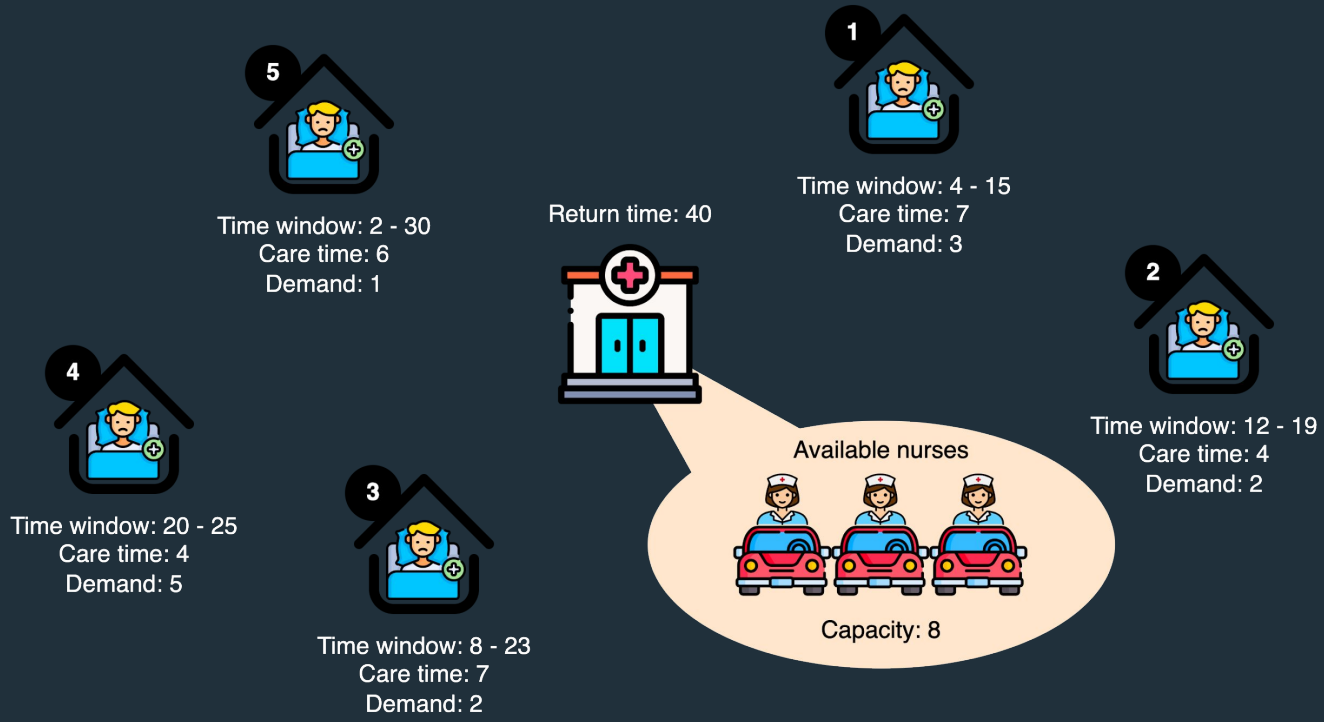
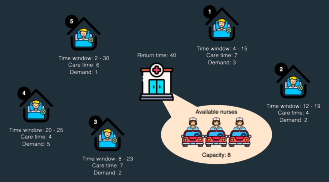
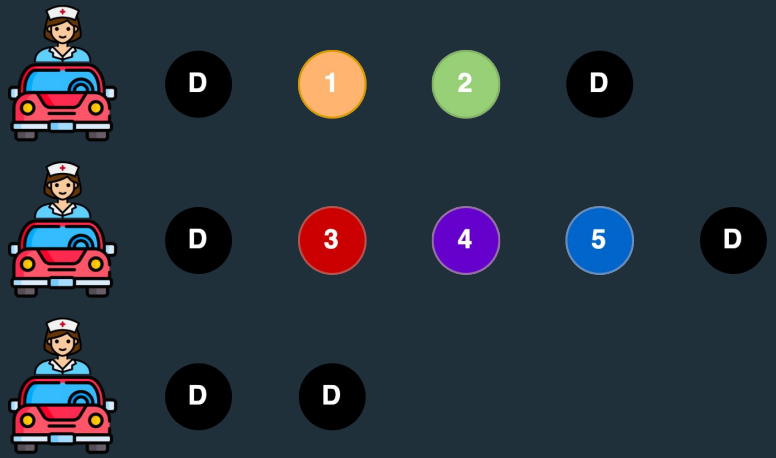
Part 1: Implementing solutions, constraints, and objective

Example of a problem instance



Example of a solution



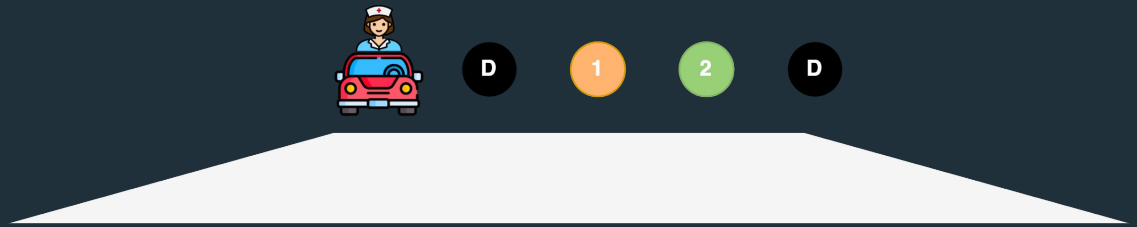


Example of a solution representation

$$\begin{bmatrix} \begin{bmatrix} 1 & 2 \end{bmatrix} \\ \begin{bmatrix} 3 & 4 & 5 \end{bmatrix} \\ \begin{bmatrix} \end{bmatrix} \end{bmatrix}$$

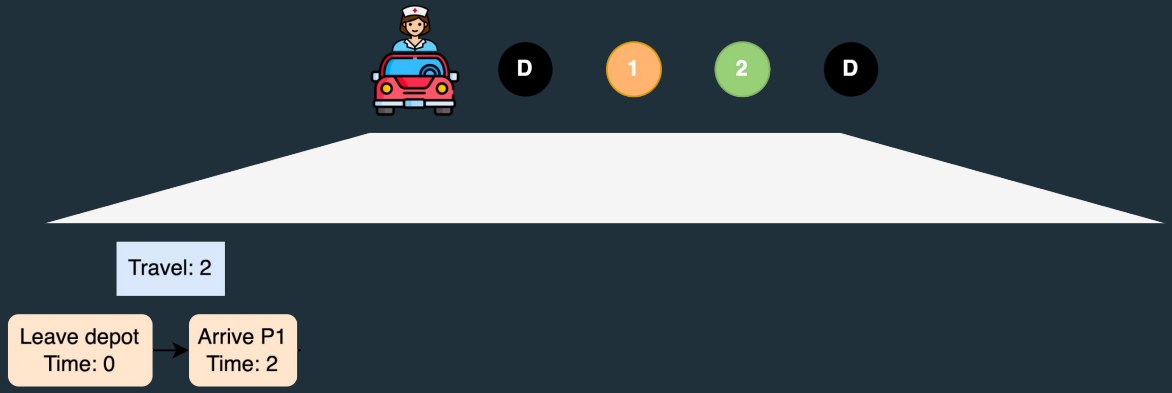
Route visit times and duration

Route visit times and duration

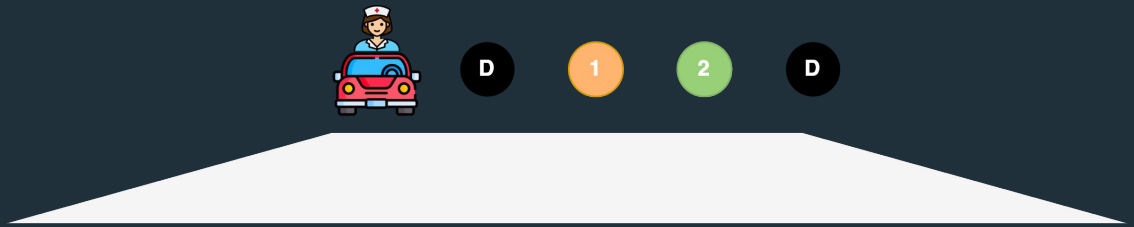


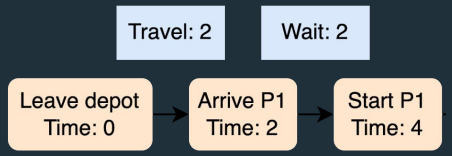
Leave depot
Time: 0

Route visit times and duration



Route visit times and duration





Time window: 4 - 15
Care time: 7
Demand: 3

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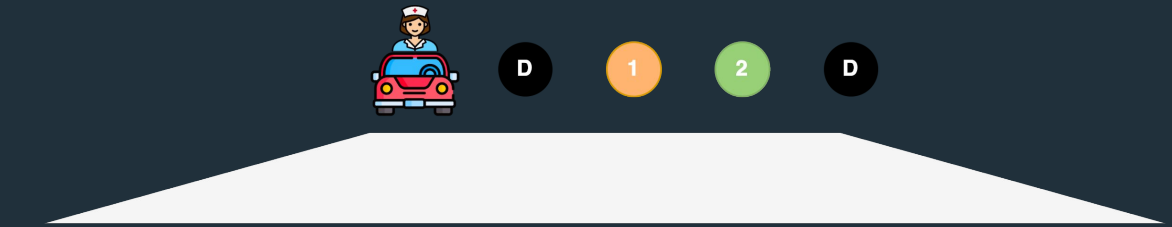
Route visit times and duration



Travel: 2 | Wait: 2 | Care: 7

Leave depot Time: 0 → Arrive P1 Time: 2 → Start P1 Time: 4 → Leave P1 Time: 11

Time window: 4 - 15
Care time: 7
Demand: 3

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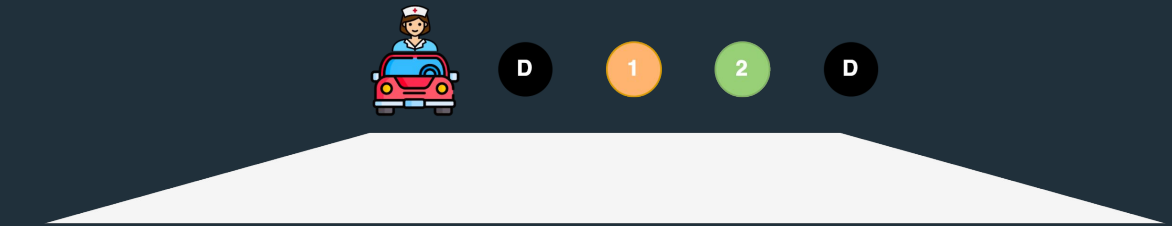
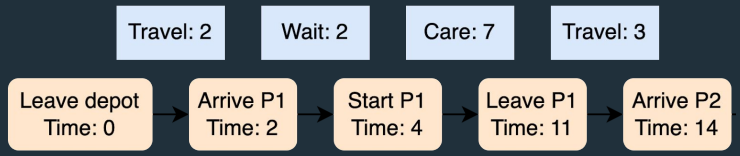
Route visit times and duration





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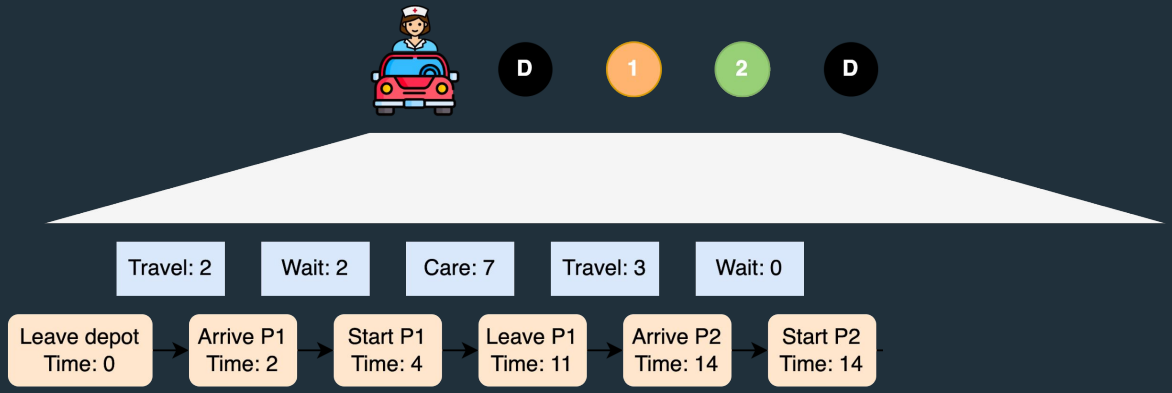

Time window: 4 - 15
Care time: 7
Demand: 3

Time window: 12 - 19
Care time: 4
Demand: 2

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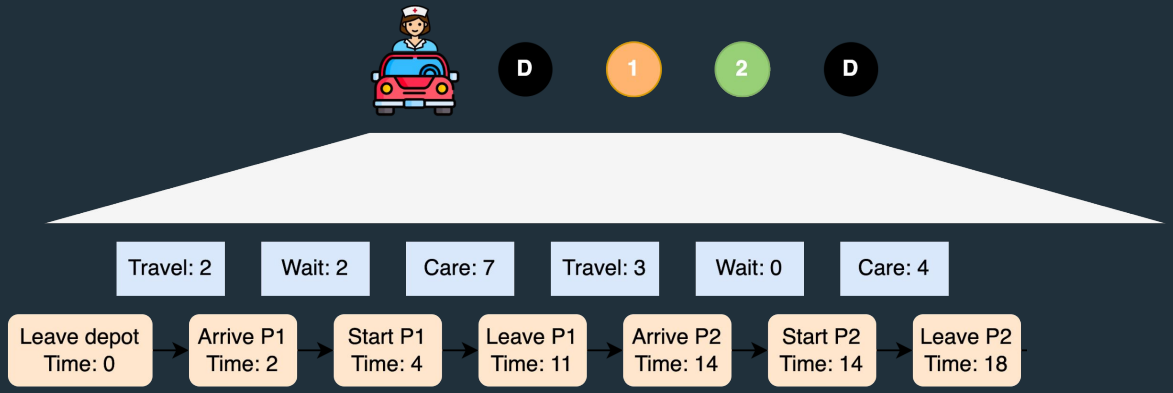
Route visit times and duration



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Care time: 7
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Time window: 12 - 19
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Demand: 2

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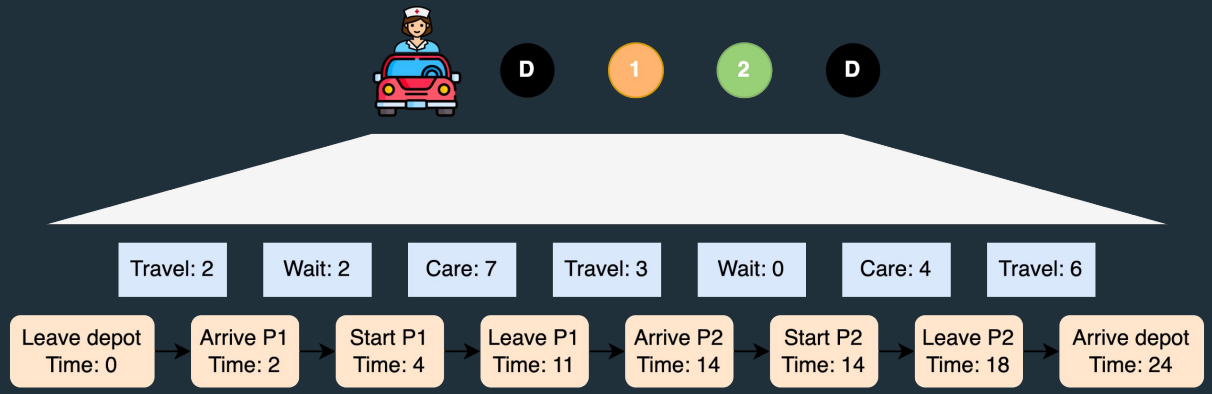

Time window: 4 - 15
Care time: 7
Demand: 3

Time window: 12 - 19
Care time: 4
Demand: 2

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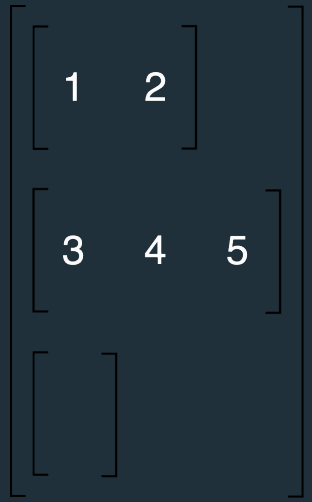
Accessing travel times

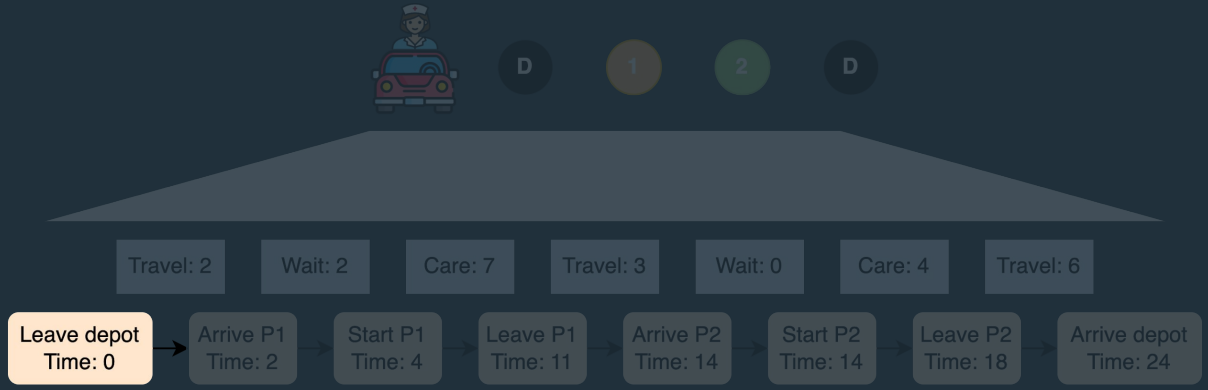
	Depot	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5
Depot	0	2	6	2	7	1
Patient 1	2	0	3	9	2	3
Patient 2	6	3	0	1	5	2
Patient 3	2	9	1	0	7	3
Patient 4	7	2	5	7	0	4
Patient 5	1	3	2	3	4	0

Revisit the constraints

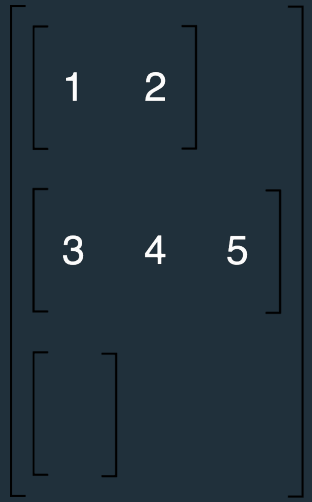


1. Each route starts at the depot on time 0.

Start route at time 0 at depot

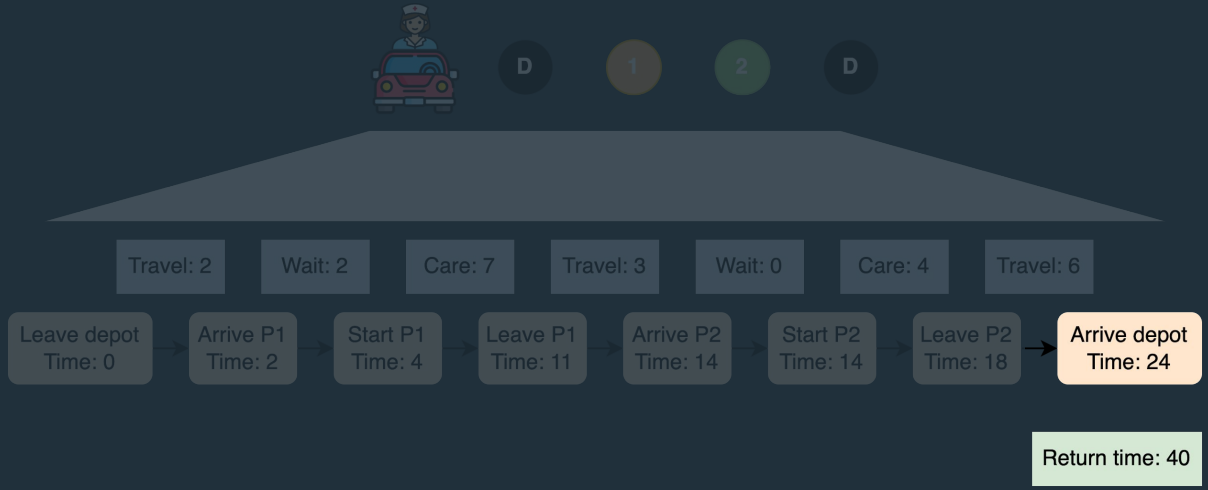


Revisit the constraints

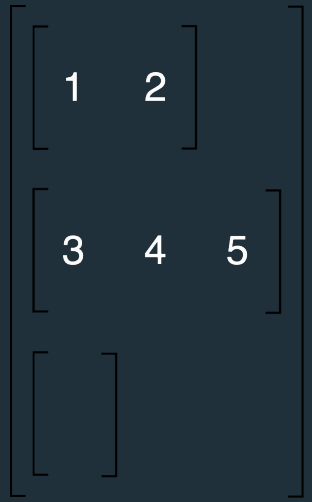


2. Each route ends at the depot and must arrive before the given depot return time.

End route at depot before return time

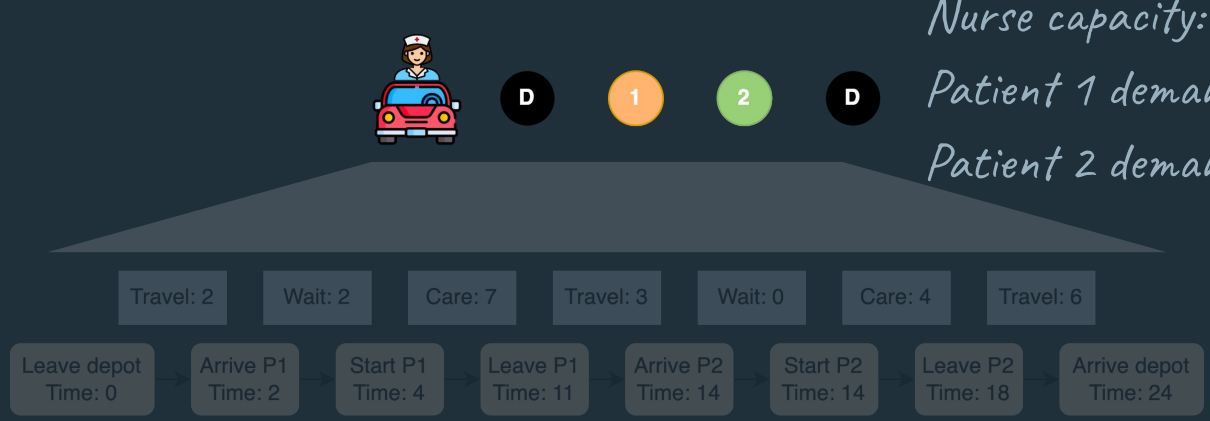


Revisit the constraints



3. The total demand on a route must be less than or equal to the nurse's capacity.

Route demand less than capacity



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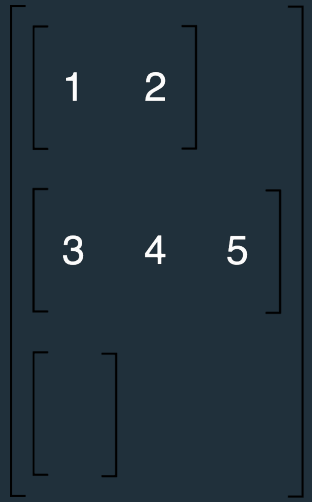
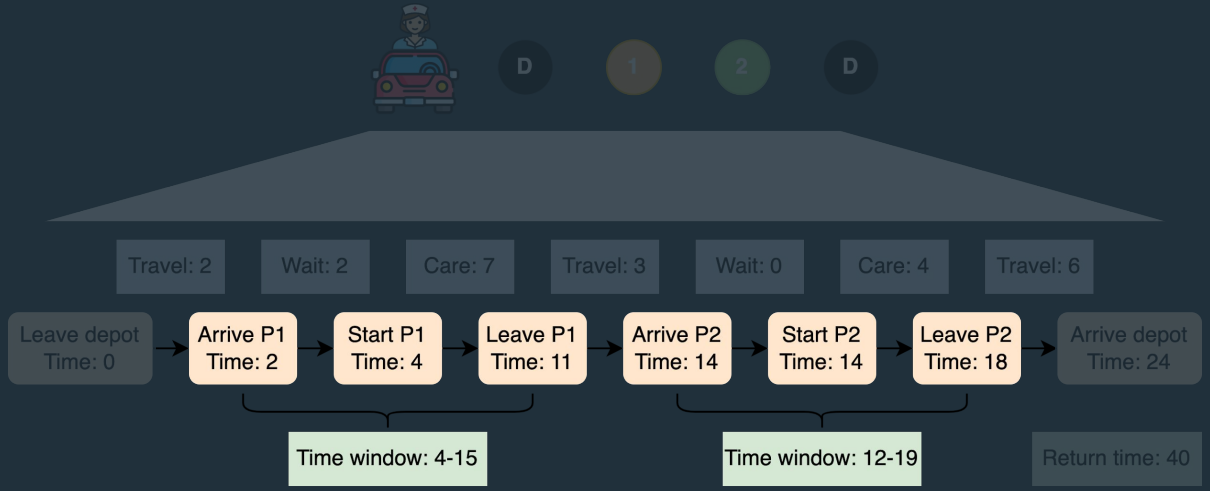
Revisit the constraints



4. Each patient visit on a route must be within the respective time windows.

Patient visits within time windows



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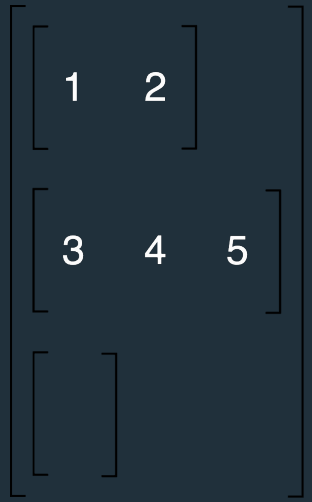
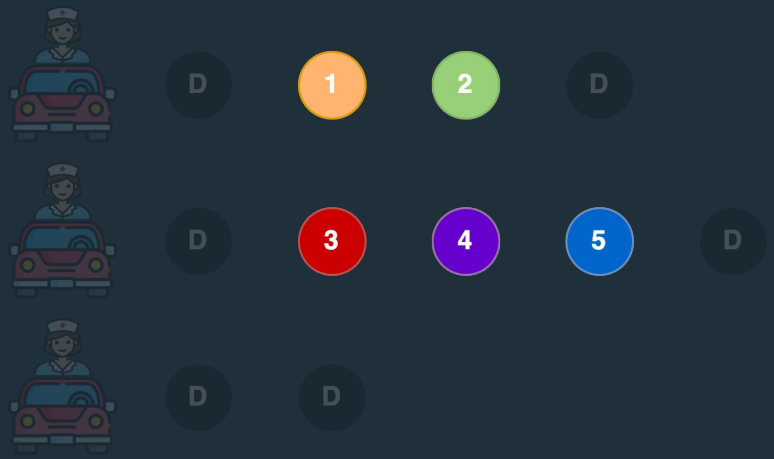
Revisit the constraints

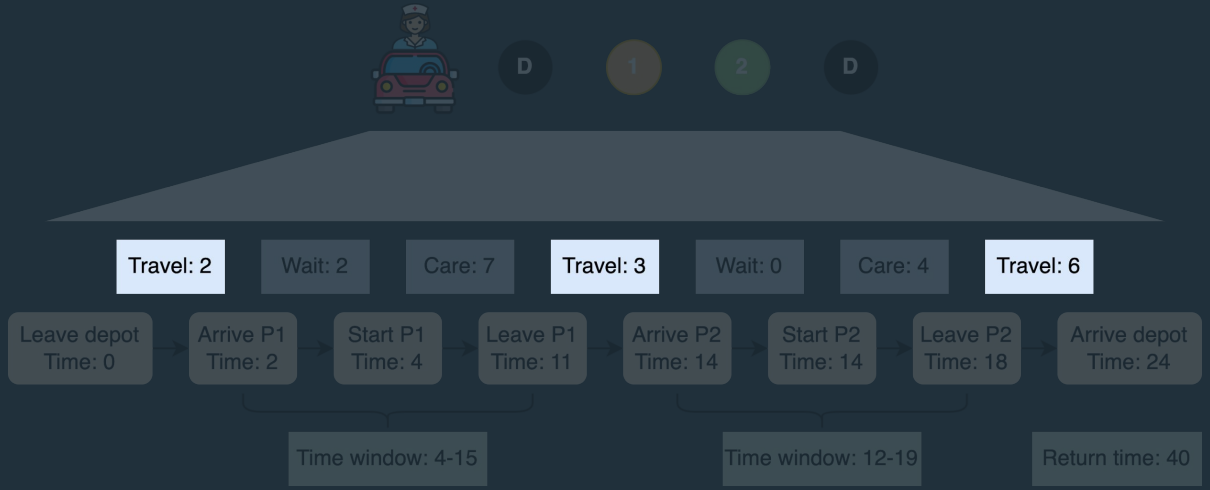


5. Each patient is visited on exactly one route.

Visit each patient exactly once



Calculating the objective



... do this for the other routes as well and sum all route travel times

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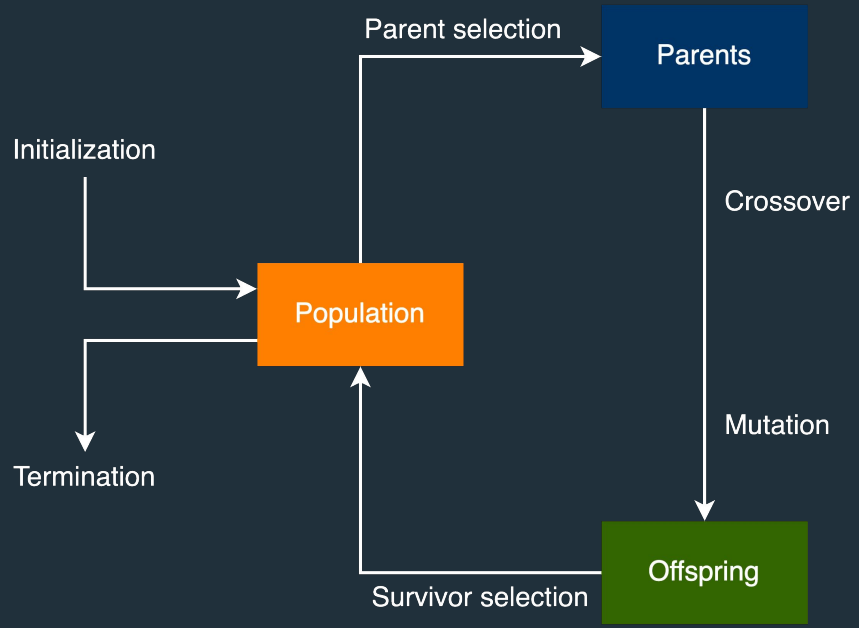
Recap

We have been through...

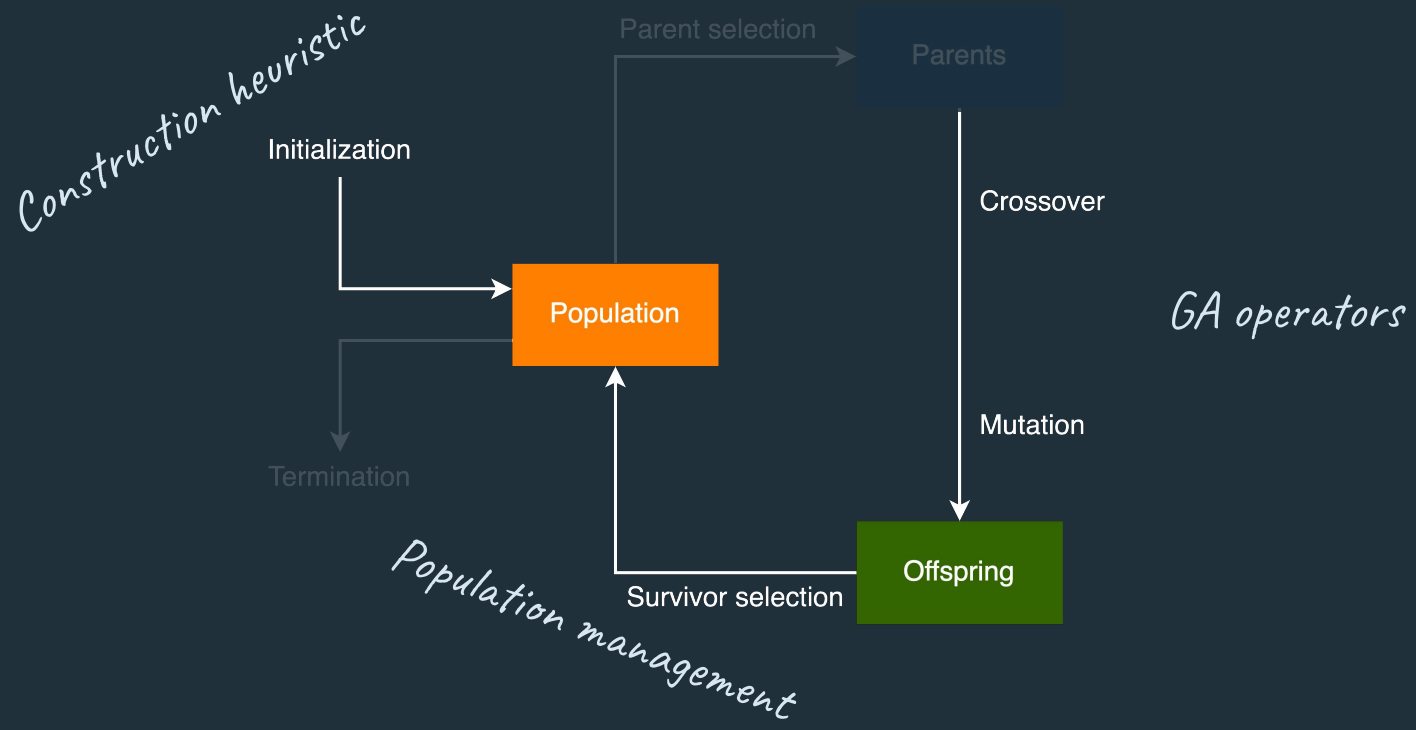
1. How a solution to the problem looks and how it can be represented
2. Making this solution adhere to the problem's constraints
3. Calculating the objective value of a solution

Part 2: Boosting GA performance

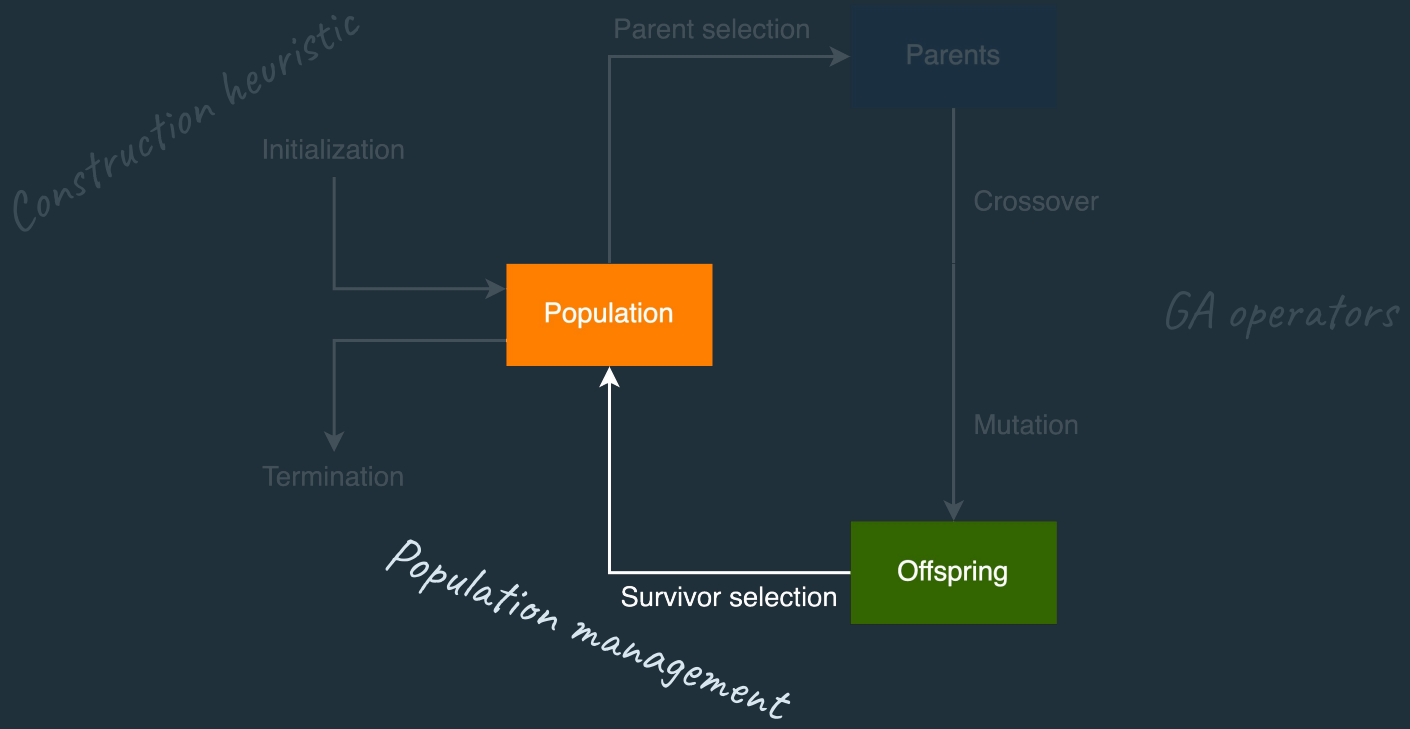
Genetic algorithm recap



Performance improvement areas



Performance improvement areas



Improving population management

Elitism 

Infeasible / feasible population 

Diversify population during search 

... and many more. Do research and be creative!

Improving population management

Elitism

Improving population management

Infeasible / feasible population

Select parents from...

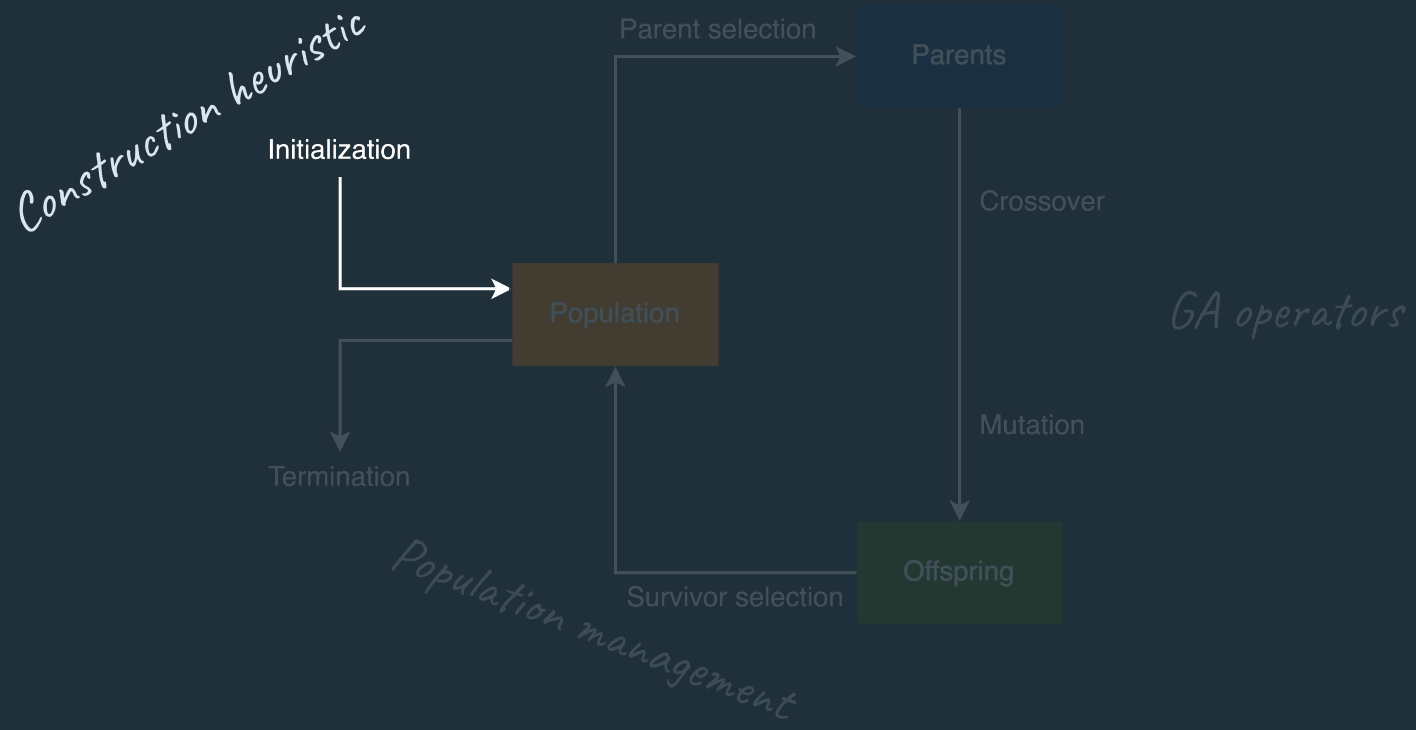
Improving population management

Diversify population during search

No improving solution for the previous Y iterations?

Keep the X best solutions, run a (random) construction heuristic to create brand new individuals

Performance improvement areas



Construction heuristic ideas

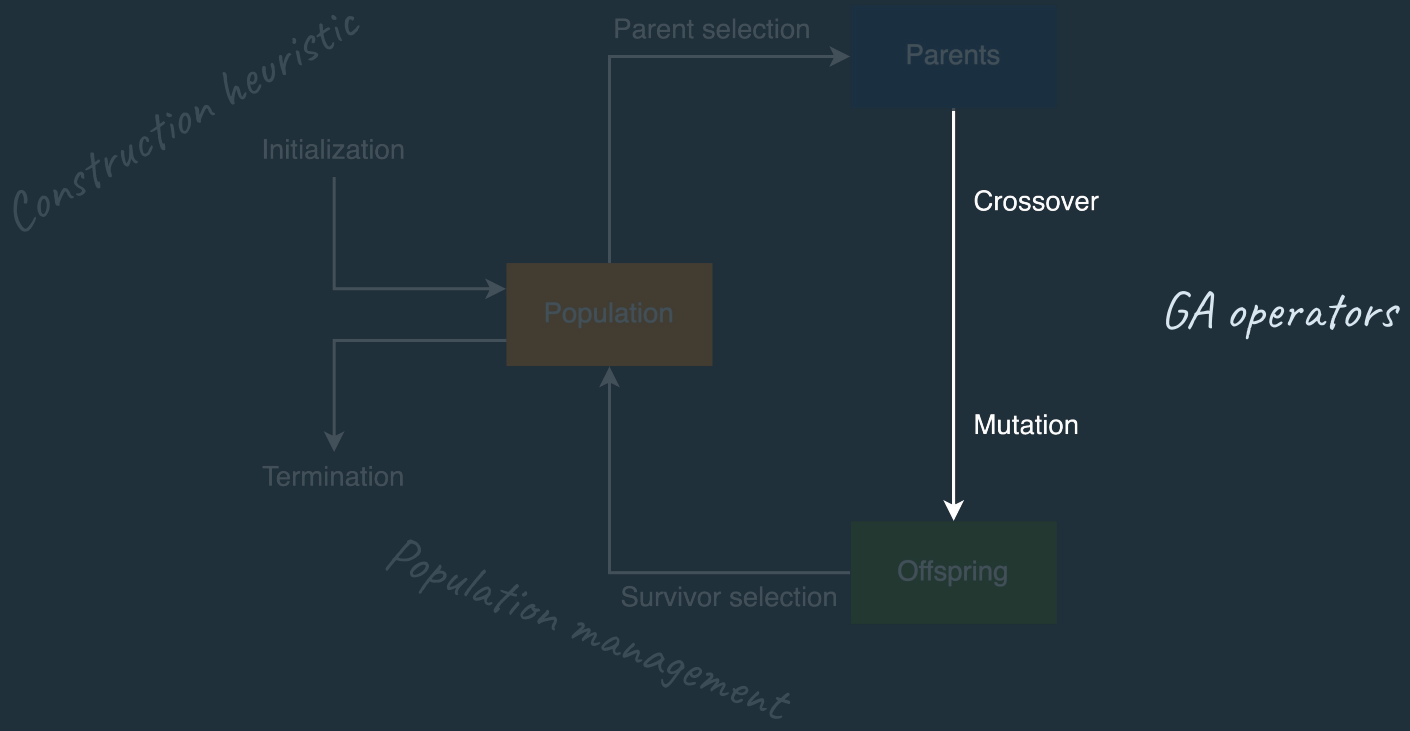
Place patients in nurse routes randomly (will yield both feasible and infeasible solutions)

Greedy heuristic (assign the patient to the nurse route where the travel time increase is smallest)

Identify clusters and assign nurses to clusters

... and many more. Do research and be creative!

Performance improvement areas



Improving GA operators

Local search (education) 

Parallel computations 

Choosing efficient data structures 

... and many more. Do research and be creative!

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Improving GA operators

Local search (education)

Marginally alter a solution (individual) and investigate the neighborhood of the solution.

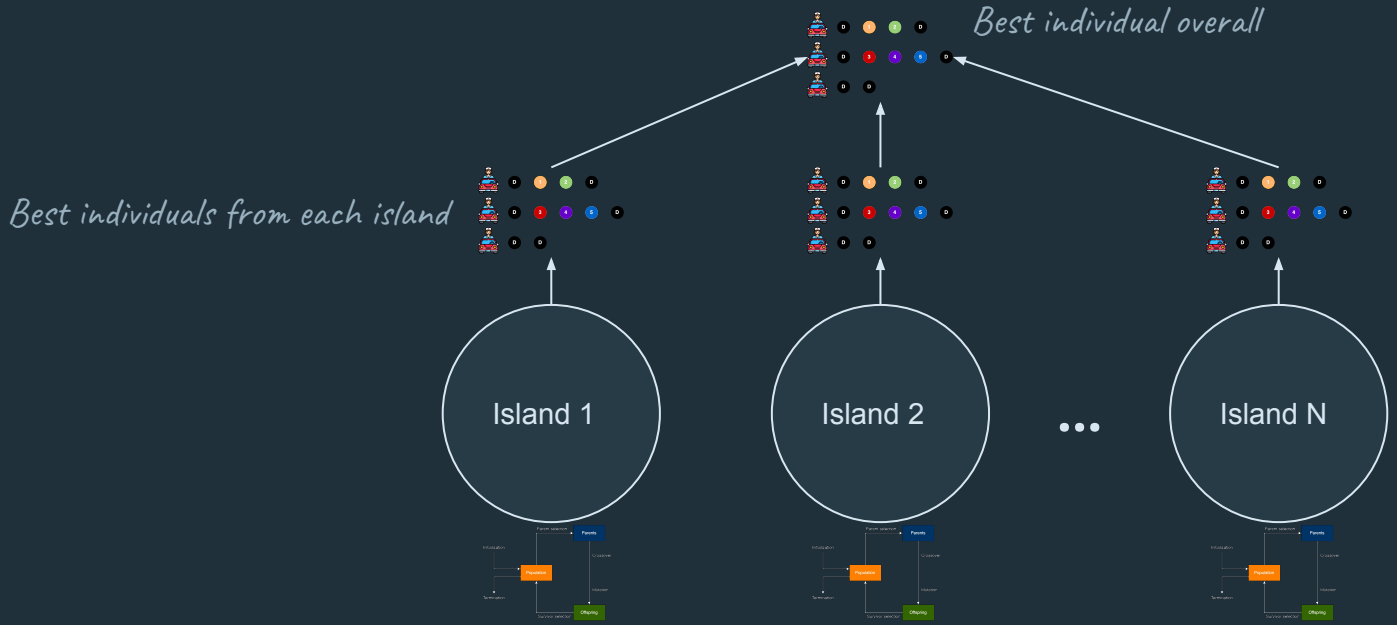
Many different local search operators can be implemented, but some are:

- Move a patient to another spot in the route
- Move a patient to another route
- Swap two patients within a route
- Swap two patients in different routes
- ...

Improving GA operators

Parallel computations

Option 1: Parallel Genetic Algorithm with “Islands”



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Improving GA operators

Parallel computations 

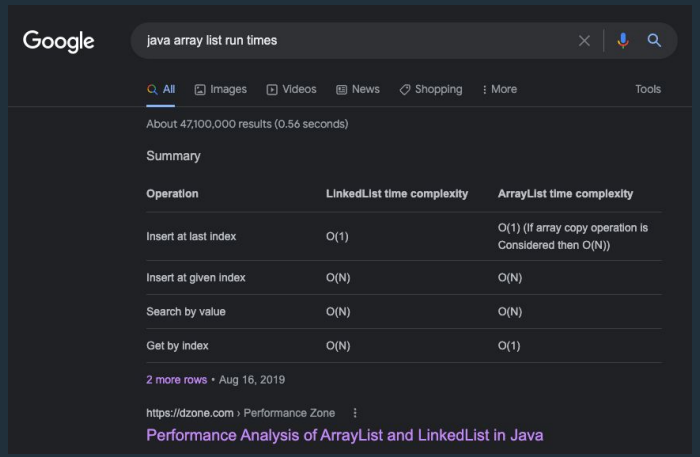
Option 2: Parallelizing the local search

Pick X solutions (individuals) to run the local search (education) on, and do so in parallel

Improving GA operators

Choosing efficient data structures

Think about what operations you will be doing on your solutions and choose an efficient data structure



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Other tips

Place time window constraint in the objective with a **large** penalty parameter

$$objective = \sum_{n=1}^{N} travel\_time_n$$

Number of nurses

Other tips

Place time window constraint in the objective with a **large** penalty parameter

Number of nurses

Number of patients

$$objective = \sum_{n=1}^{N} travel\_time_n + penalty * \sum_{p=1}^{P} time\_window\_violation_p$$

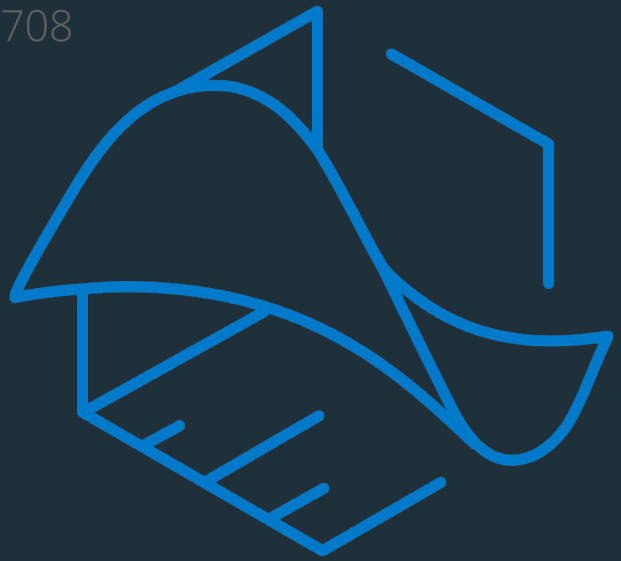
Remember to implement the ability to use the penalty and not! In population management and parent selection, you want the penalized version. When displaying your best solutions, you need the actual objective value, i.e. just the travel time.

Agenda

Introduction to Visma, Resolve, and our involvement in IT3708
Introduction to route planning in the home health care
Deep dive into our Operational Route Planner (ORP)

15-minute break

Introduction to IT3708 project 2
Implementation tips & tricks
The competition web page



Basic info about the competition

Completely **optional** and nothing to do with your score in the project or course.

Run your algorithm locally on a specified instance, upload it and get a score.

High score list.

Best score at 09.00 on March 10th: gift card for komplett.no worth 1000 NOK

https://it3708.resolve.visma.com

Entrepreneurial

Responsible

Dedicated

Inclusive

Make progress happen

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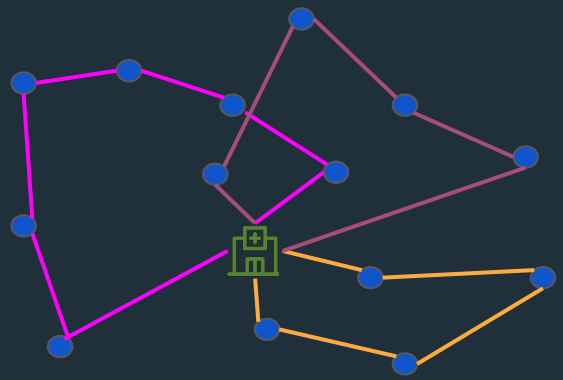
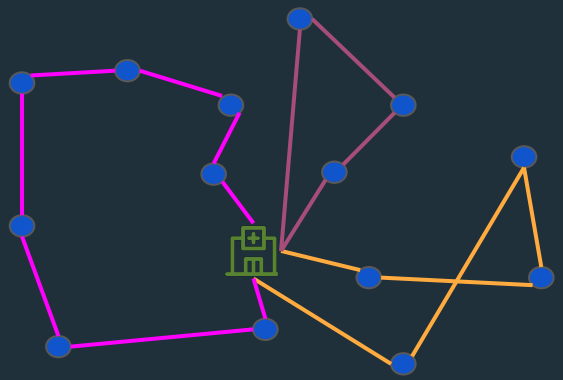
Appendix: Crossover

Individual 1



Individual 4



How can we **combine features** from the two individuals to create two **new offsprings**?

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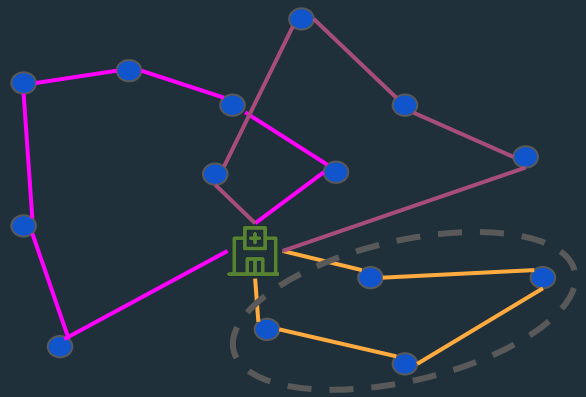
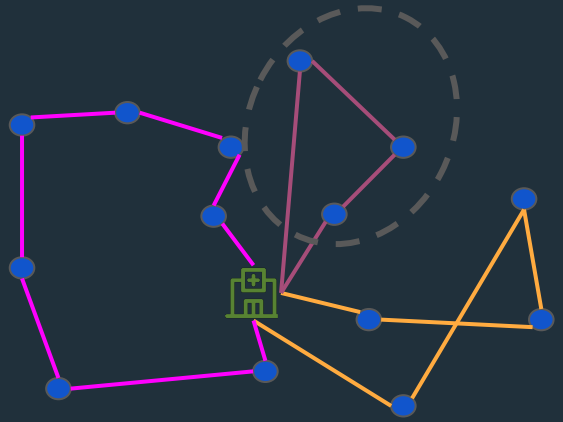
Appendix: Crossover

Individual 1



Individual 4



Select two random nurses' routes

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Appendix: Crossover

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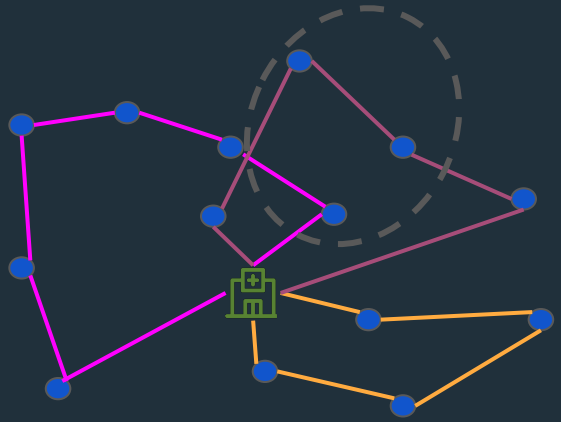
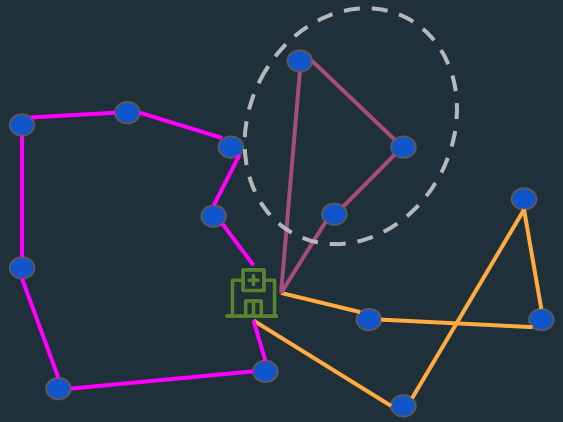


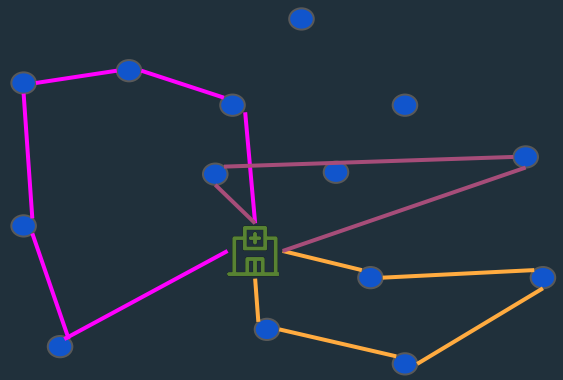
Individual 4



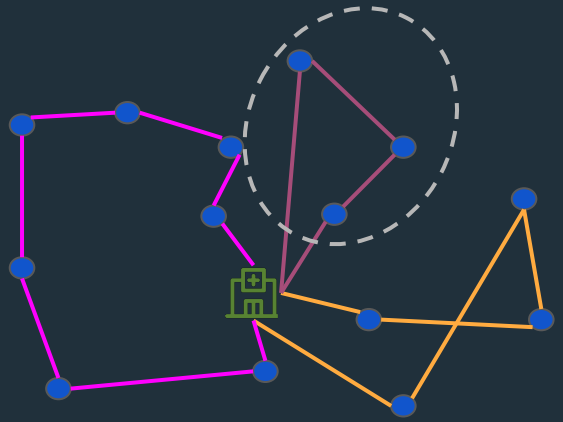
Identify the patients selected from Individual 4 in Individual 1

Appendix: Crossover

Individual 1



Individual 4



Remove the patients from Individual 1

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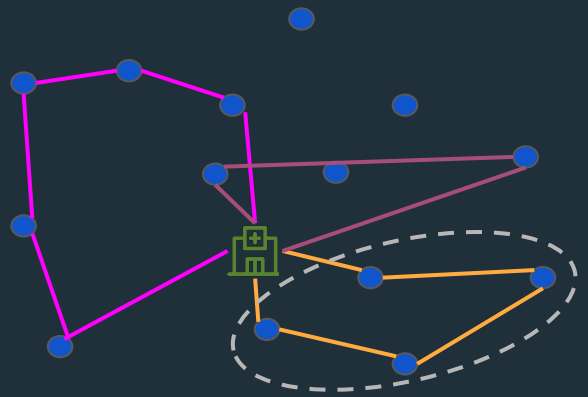
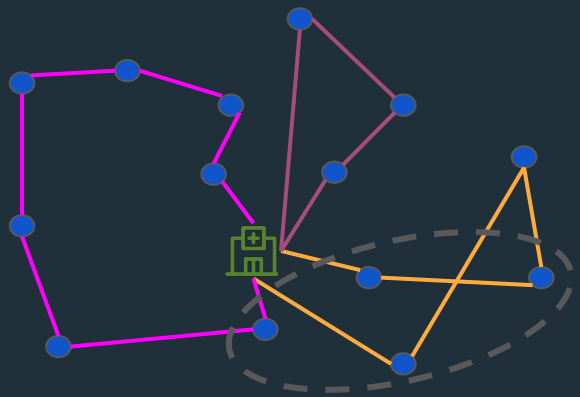
Appendix: Crossover

Individual 1



Individual 4



Identify the patients selected from Individual 1 in Individual 4

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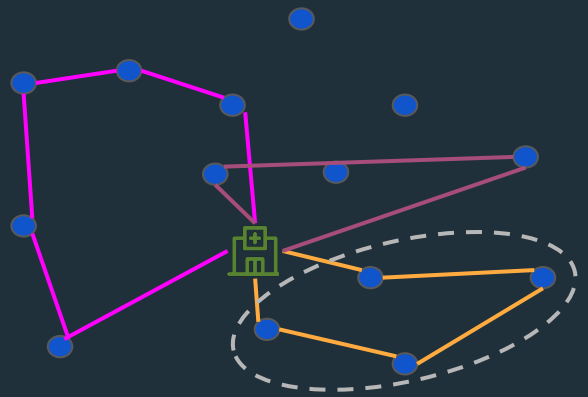
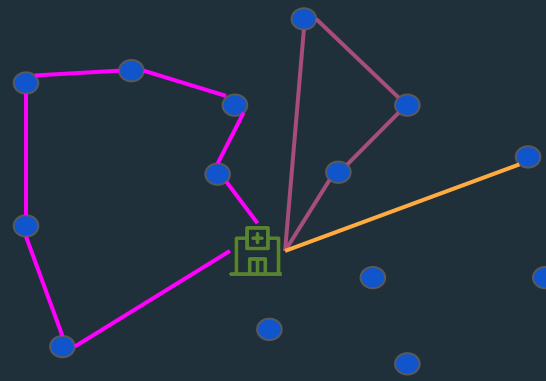
Appendix: Crossover

Individual 1



Individual 4



Remove the patients from Individual 4

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Appendix: Crossover

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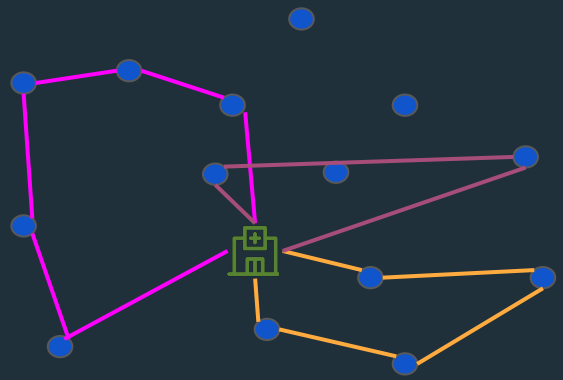
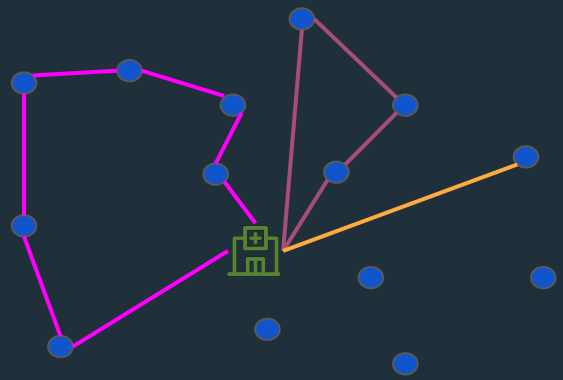


Individual 4



Result after removing patients in crossover

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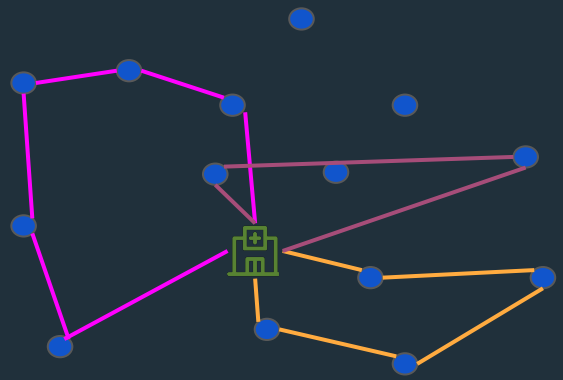

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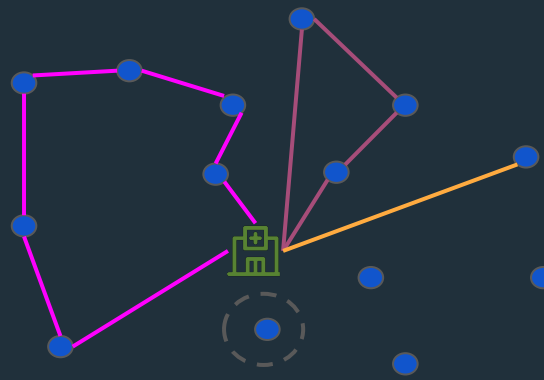

For each patient without a visitor, find the best insertion

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Appendix: Crossover

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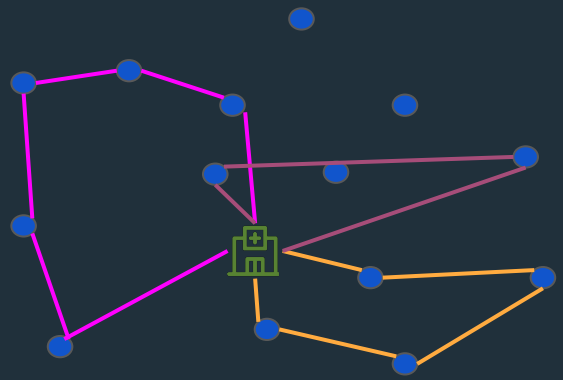
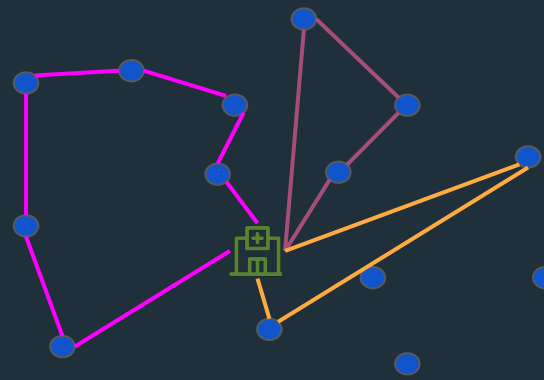


Individual 4



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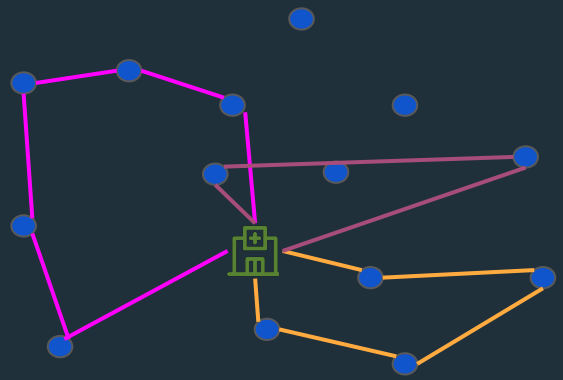
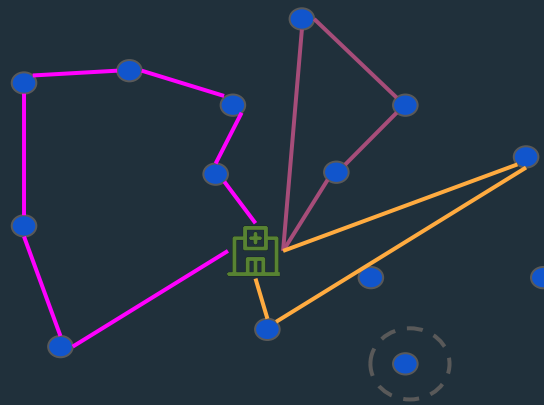


Individual 4



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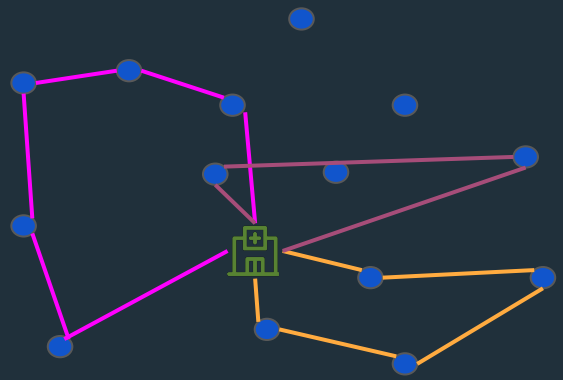

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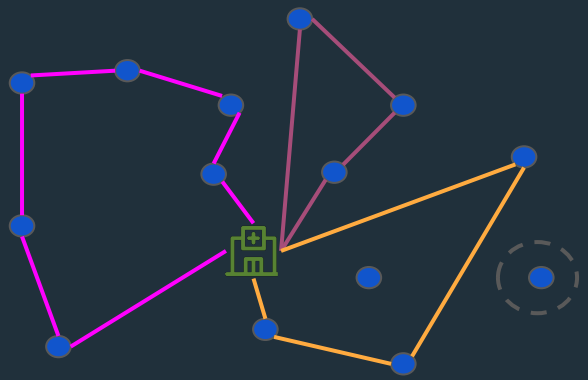

For each patient without a visitor, find the best insertion

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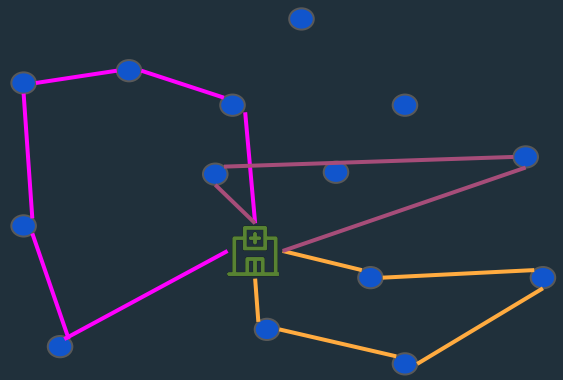
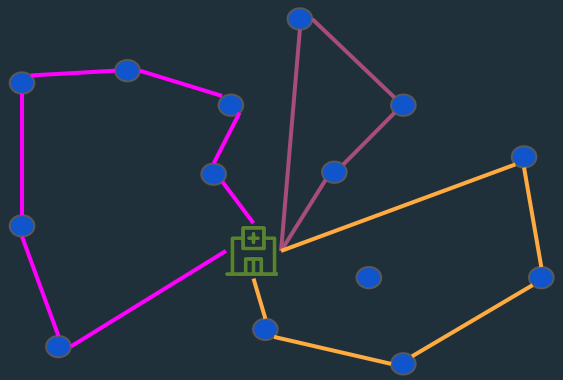


Individual 4



For each patient without a visitor, find the best insertion

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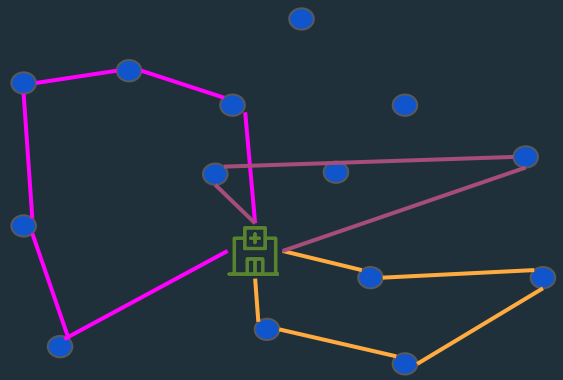

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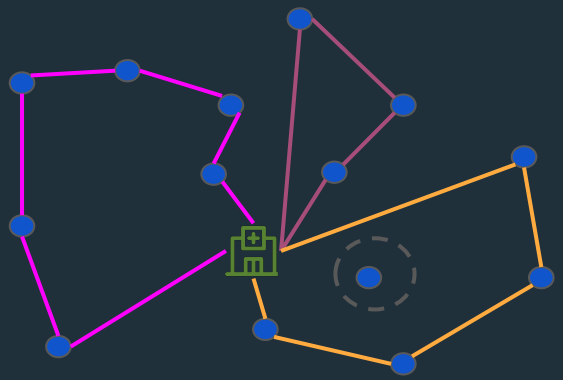

For each patient without a visitor, find the best insertion

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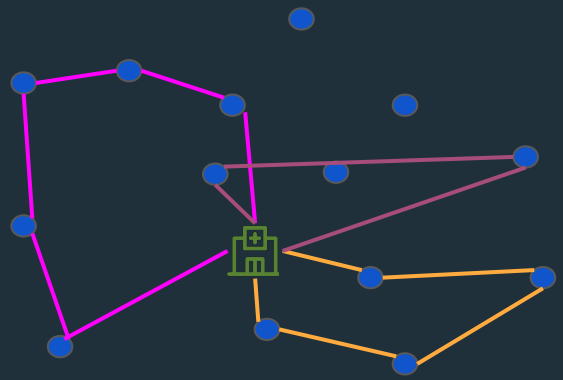

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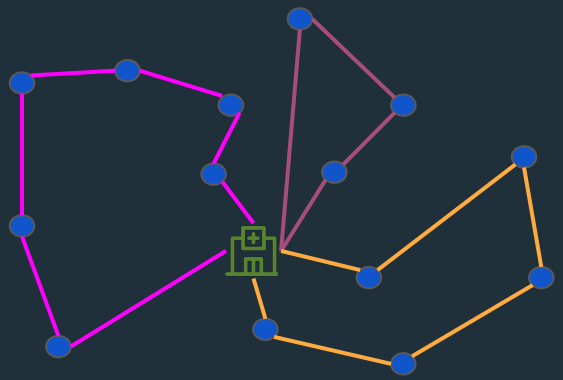

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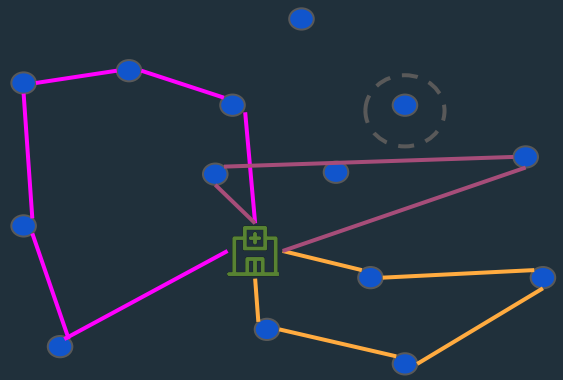

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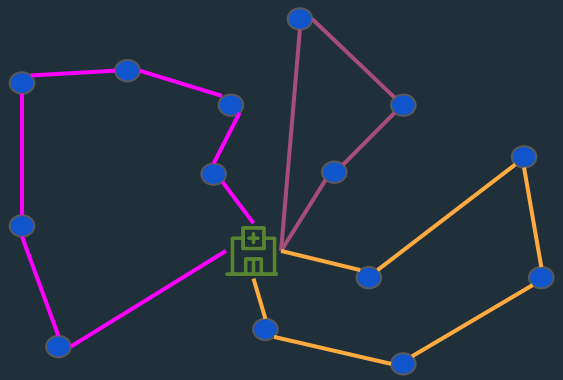

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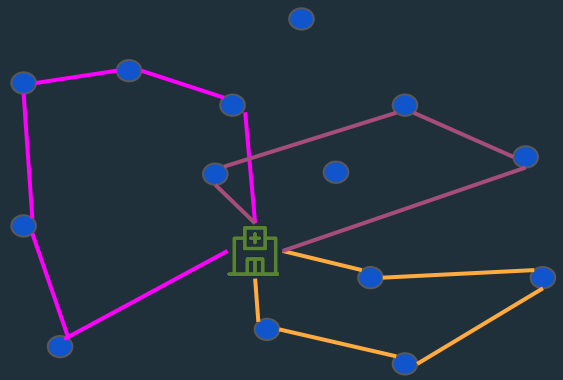

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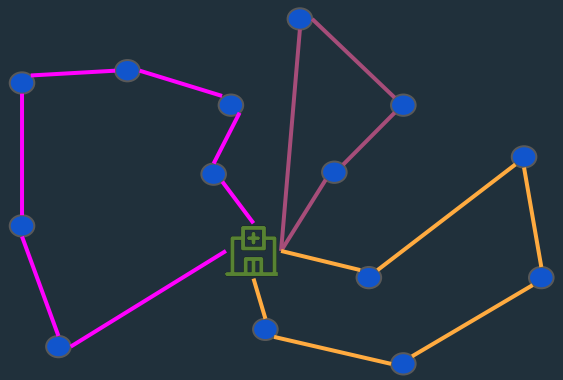

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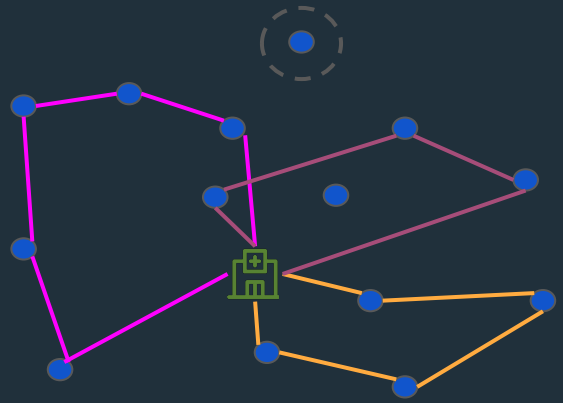
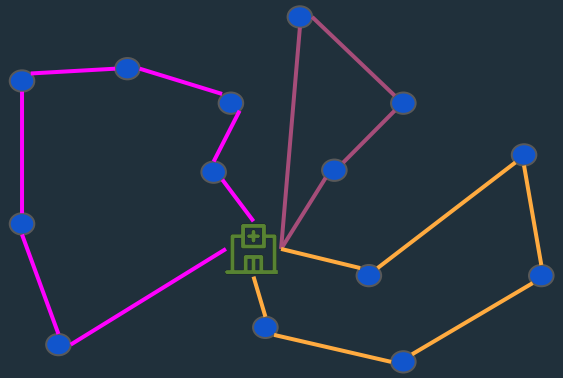


Individual 4

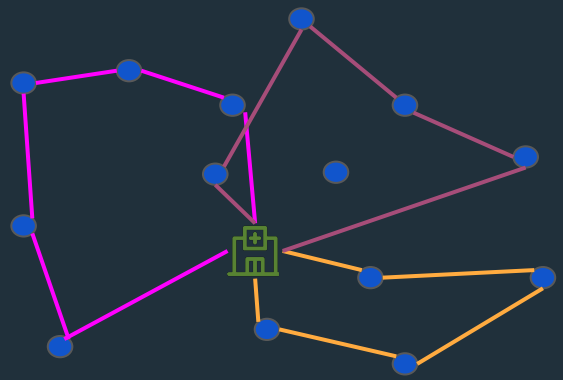


For each patient without a visitor, find the best insertion

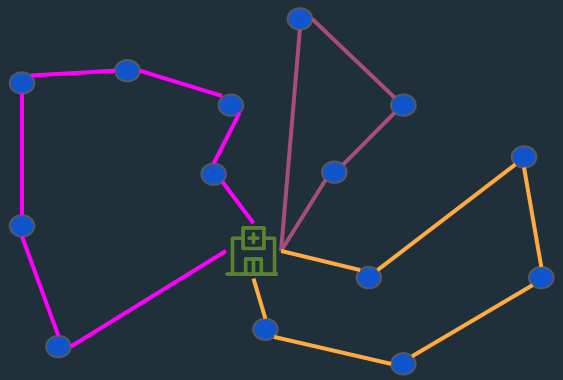
VISMA

Appendix: Crossover

Individual 1



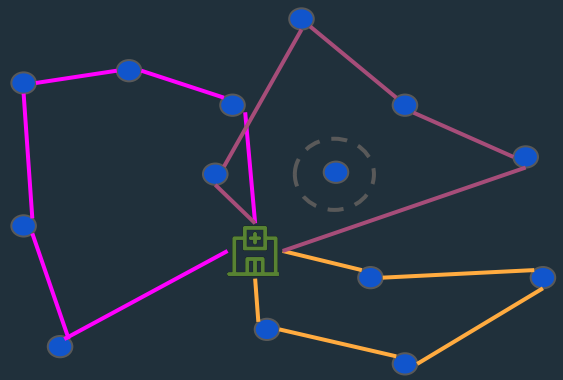
Individual 4



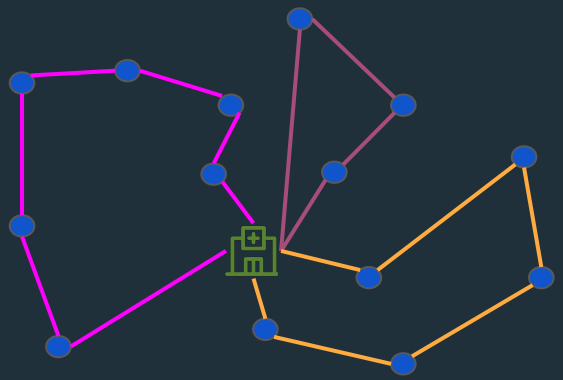
For each patient without a visitor, find the best insertion

Appendix: Crossover

Individual 1



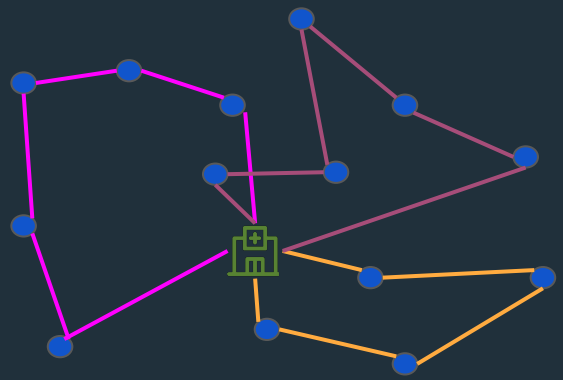
Individual 4



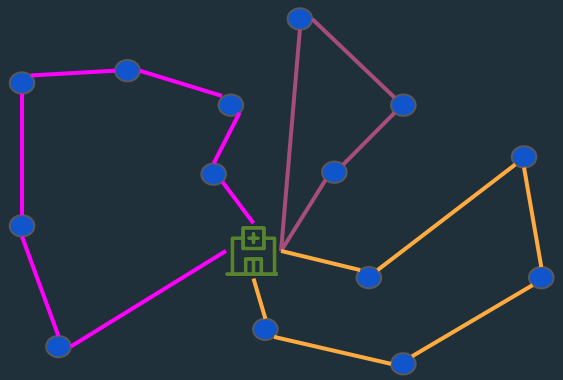
For each patient without a visitor, find the best insertion

Appendix: Crossover

Individual 1



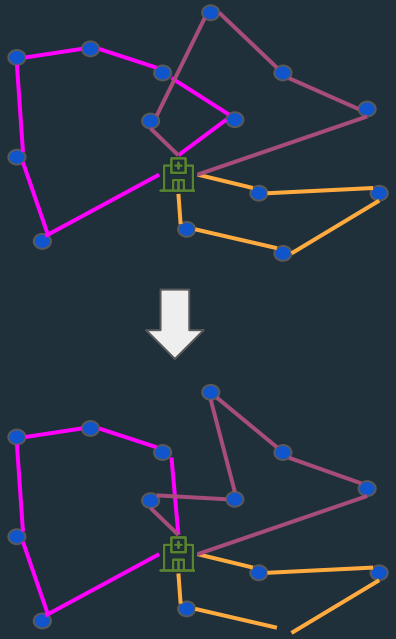
Individual 4



For each patient without a visitor, find the best insertion

Appendix: Crossover

Individual 1



Individual 4