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ACT. 4.24 OPTIMIZACIÓN DE RUTAS DE INSPECCIÓN DE MANTENIMIENTO

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Programa Misiones de I+D en Inteligencia Artificial 2021, en el marco de la Agenda España Digital 2025 y de la Estrategia Nacional de Inteligencia Artificial, Proyecto IA4TES financiado por el Plan de Recuperación, Transformación y Resiliencia.

Número de expediente TSI-100408-2021-0

MAINTENANCE ROUTE OPTIMIZATION

INDEX

1. OUR PROBLEM

Overview of the Multi-Period Team Orienteering Problem with Time Windows (TOPTW), focused on optimizing routes by considering power generators, time constraints, and team availability.

2. RL

Application of reinforcement learning algorithms to address combinatorial optimization challenges, emphasizing their adaptability compared to heuristic methods.

3. HEURISTIC

Development of daily updated solutions incorporating merging processes to effectively manage multi-period complexities, balancing practicality with efficiency.

4. RESULTS

Analysis of average outcomes across 256 instances, demonstrating the advantages of RL over heuristics in computational efficiency and performance under specific conditions.

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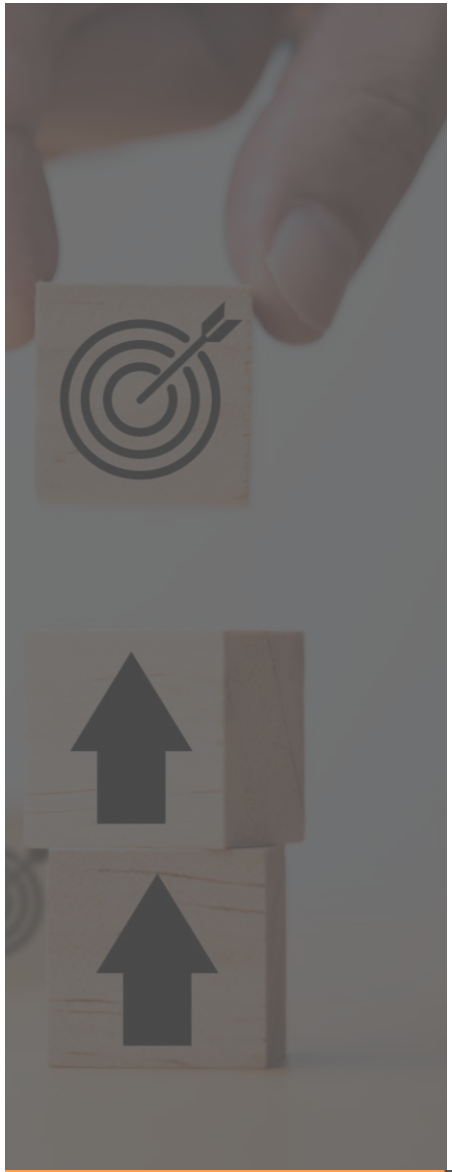

LEARN TO DEVELOP RL ALGORITHMS TO SOLVE COMBINATORIAL OPTIMIZA-TION PROBLEMS.

- Understand the drawbacks of RL in comparison to heuristics.
- Explore the advantages of RL over heuristics.

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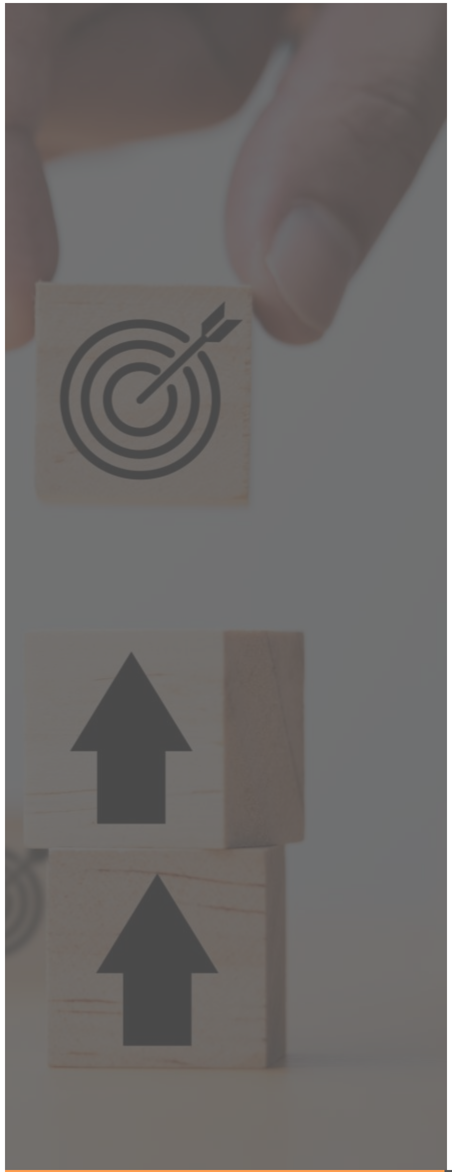

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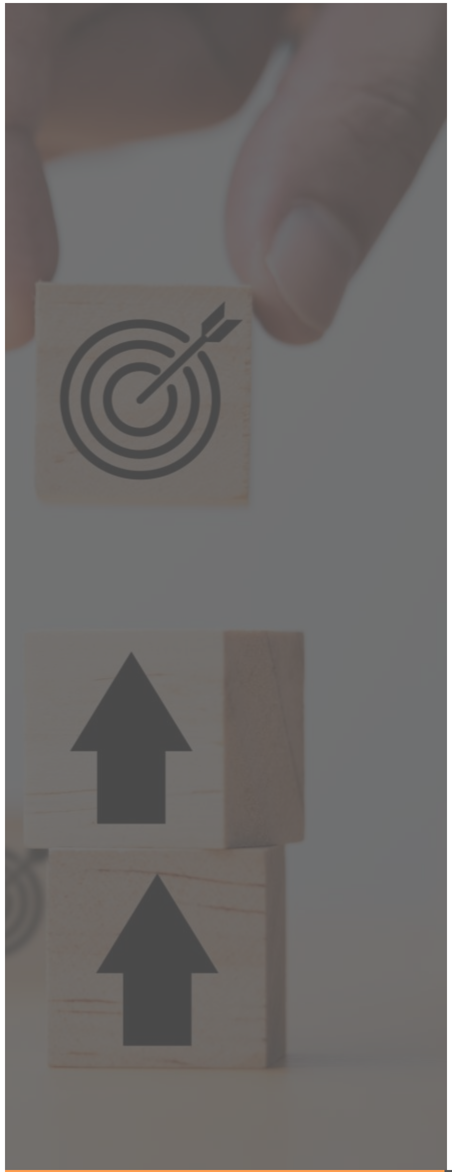
DEVELOP A RL METHOD



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DEVELOP A RL METHOD

DEVELOP A BR - HEURISTIC

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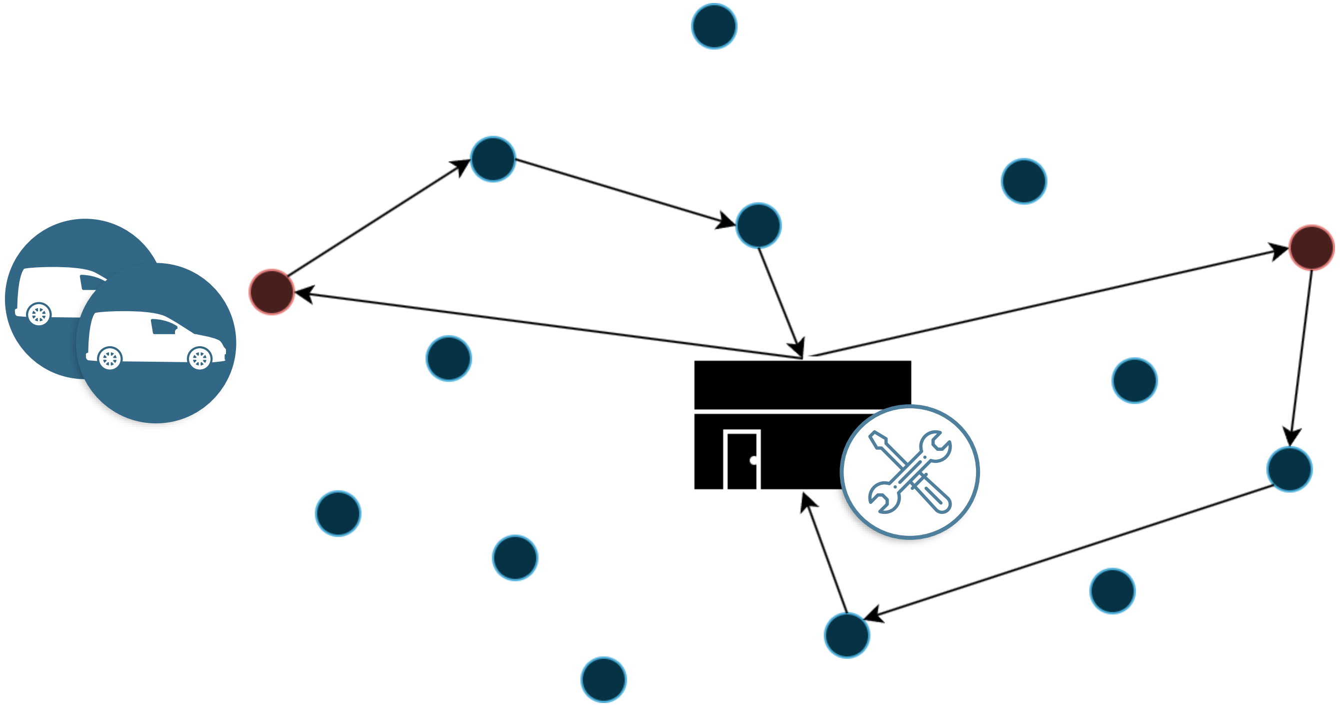
TOP

Team Orienteering Problem

MAINTENANCE ROUTE OPTIMIZATION

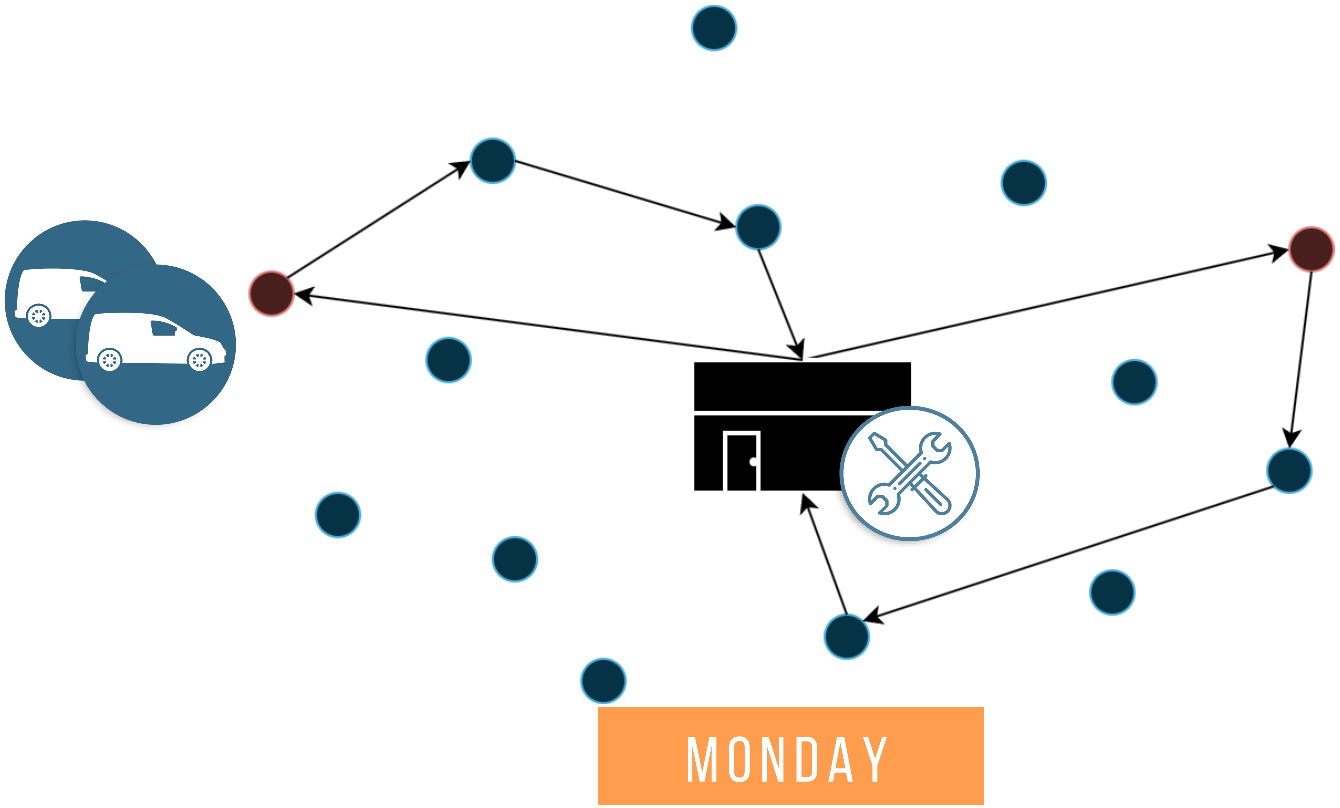
OUR PROBLEM



TOP

Team Orienteering Problem

MULTI - PERIOD



M A I N T E N A N C E R O U T E O P T I M I Z A T I O N

OUR PROBLEM

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TOP

Team Orienteering Problem

MULTI - PERIOD

TW

Time Windows

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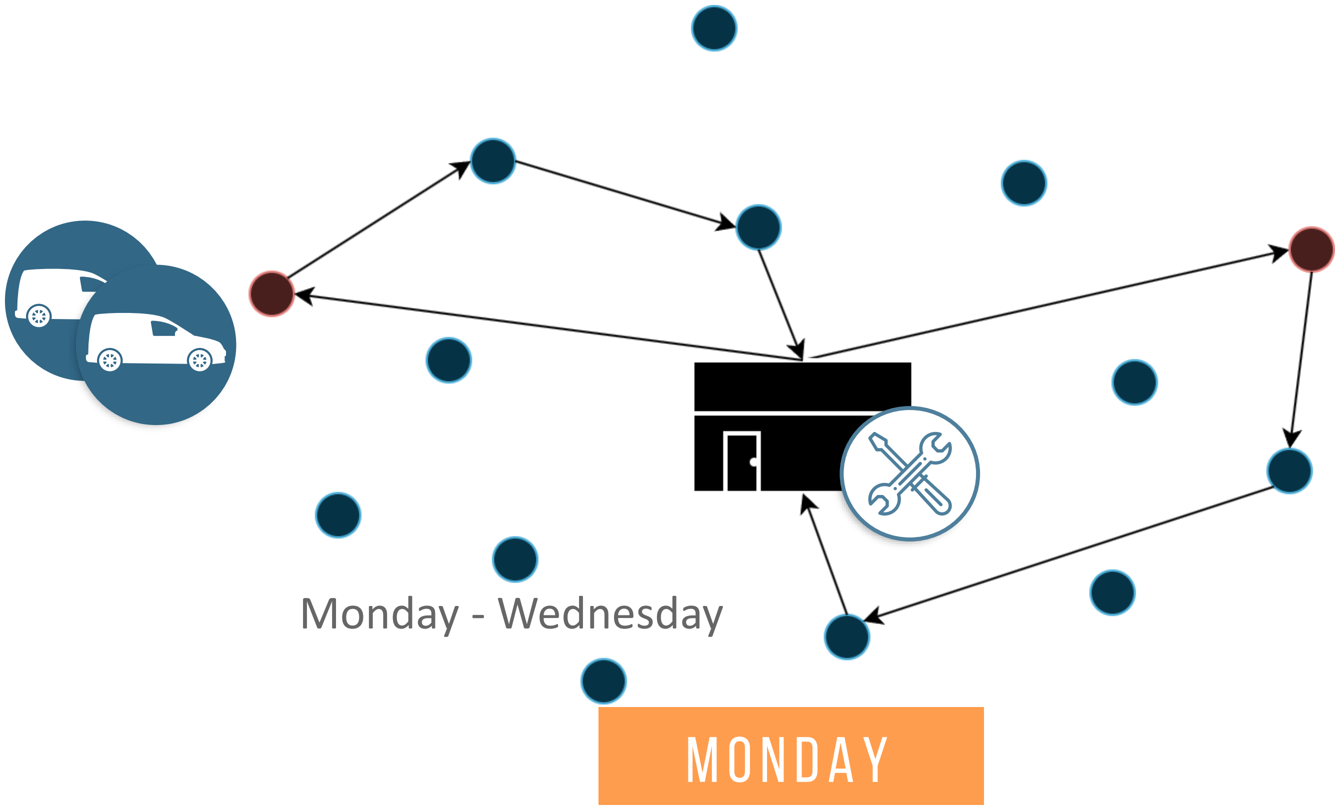
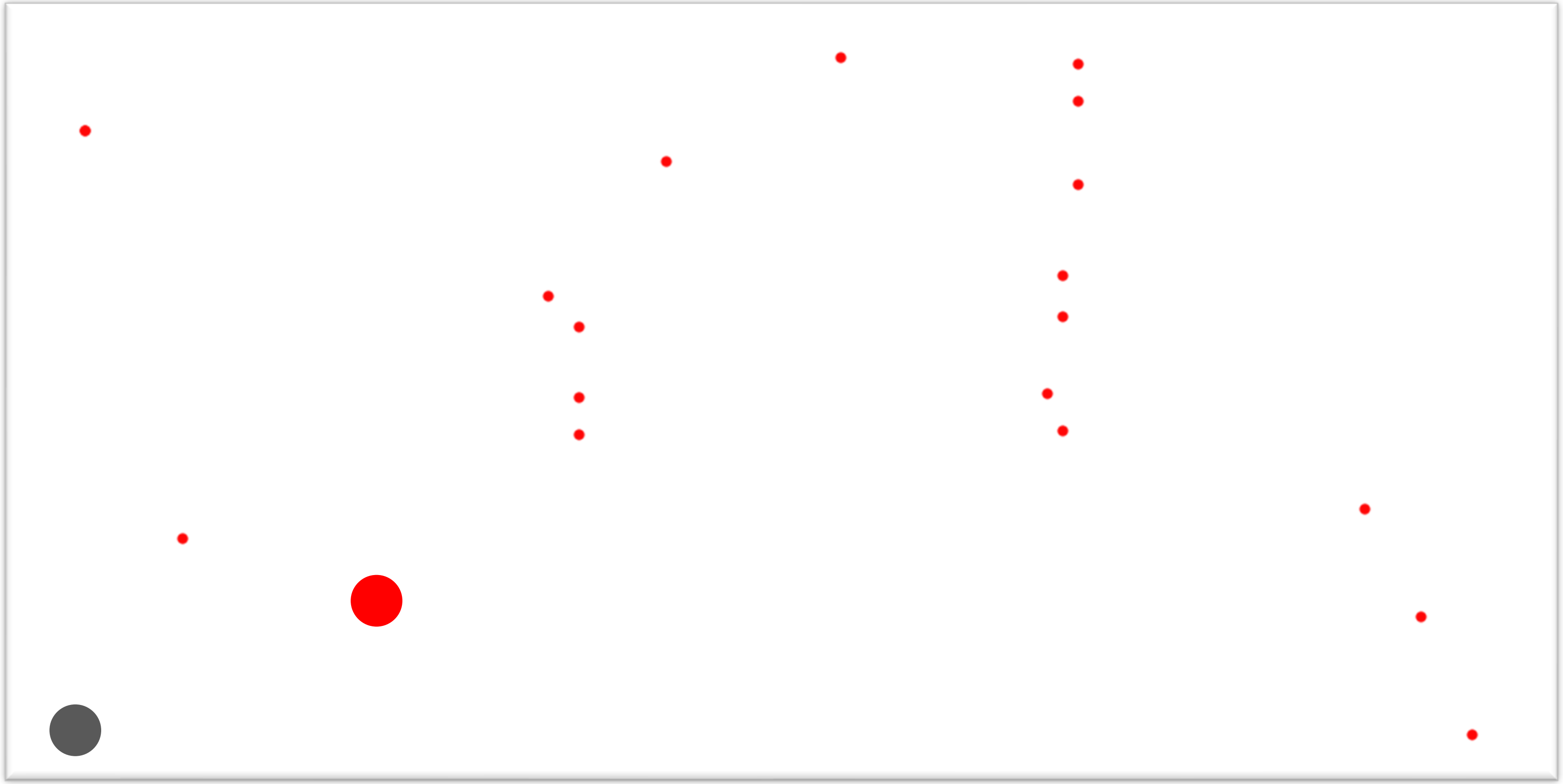
MAINTENANCE ROUTE OPTIMIZATION

OUR PROBLEM



MULTI-PERIOD TOPTW

OUR PROBLEM



POWER GENERATORS / NODES

STARTING / ENDING POINT

MAINTENANCES:

- Corrective
- Preventive
- Predictive

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MULTI-PERIOD TOPTW

OUR PROBLEM

POWER GENERATORS / NODES

STARTING / ENDING POINT

ASPECTS TO CONSIDER:

- Monday to Friday
- Work 8 hours/480 min
- Multiple teams
- Travel times
- Maintenance duration
- Time Windows (TW)
- Energy production
- Energy price

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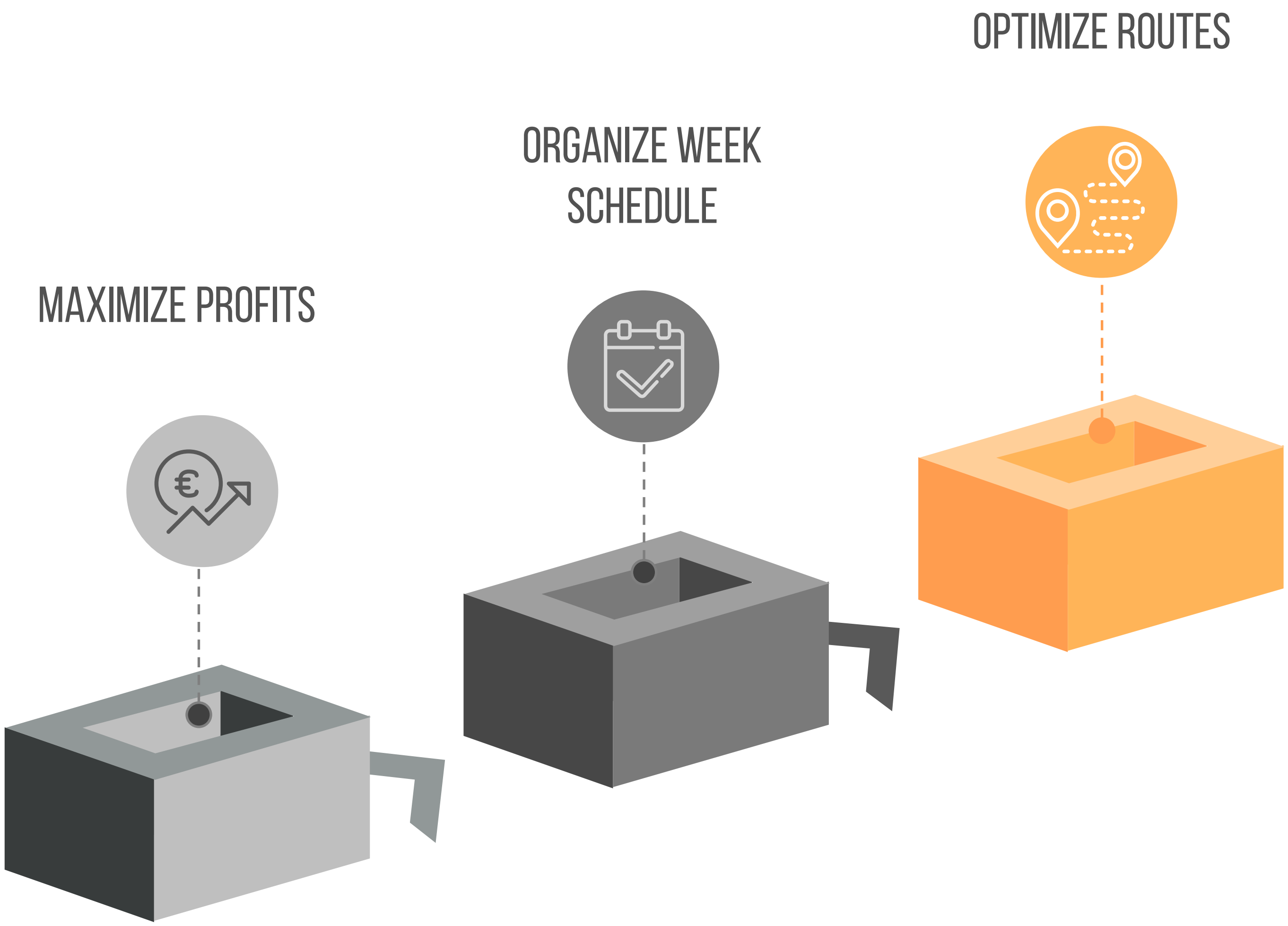
MAINTENANCE ROUTE OPTIMIZATION

OUR PROBLEM GOAL



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MAINTENANCE ROUTE OPTIMIZATION

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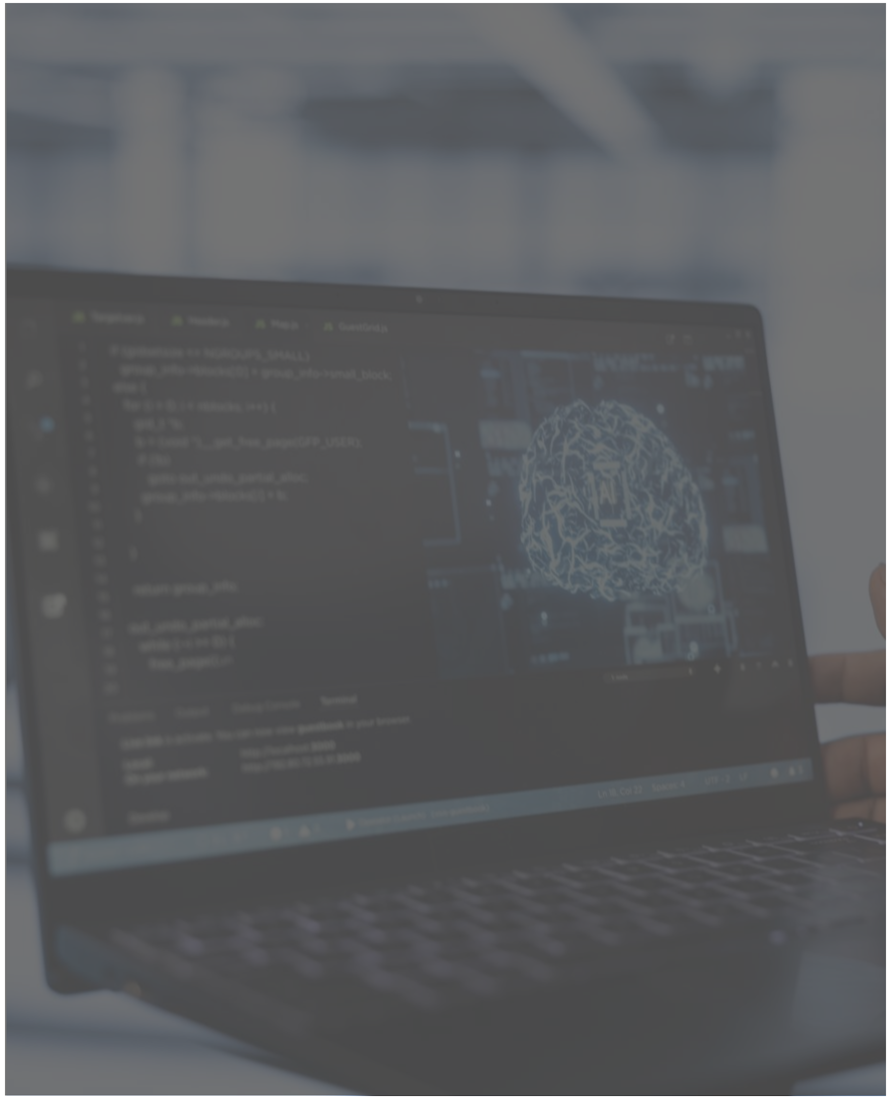
METHODOLOGY (RL)

REINFORCEMENT LEARNING

AGENT

ENVIRONMENT



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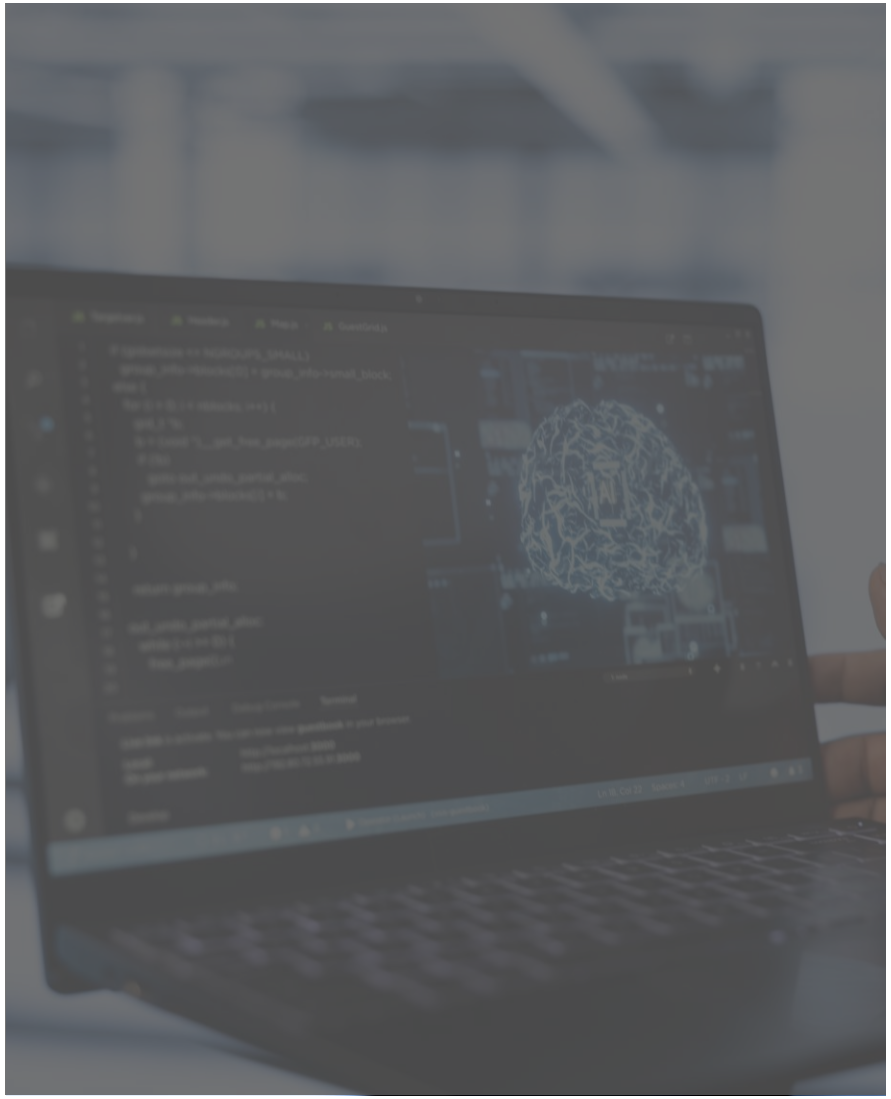
METHODOLOGY (RL)

REINFORCEMENT LEARNING



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METHODOLOGY (RL)

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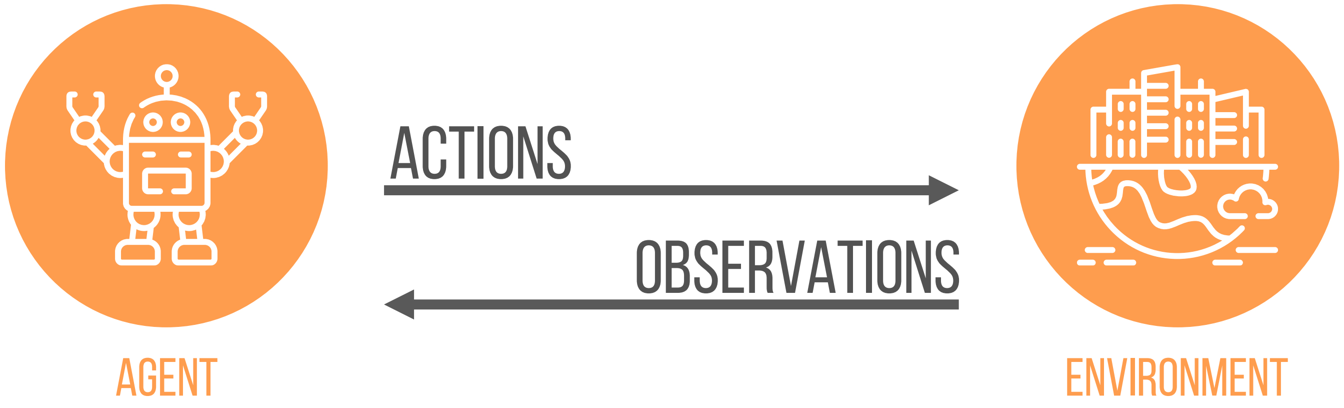

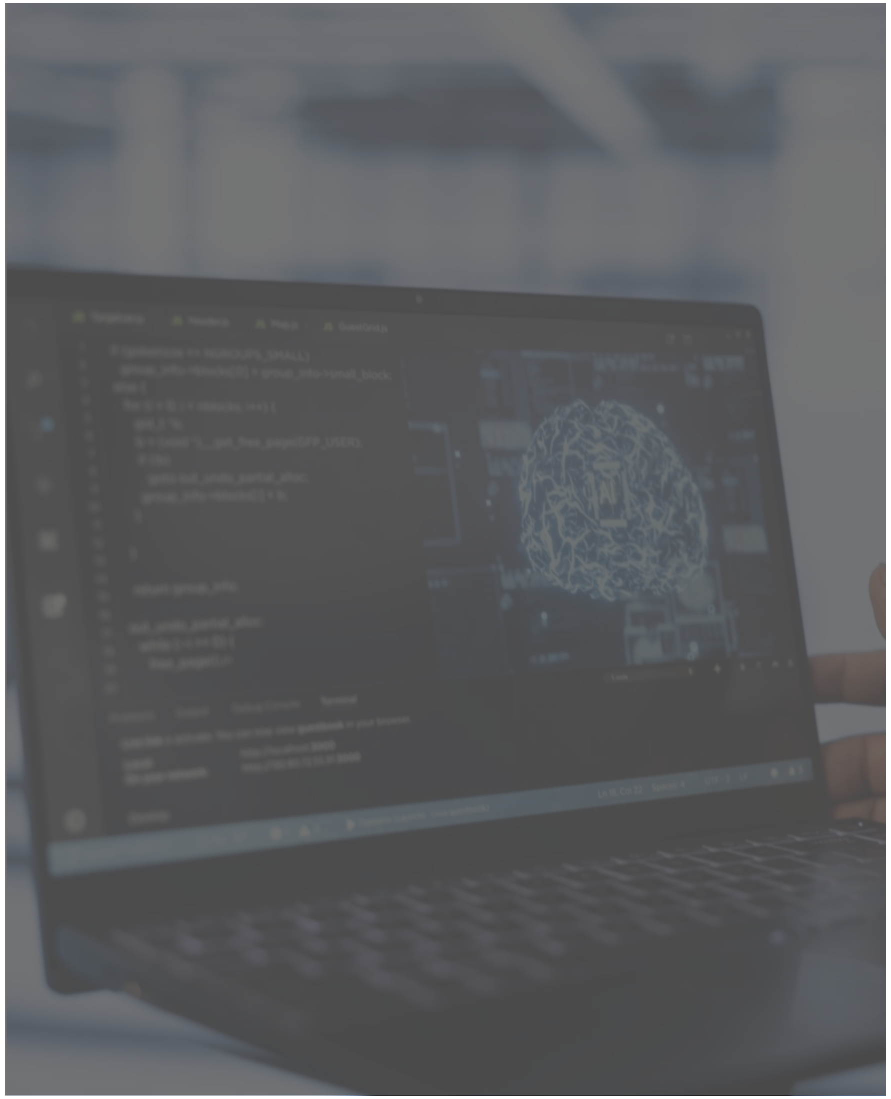

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METHODOLOGY (RL)

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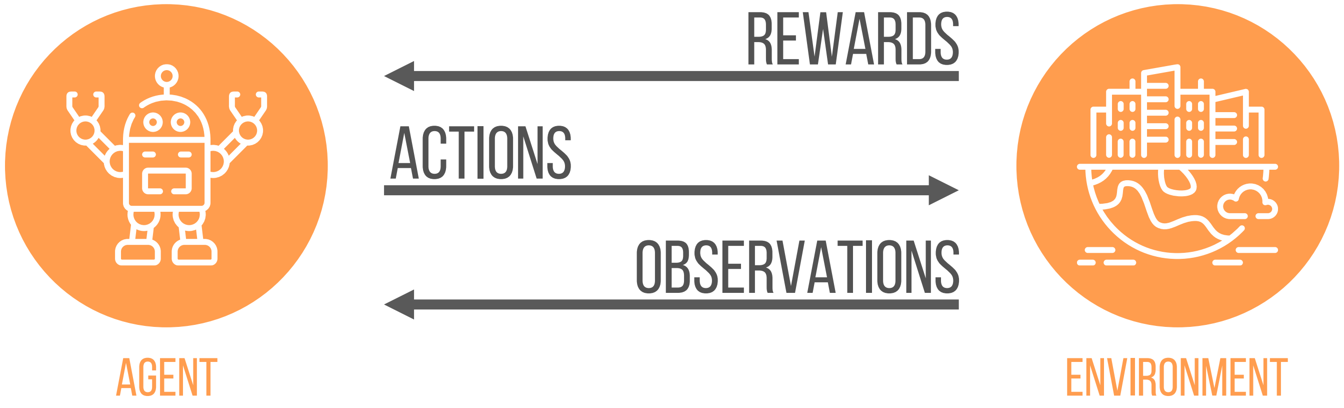

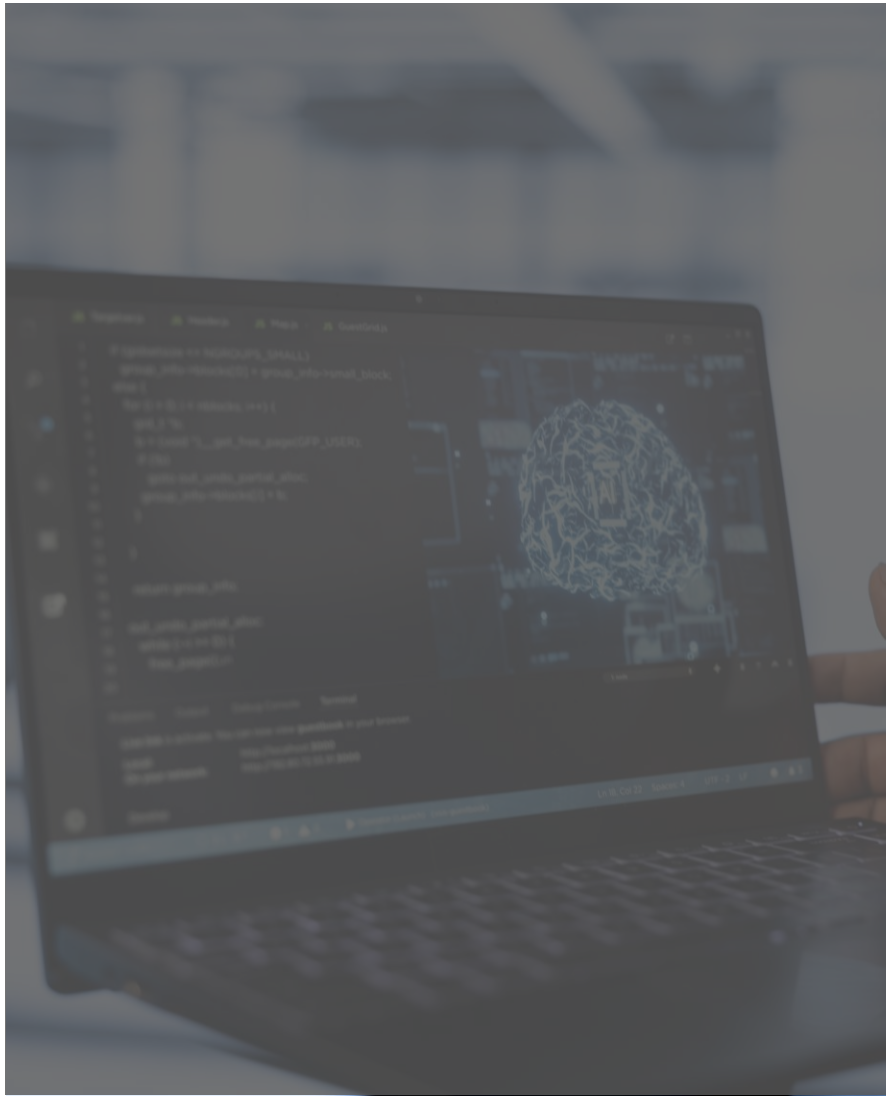

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METHODOLOGY (RL)

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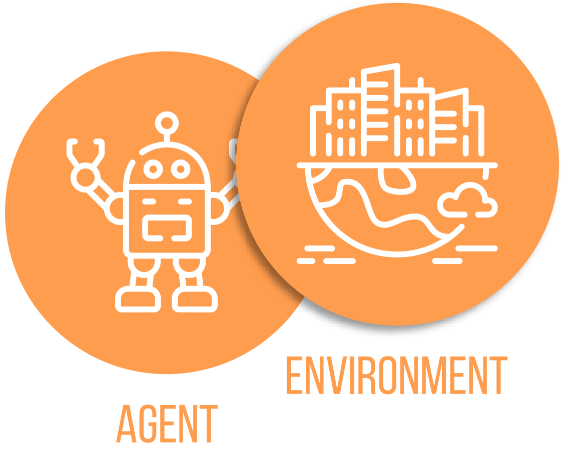

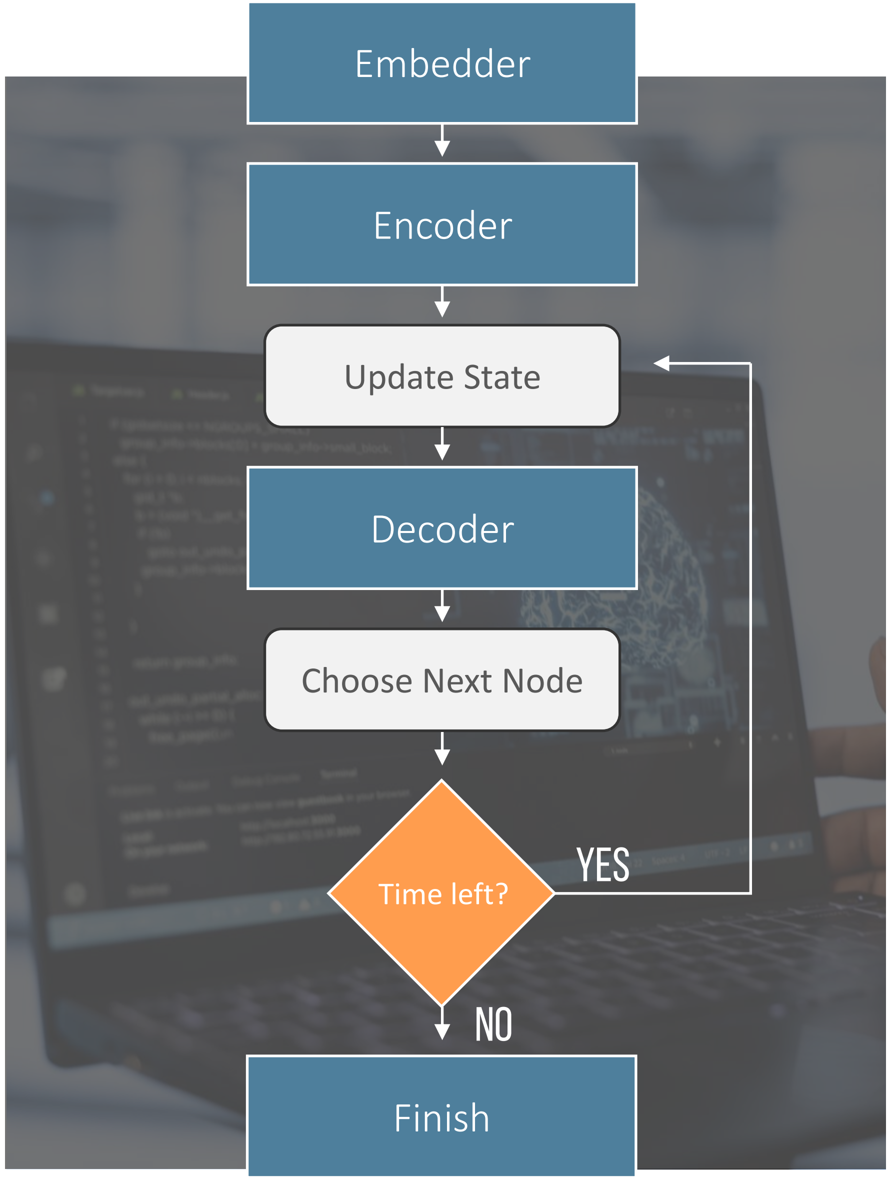

METHODOLOGY (RL)

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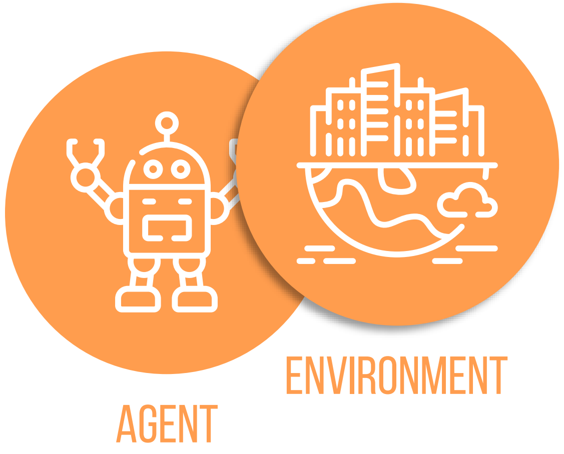
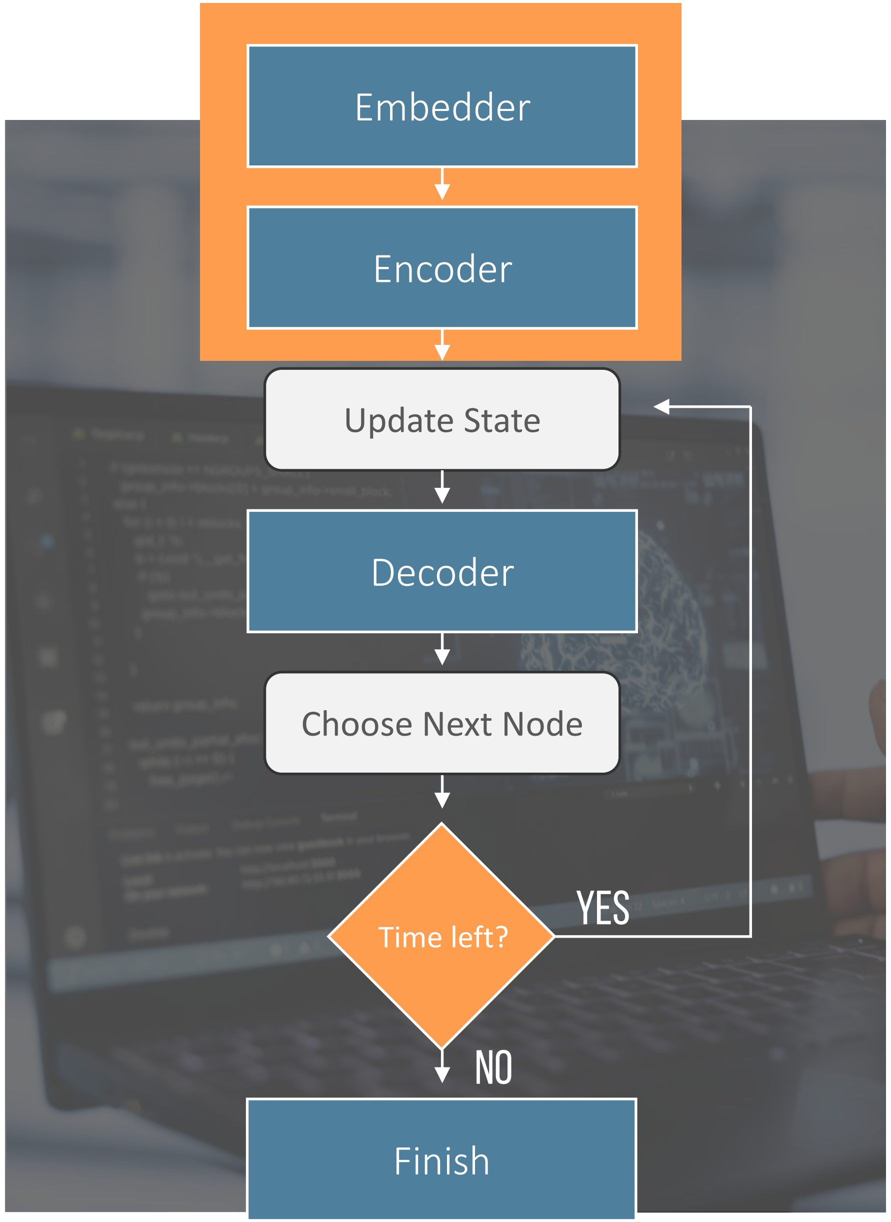
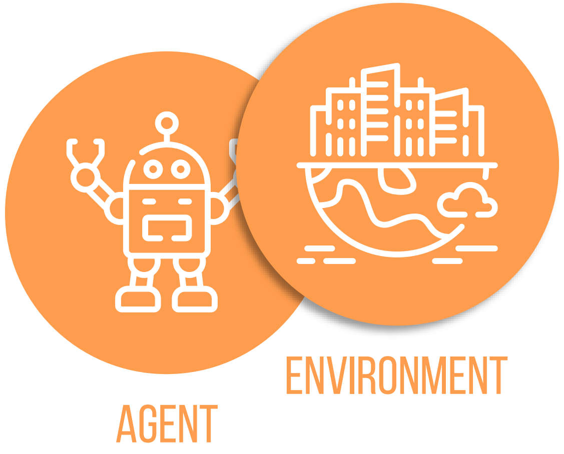
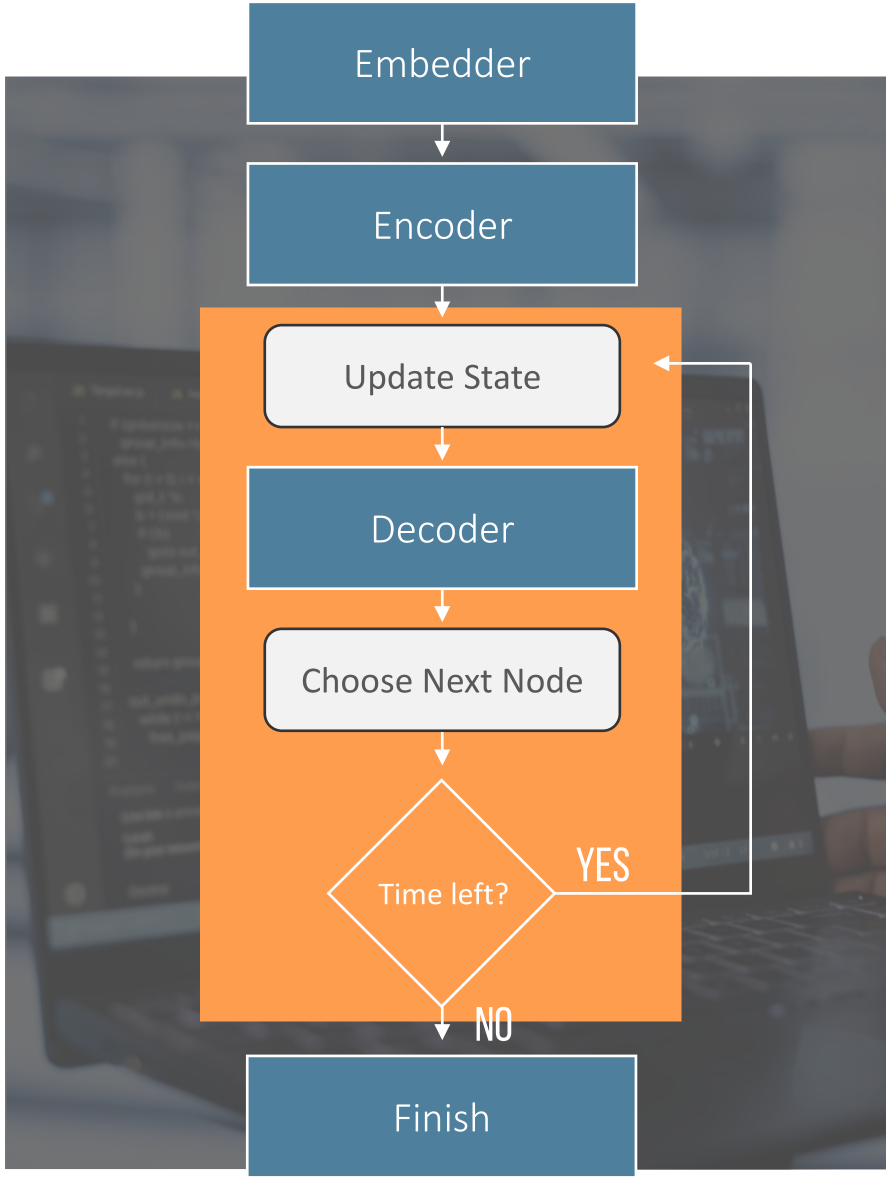




METHODOLOGY (RL)

REINFORCEMENT LEARNING





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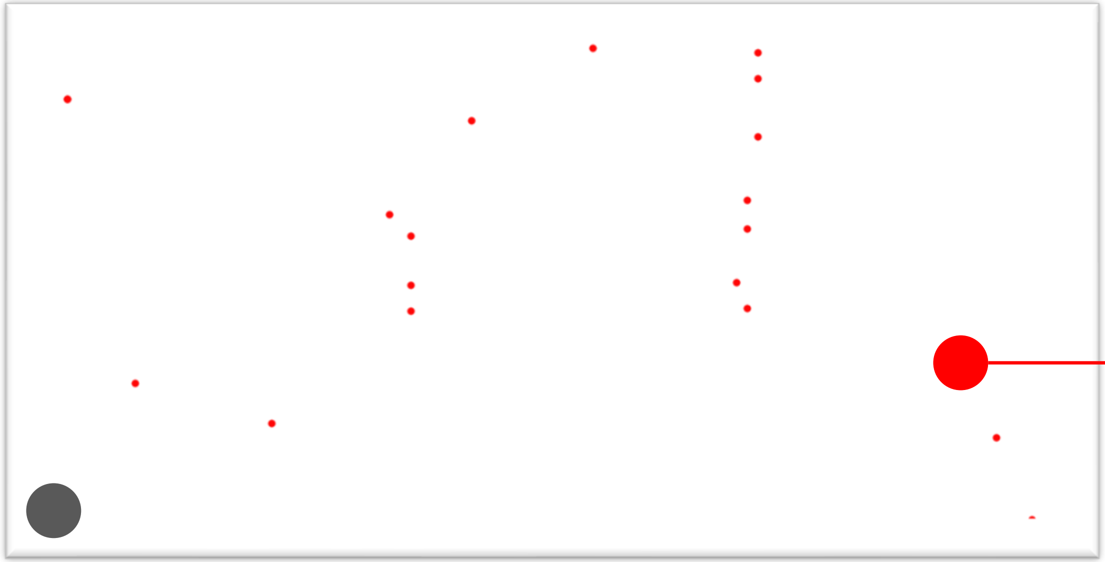
NODE REPRESENTATION

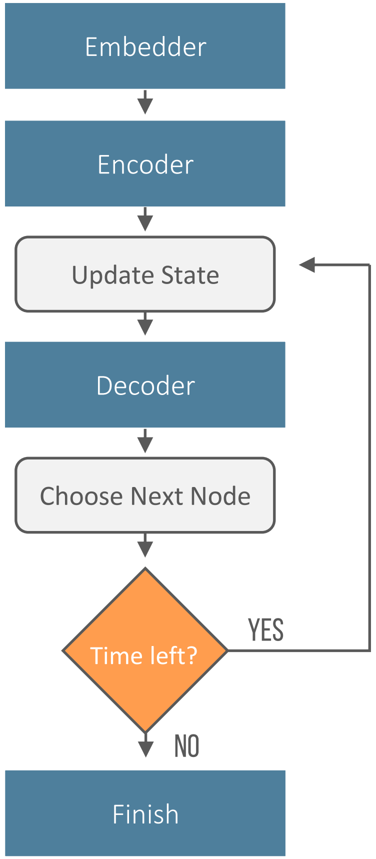
POWER GENERATORS / NODES
STARTING / ENDING POINT



NODE

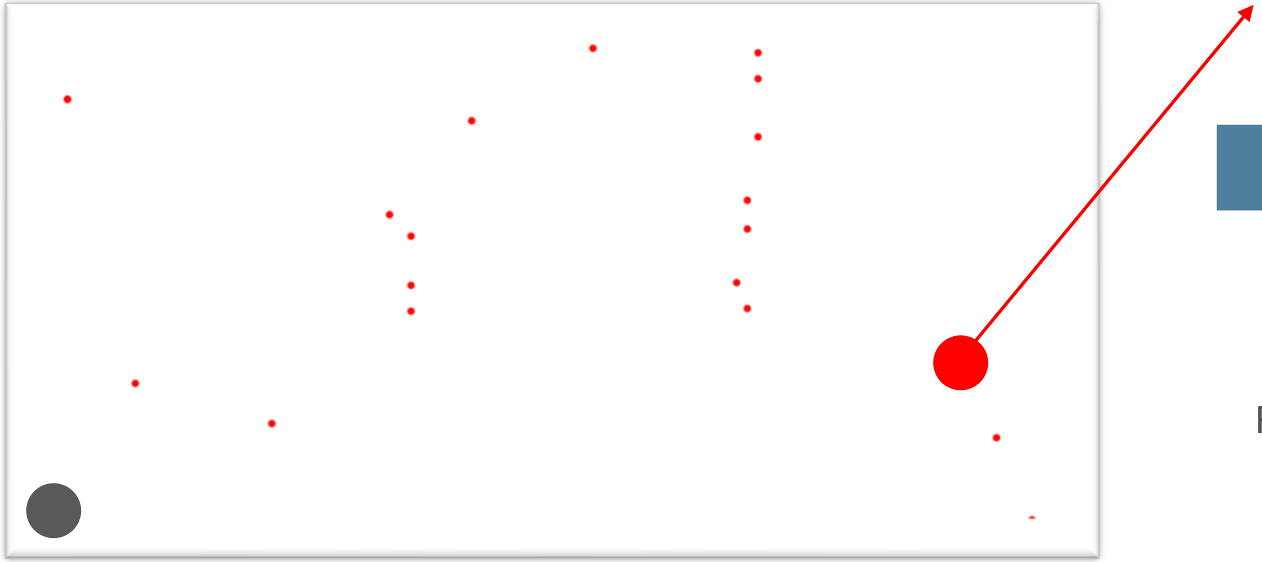
CHARACTERISTICS

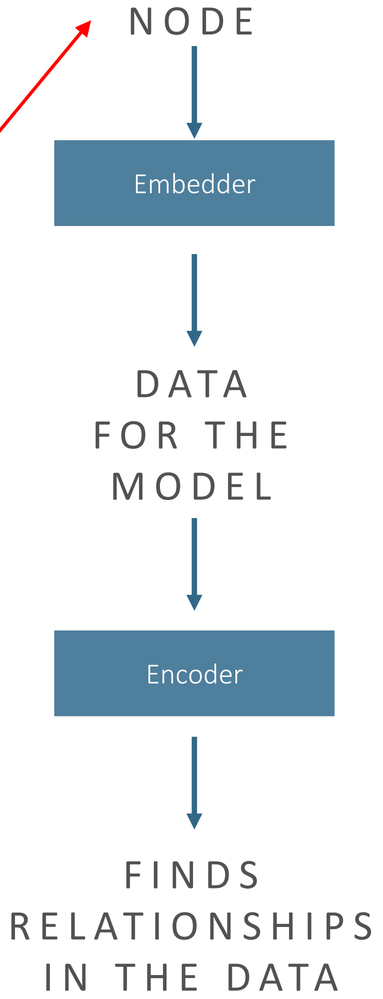
Position,
etc.

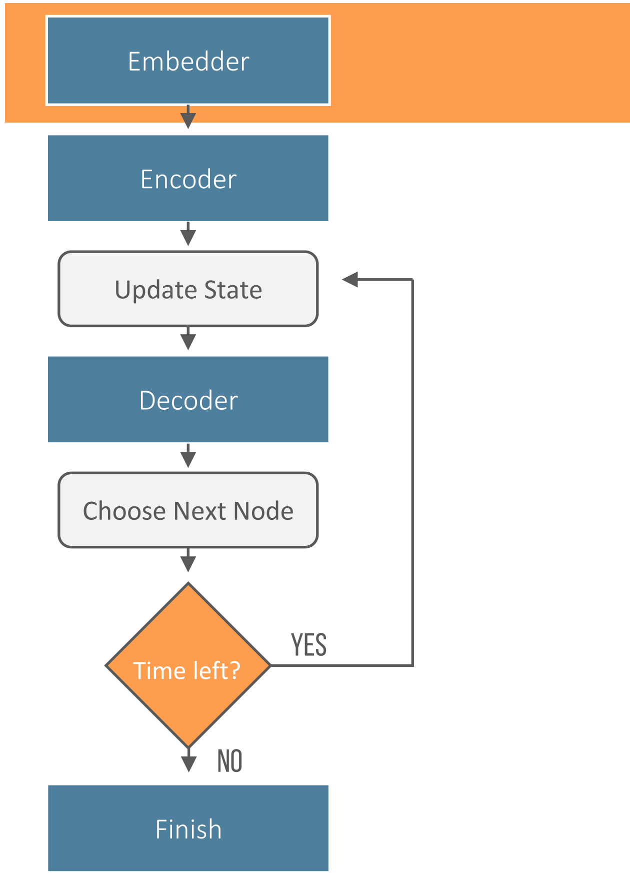


EMBEDDER

POWER GENERATORS / NODES
STARTING / ENDING POINT







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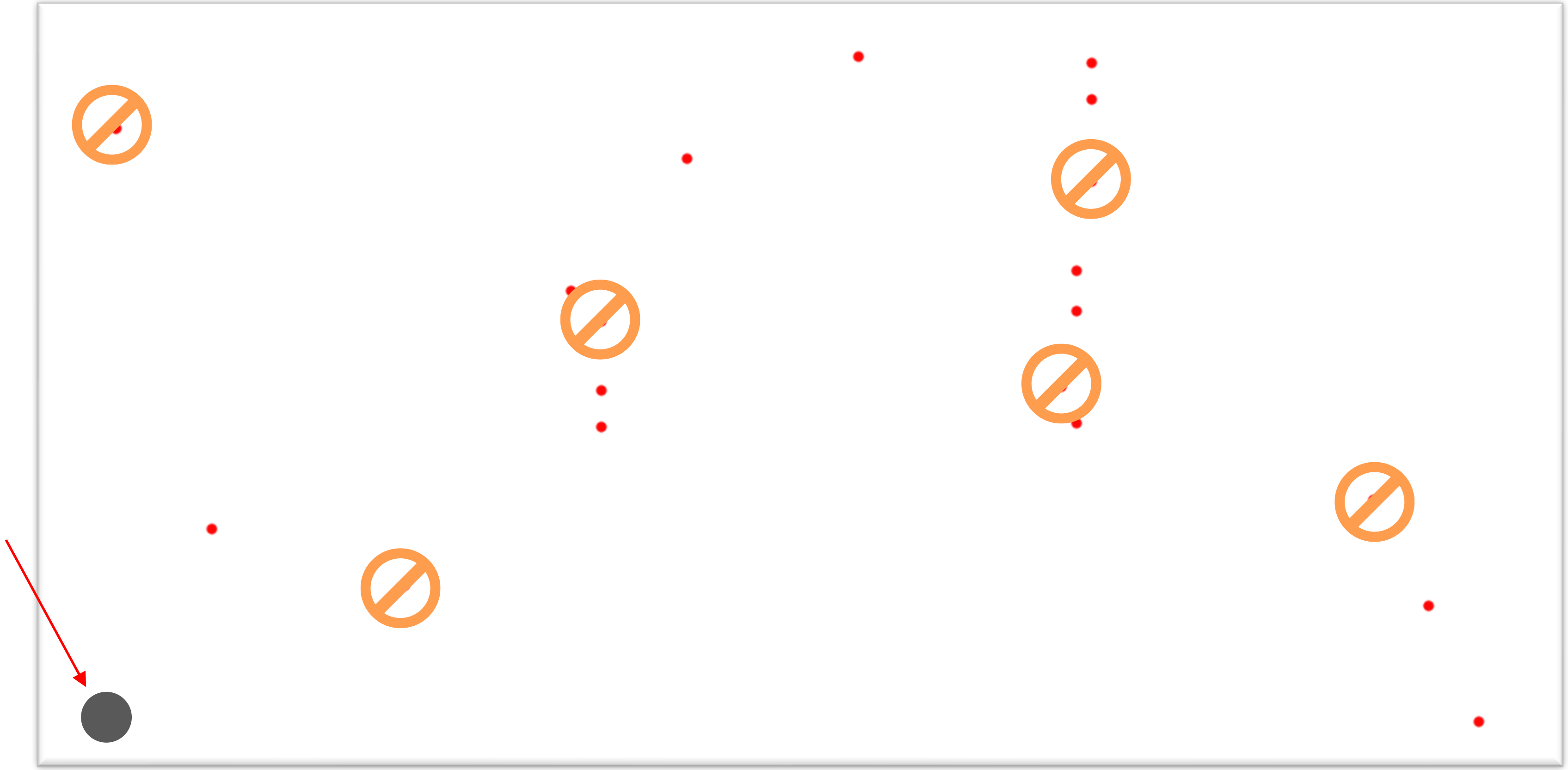
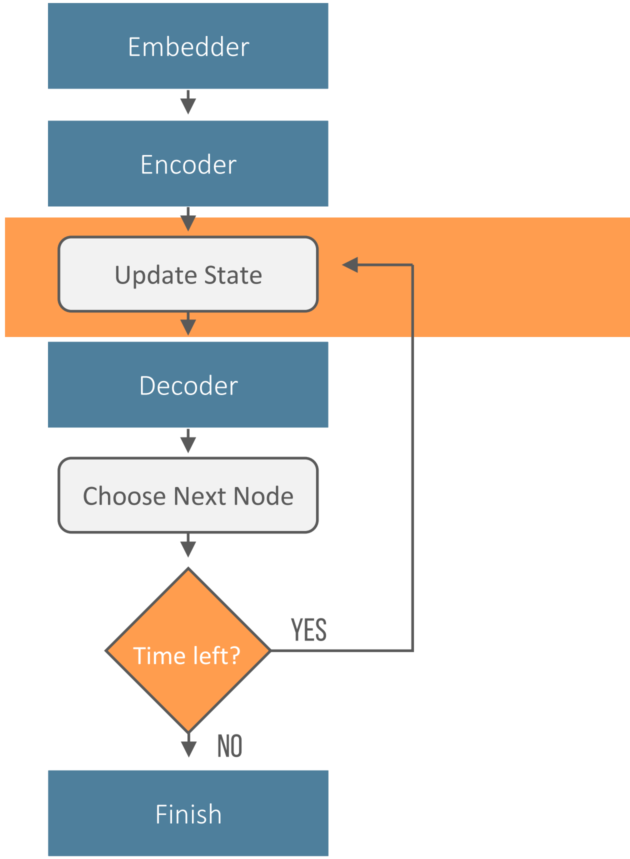
● POWER GENERATORS / NODES
● STARTING / ENDING POINT

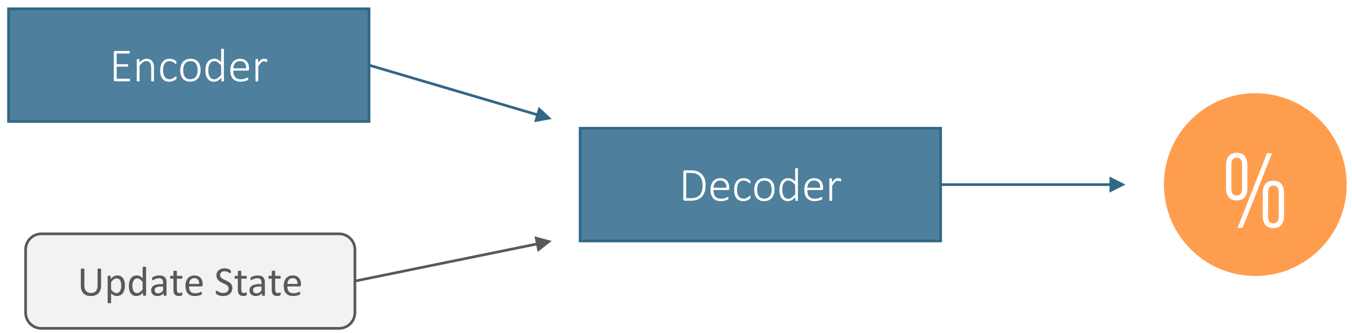
UPDATE STATE



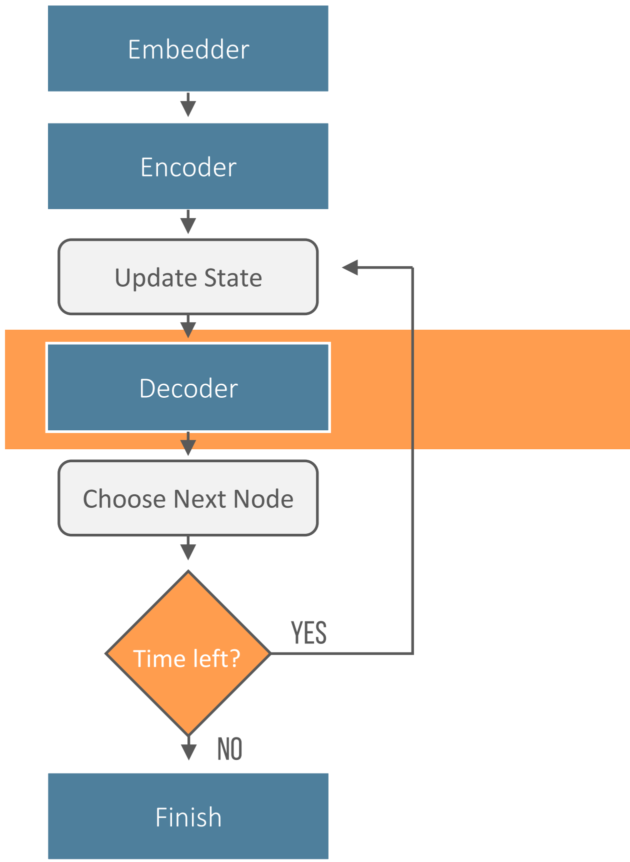
T=0



DECODER



Encoder
Update State
Decoder
%

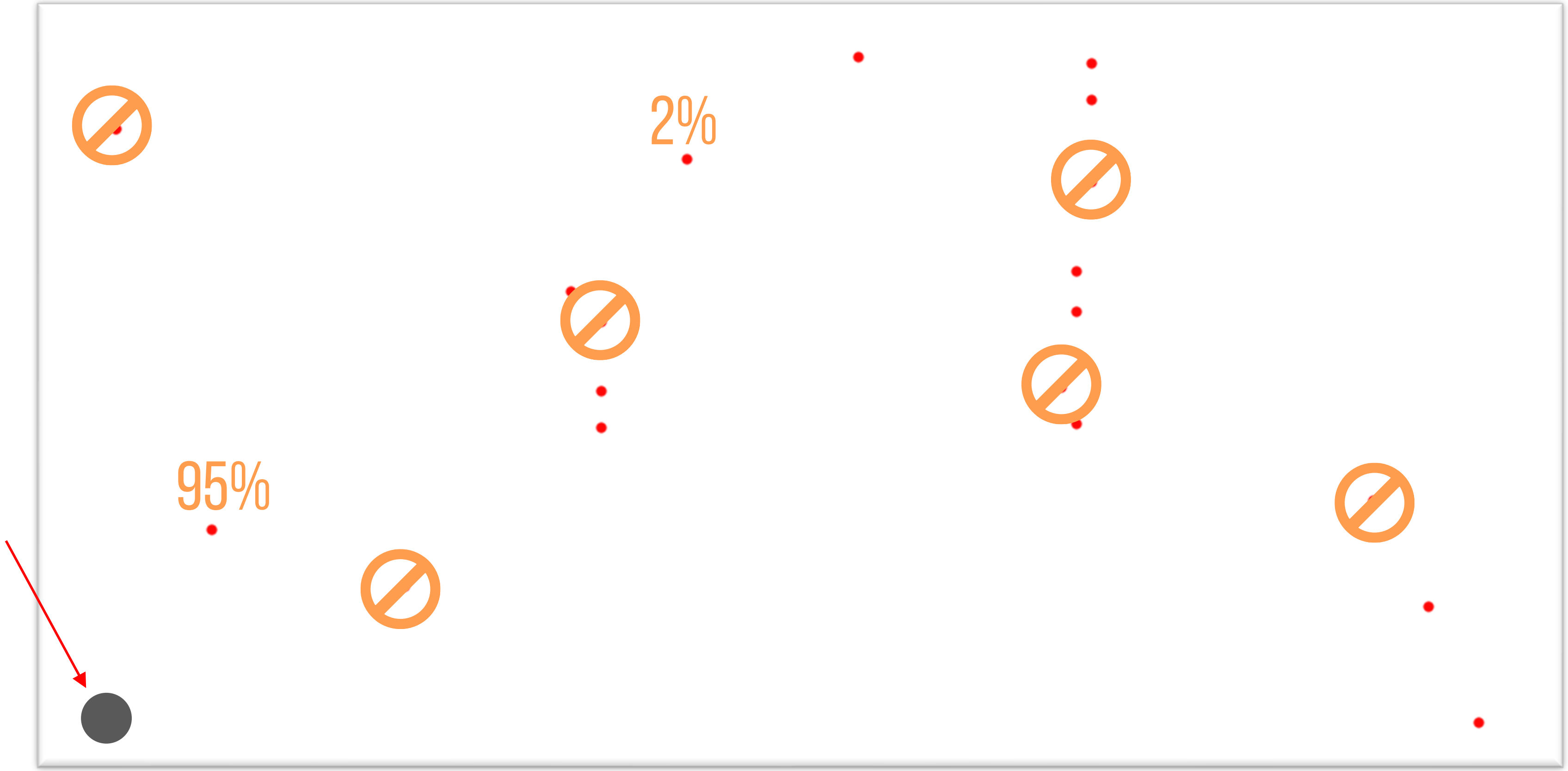


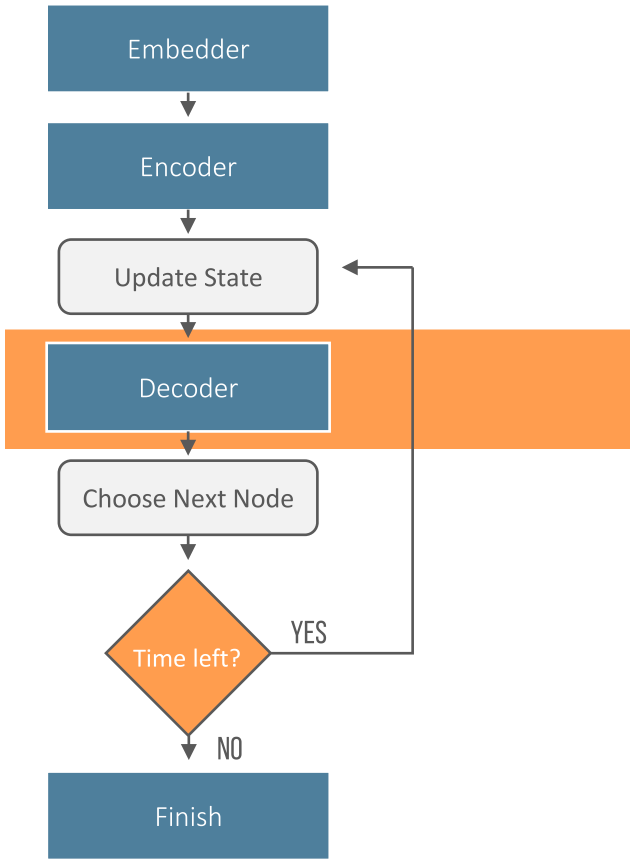
Embedder
Encoder
Update State
Decoder
Choose Next Node
Time left?
YES
NO
Finish

DECODER

POWER GENERATORS / NODES

STARTING / ENDING POINT

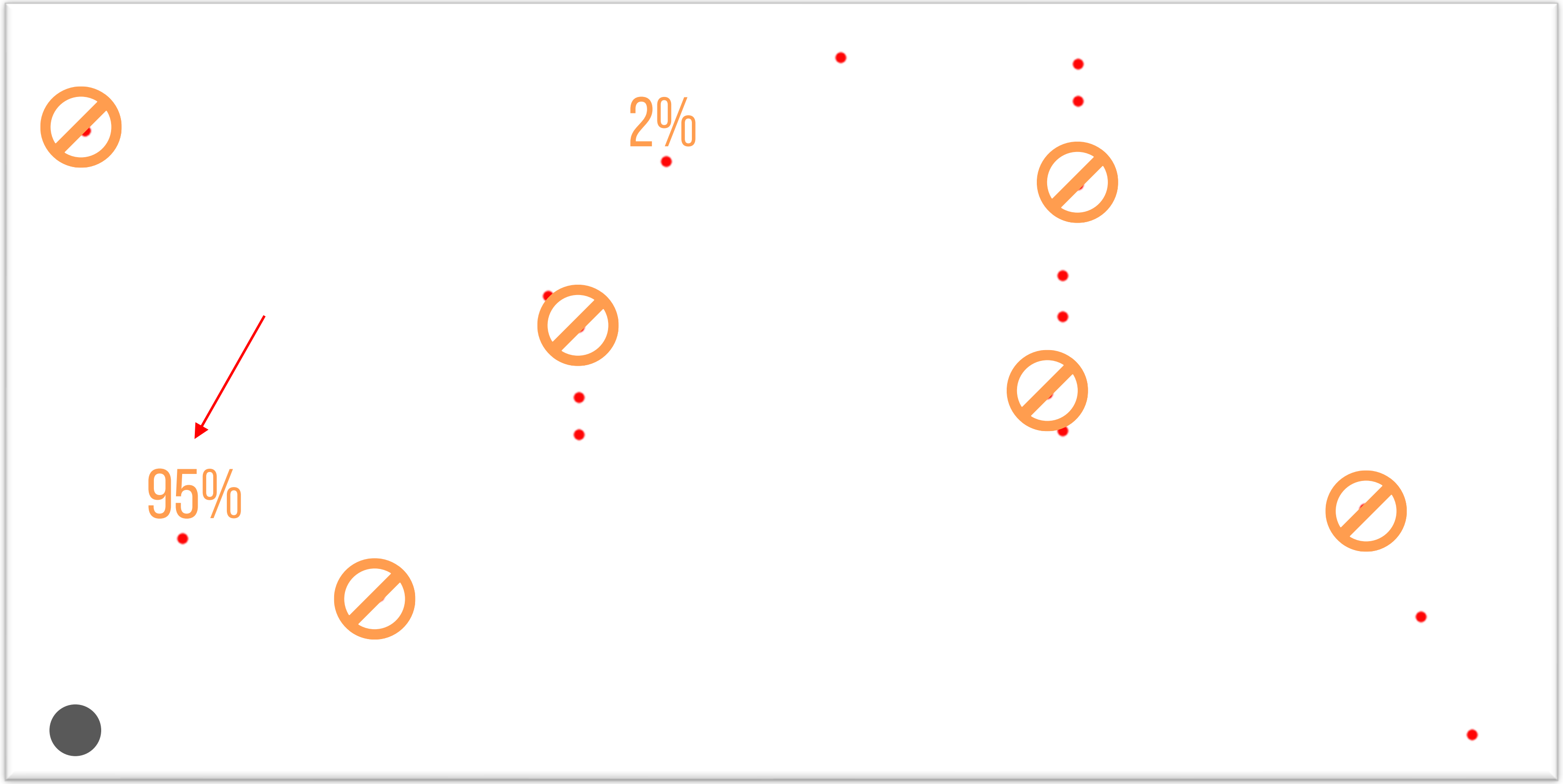


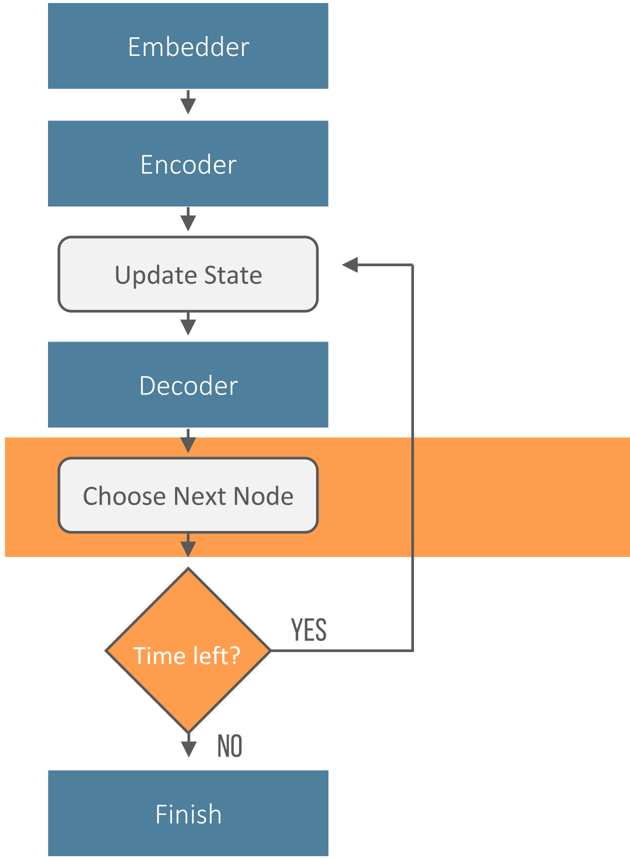


POWER GENERATORS / NODES

STARTING / ENDING POINT

CHOOSE NEXT NODE





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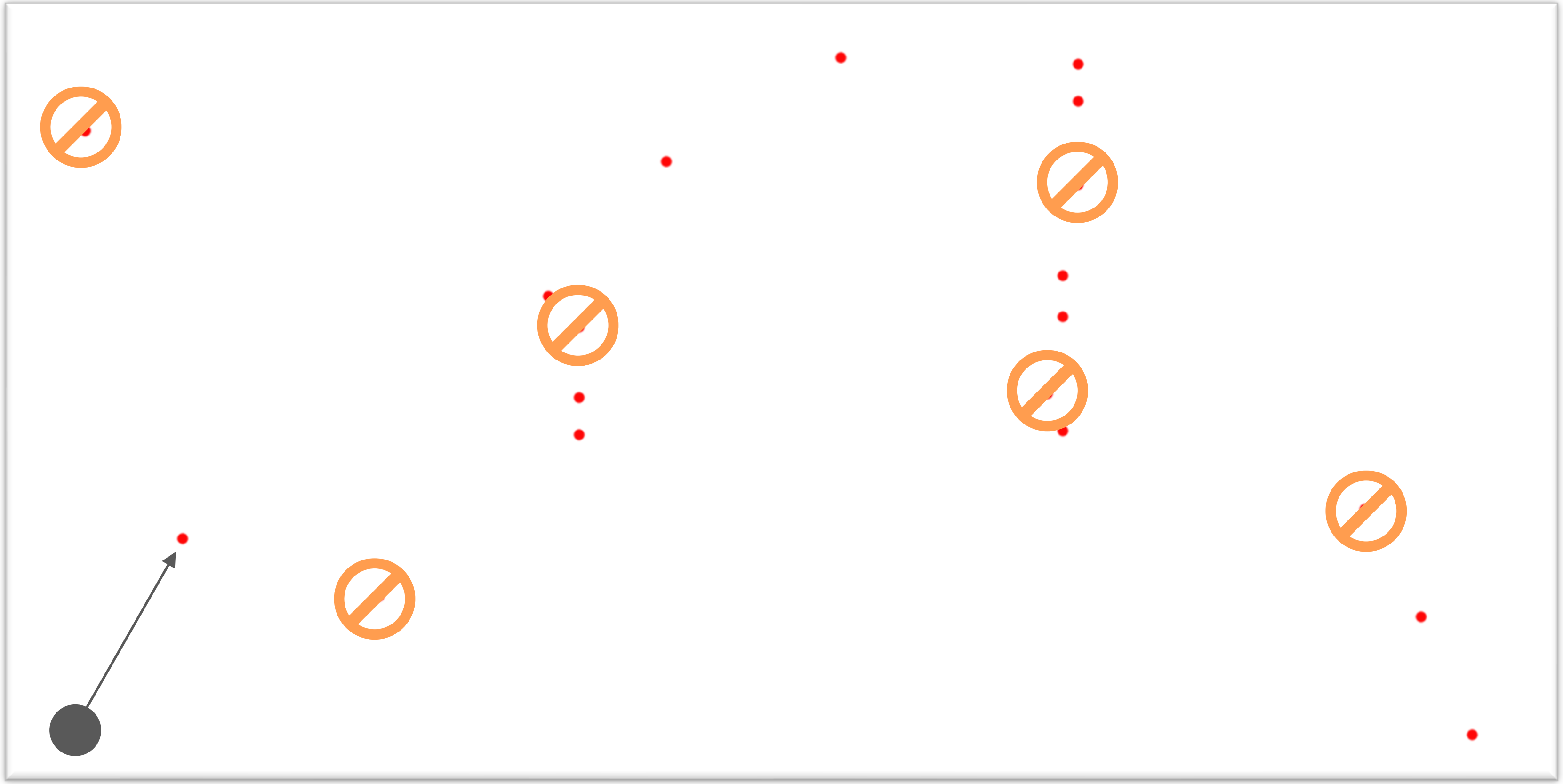
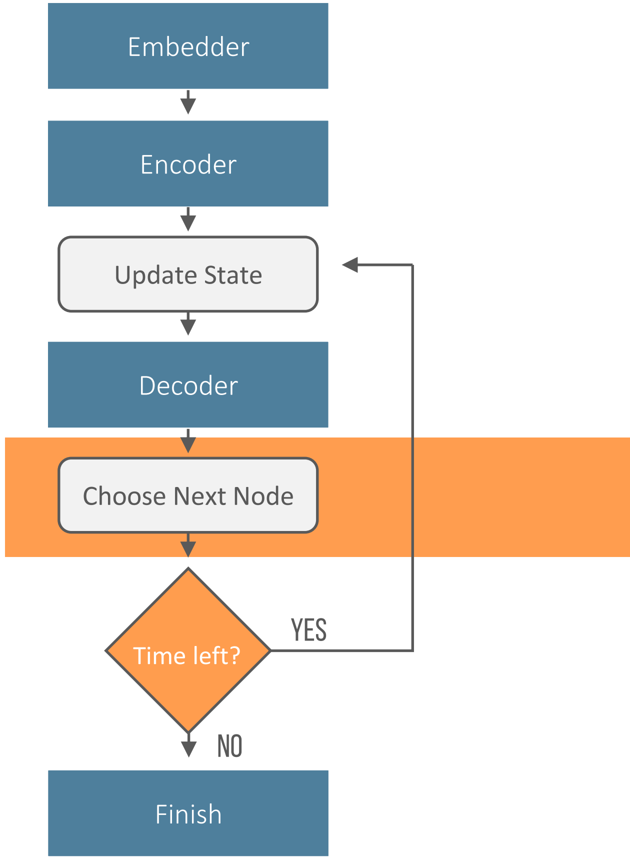
CHOOSE NEXT NODE

POWER GENERATORS / NODES
STARTING / ENDING POINT

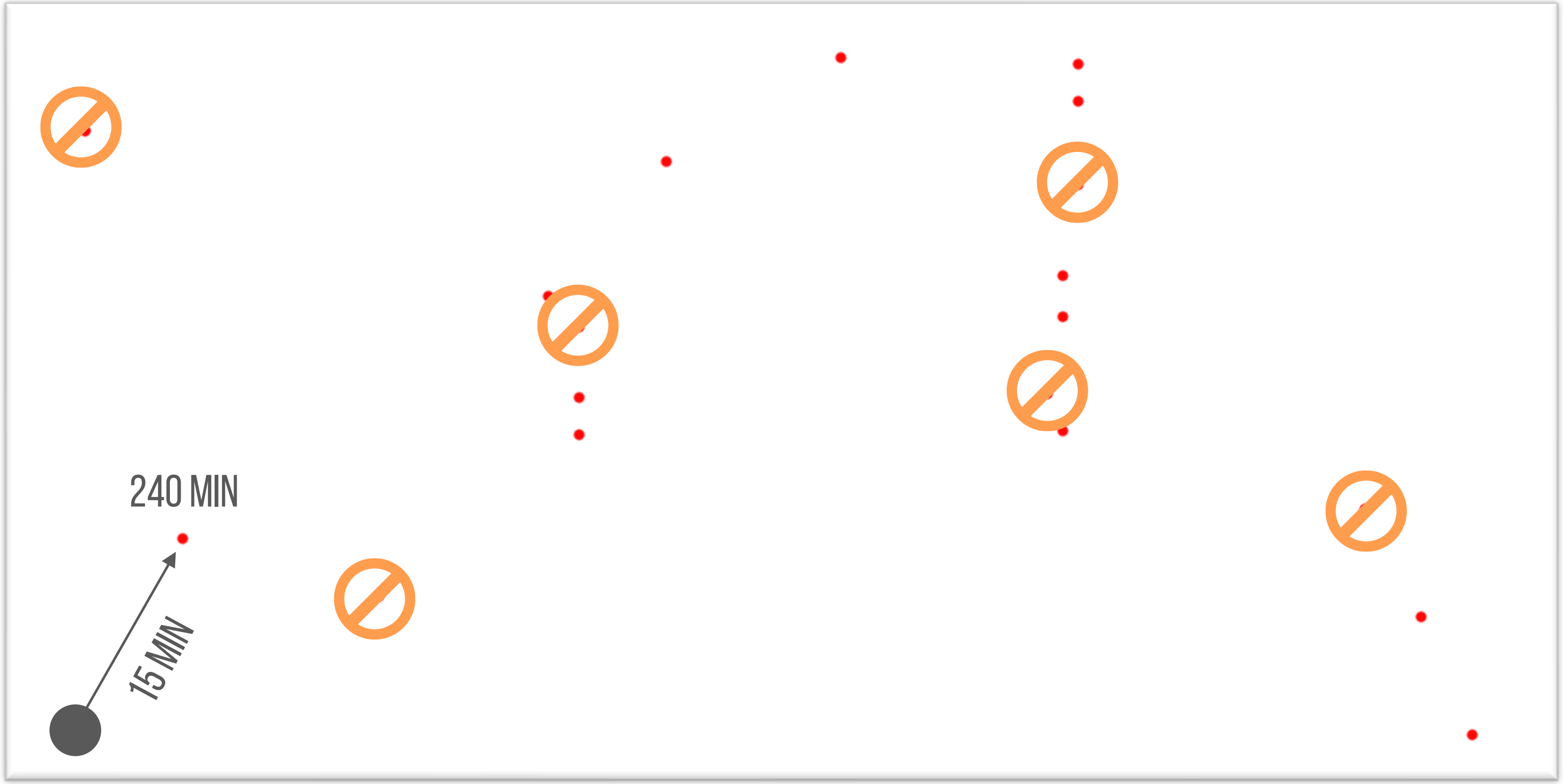




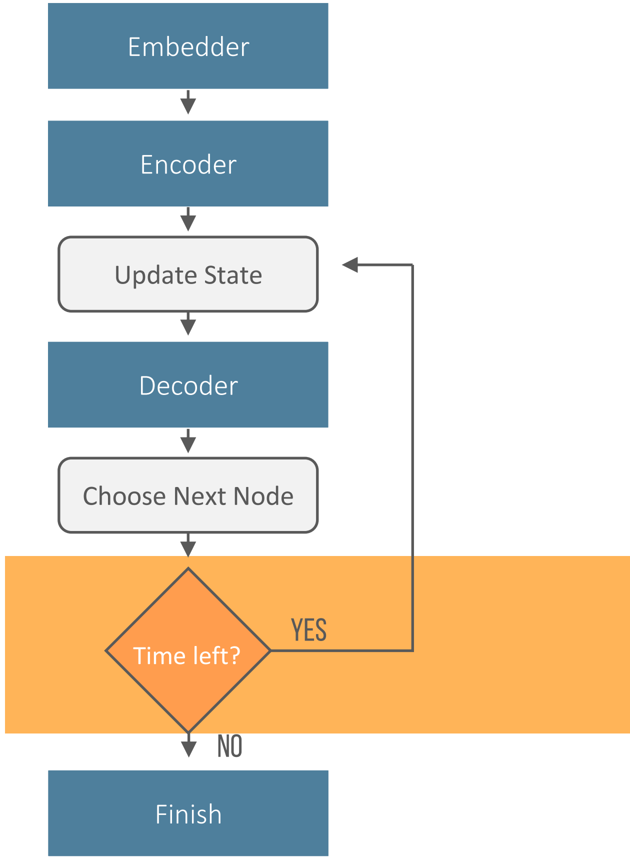
POWER GENERATORS / NODES

STARTING / ENDING POINT

TIME LEFT?



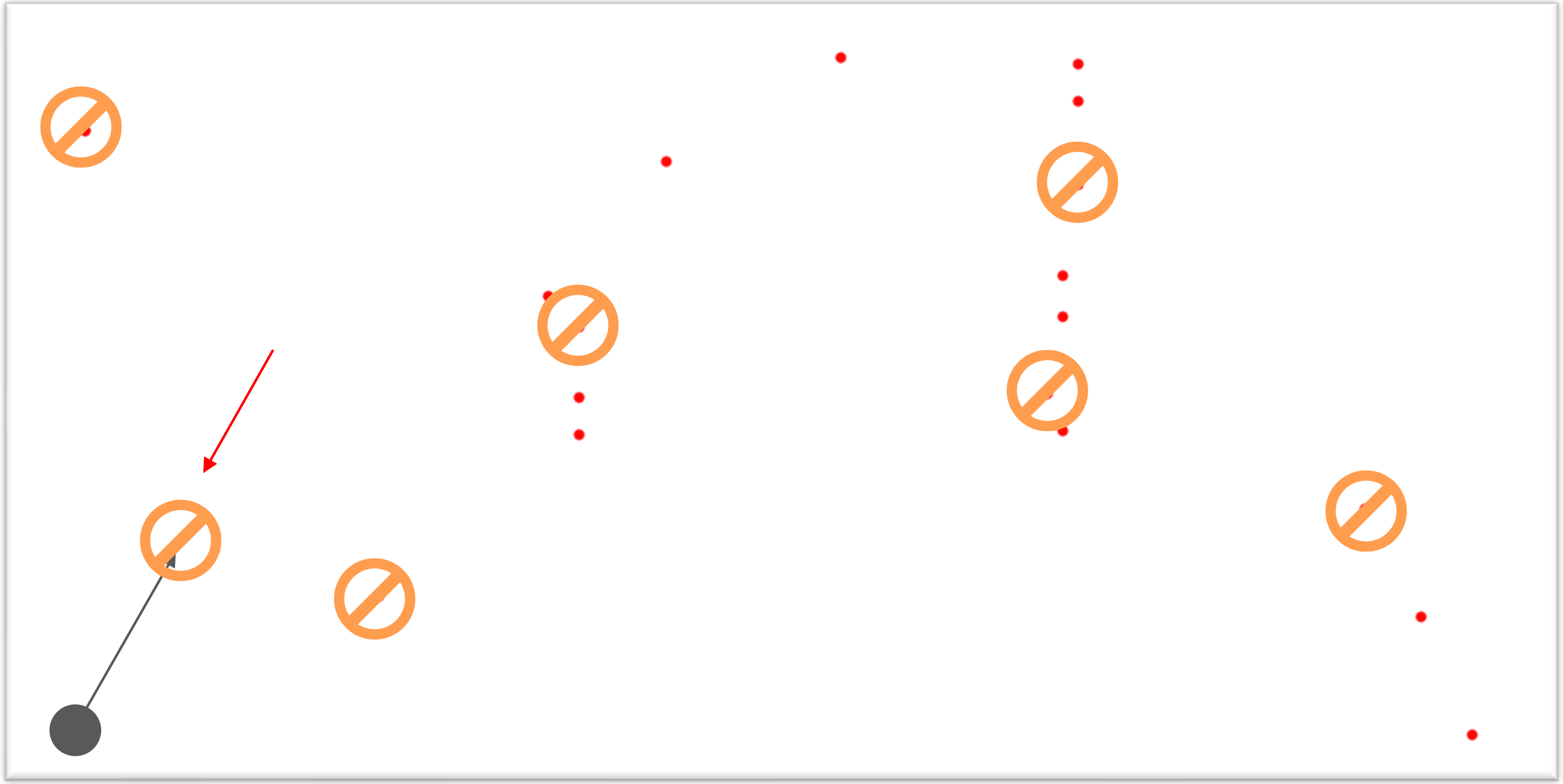
480 -240 – 15 = 225 MIN LEFT

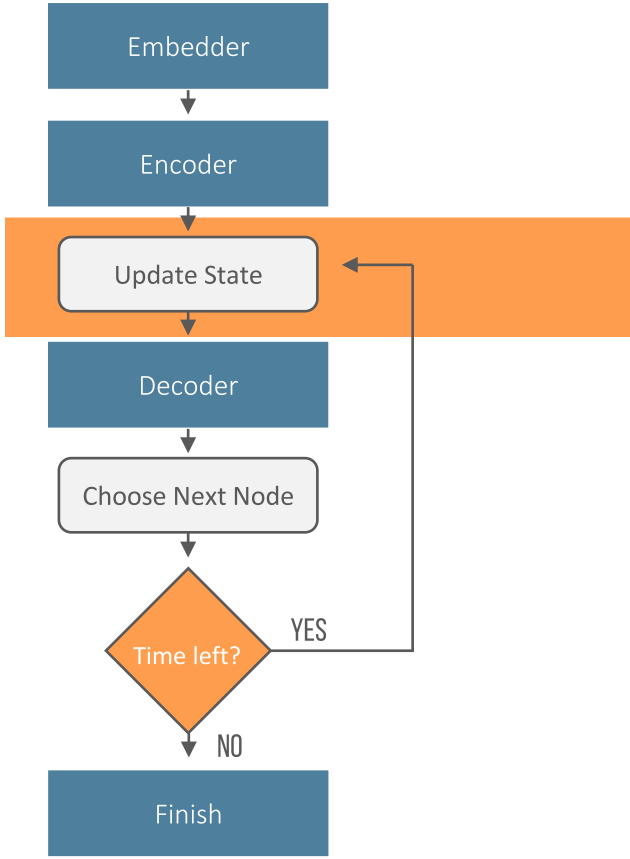


UPDATE STATE

POWER GENERATORS / NODES

STARTING / ENDING POINT

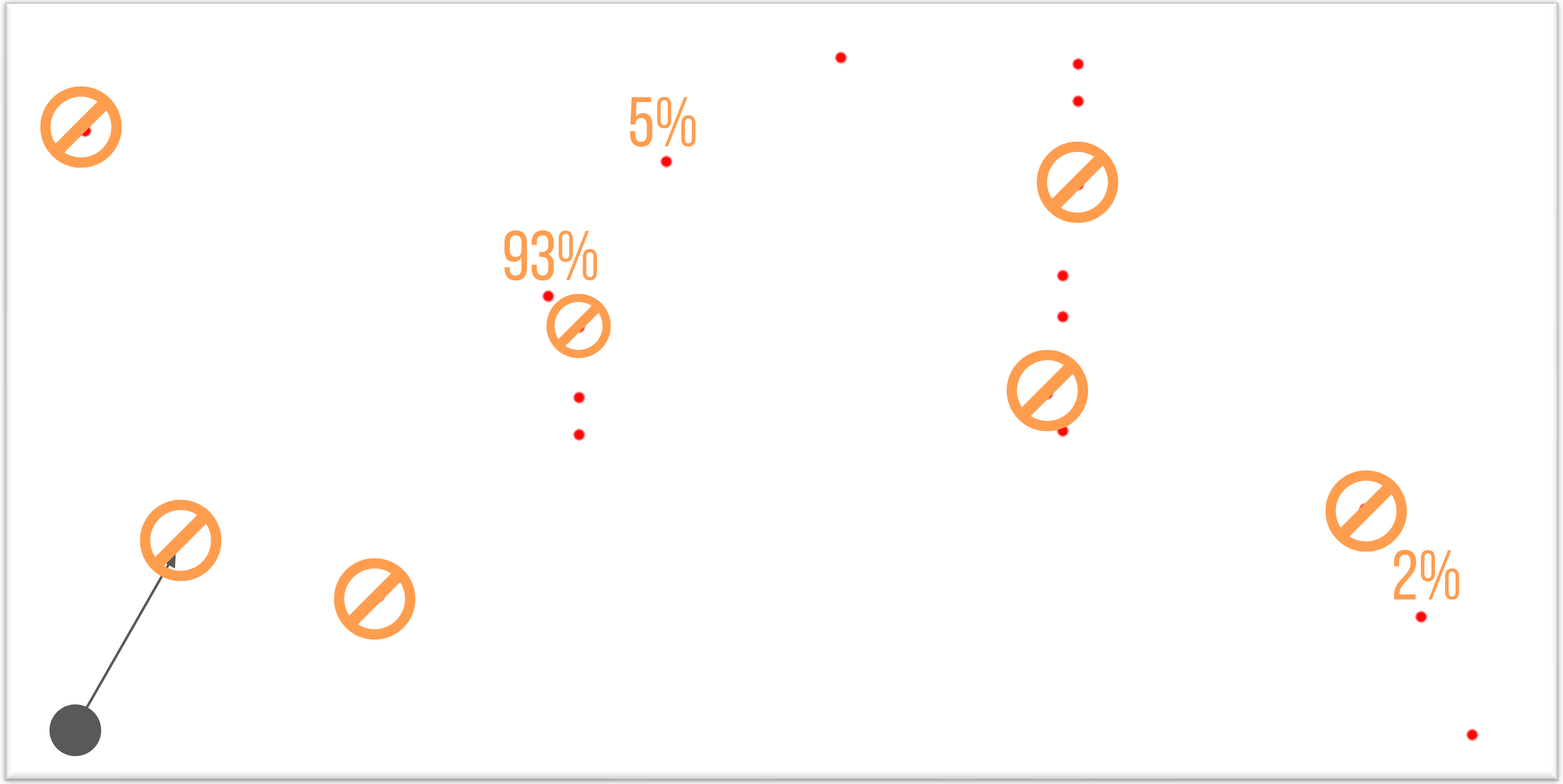


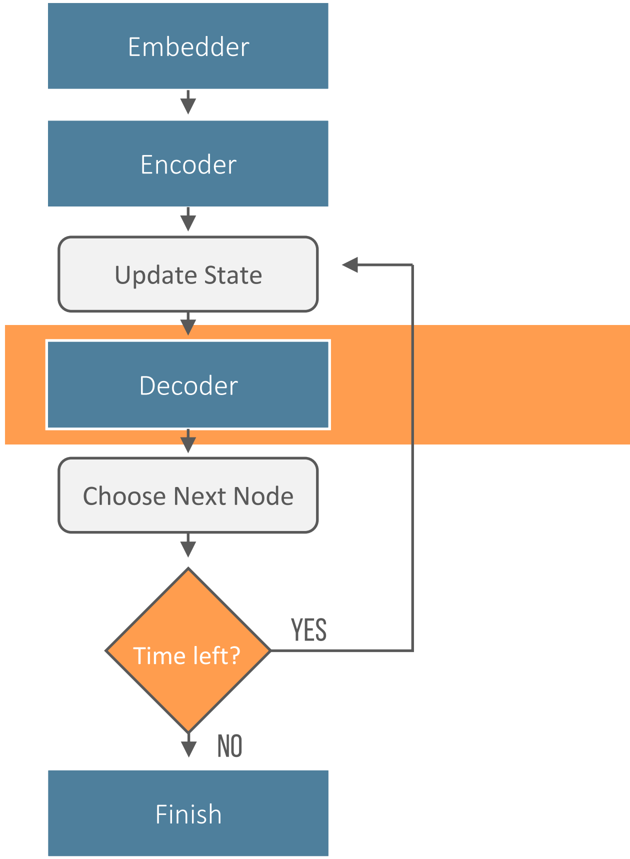


POWER GENERATORS / NODES

STARTING / ENDING POINT

DECODER

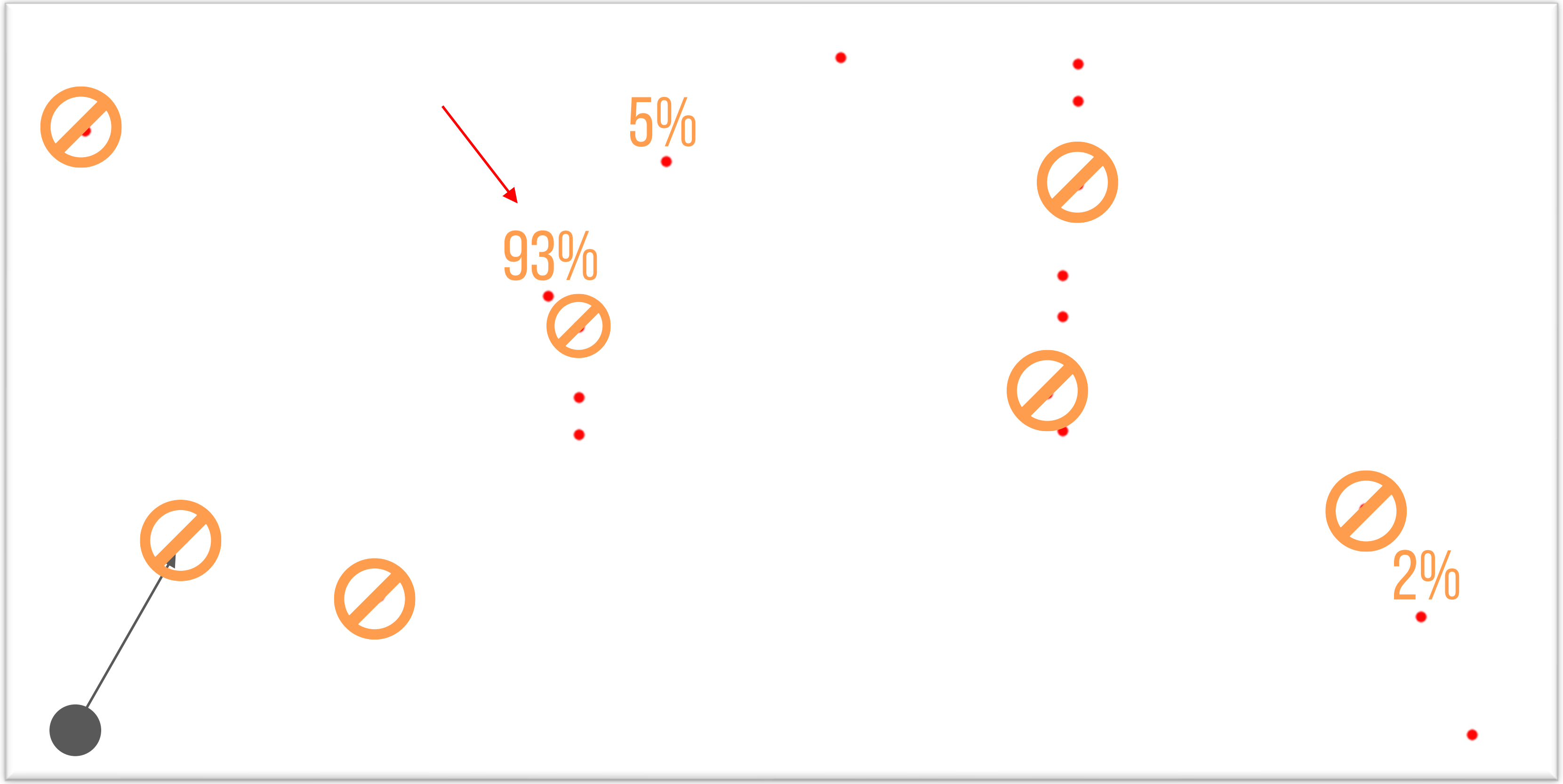


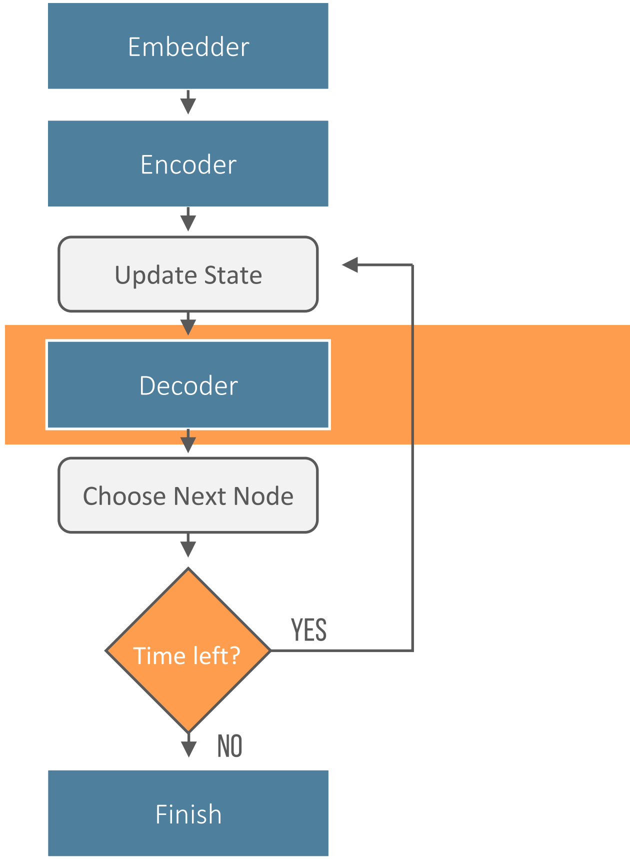


DECODER

POWER GENERATORS / NODES

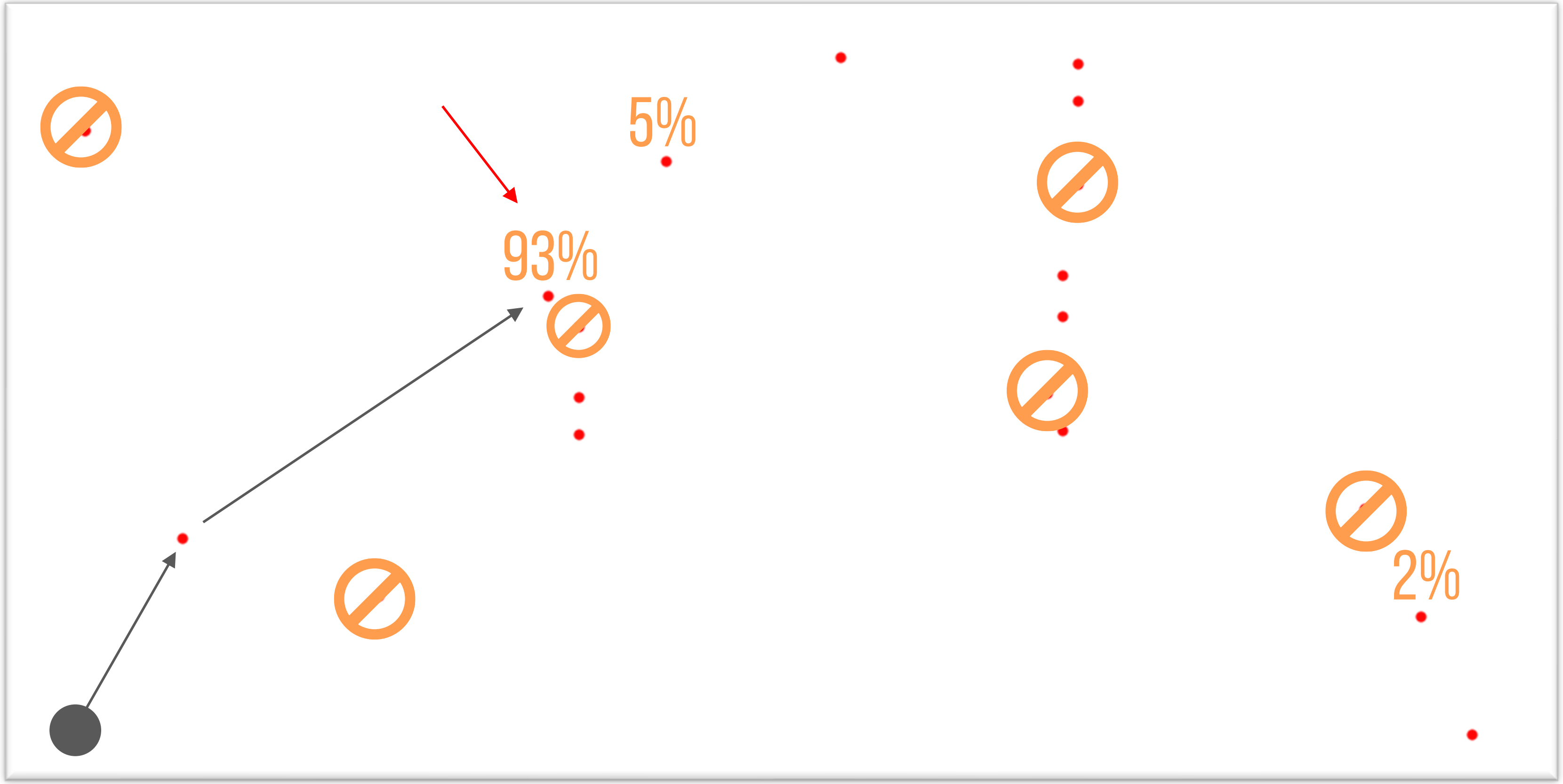
STARTING / ENDING POINT

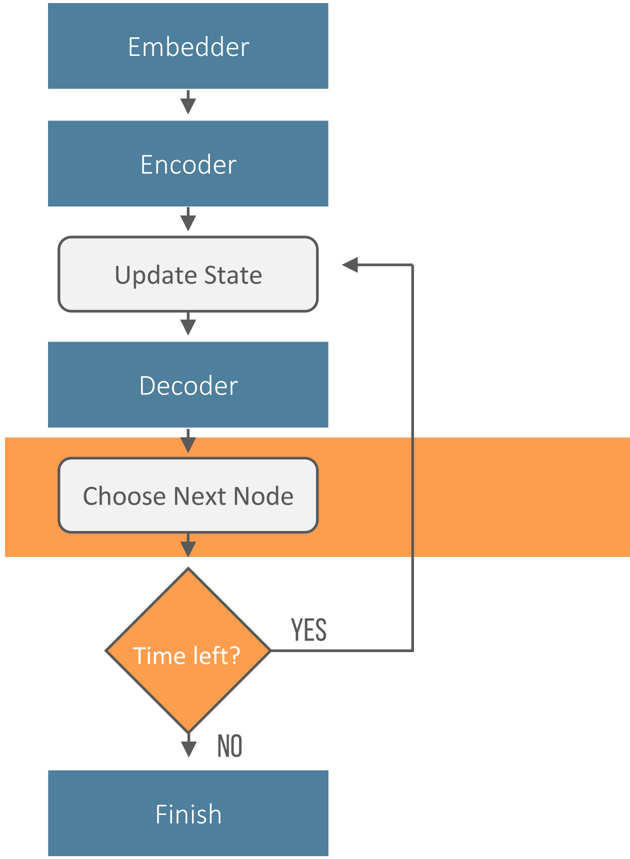




CHOOSE NEXT NODE

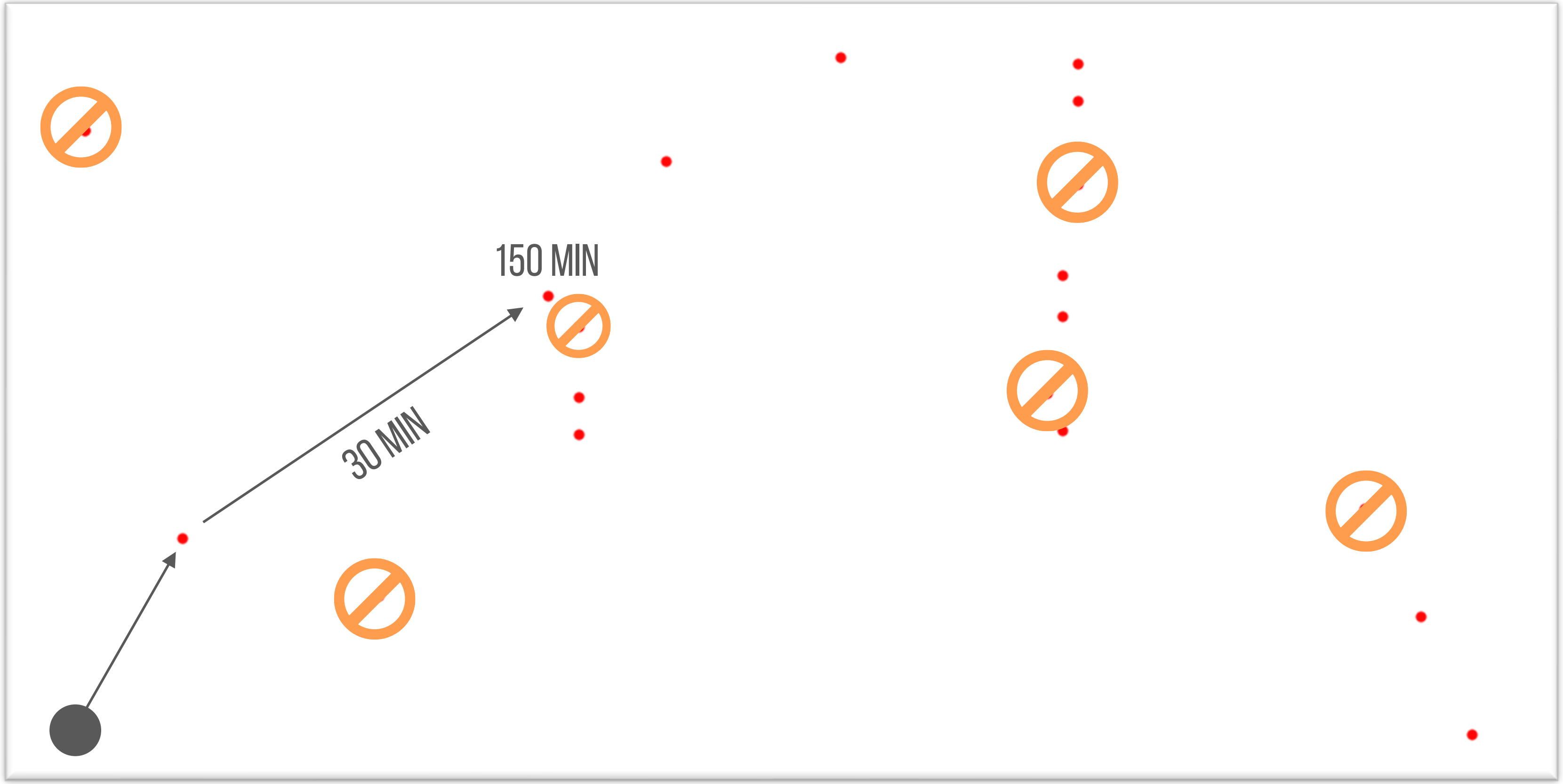
POWER GENERATORS / NODES
STARTING / ENDING POINT

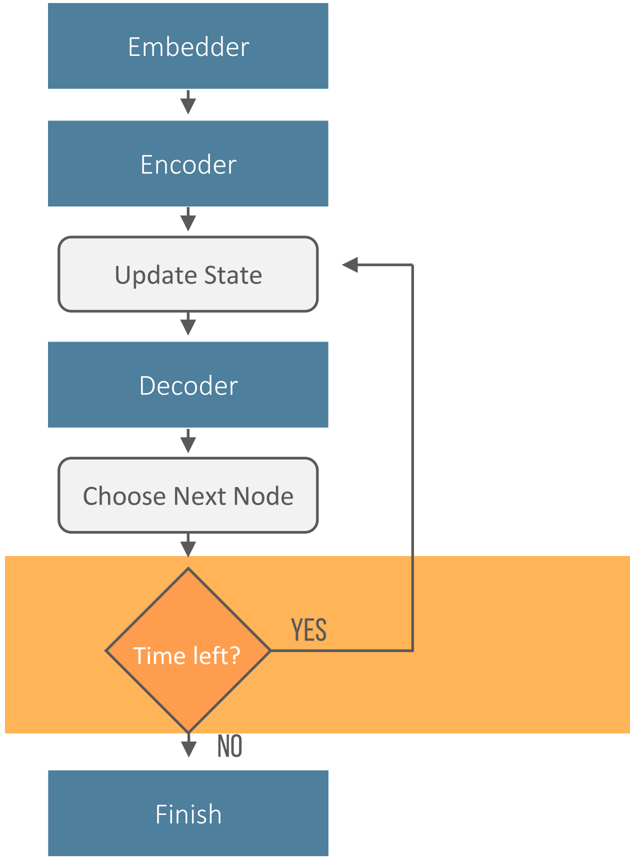




● POWER GENERATORS / NODES
● STARTING / ENDING POINT

TIME LEFT?



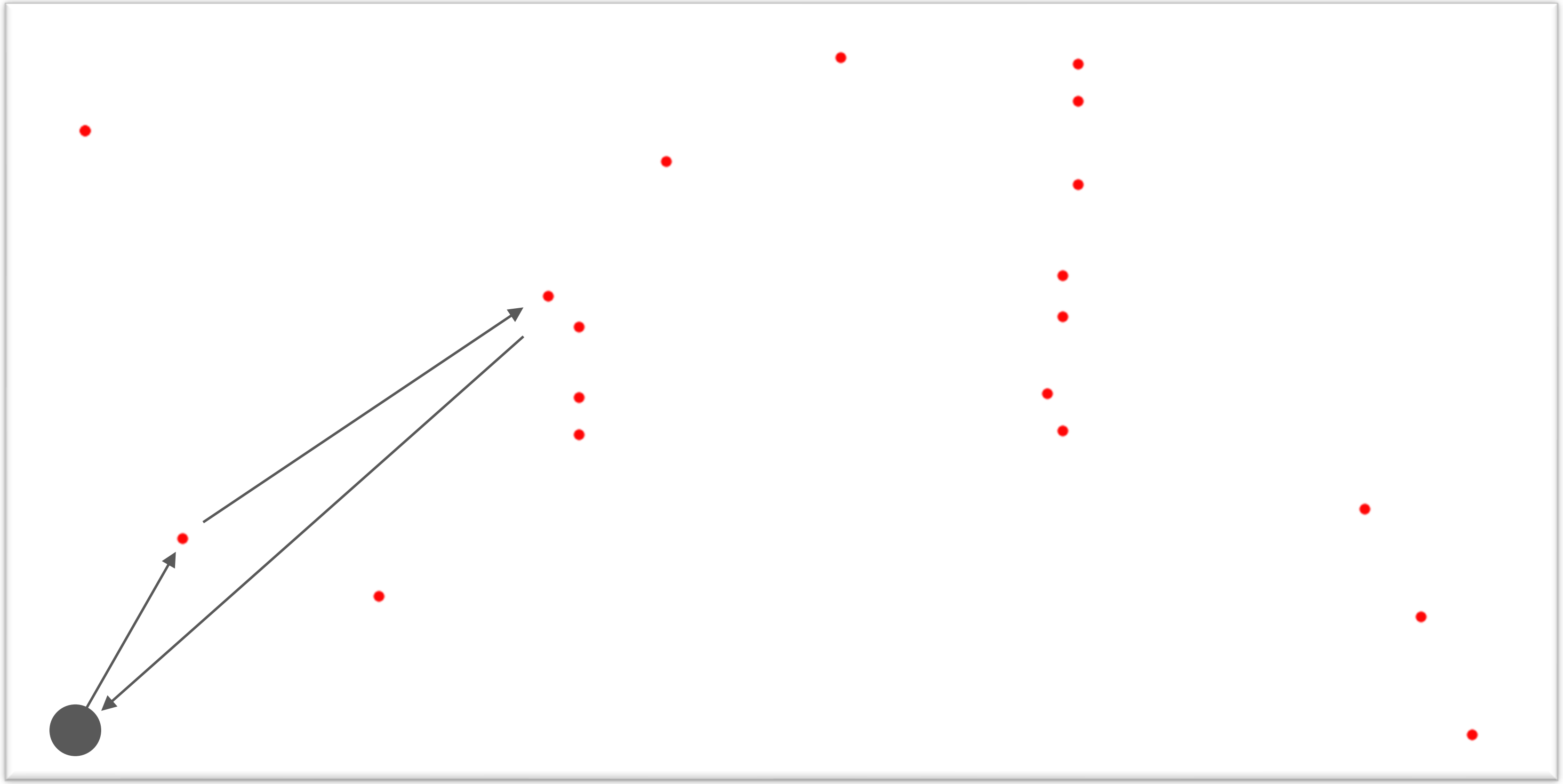


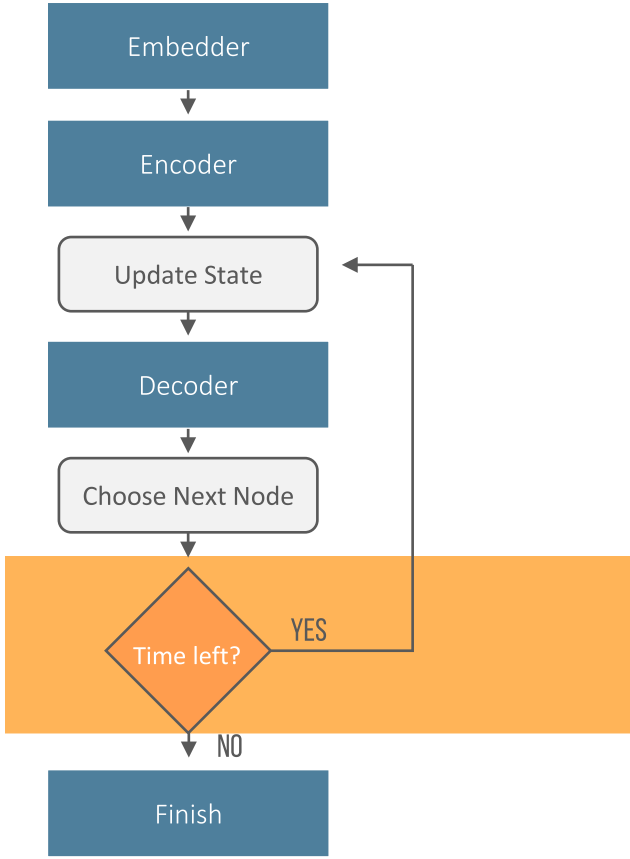
225 - 150 – 30 = 45 MIN LEFT

POWER GENERATORS / NODES

STARTING / ENDING POINT

TIME LEFT?





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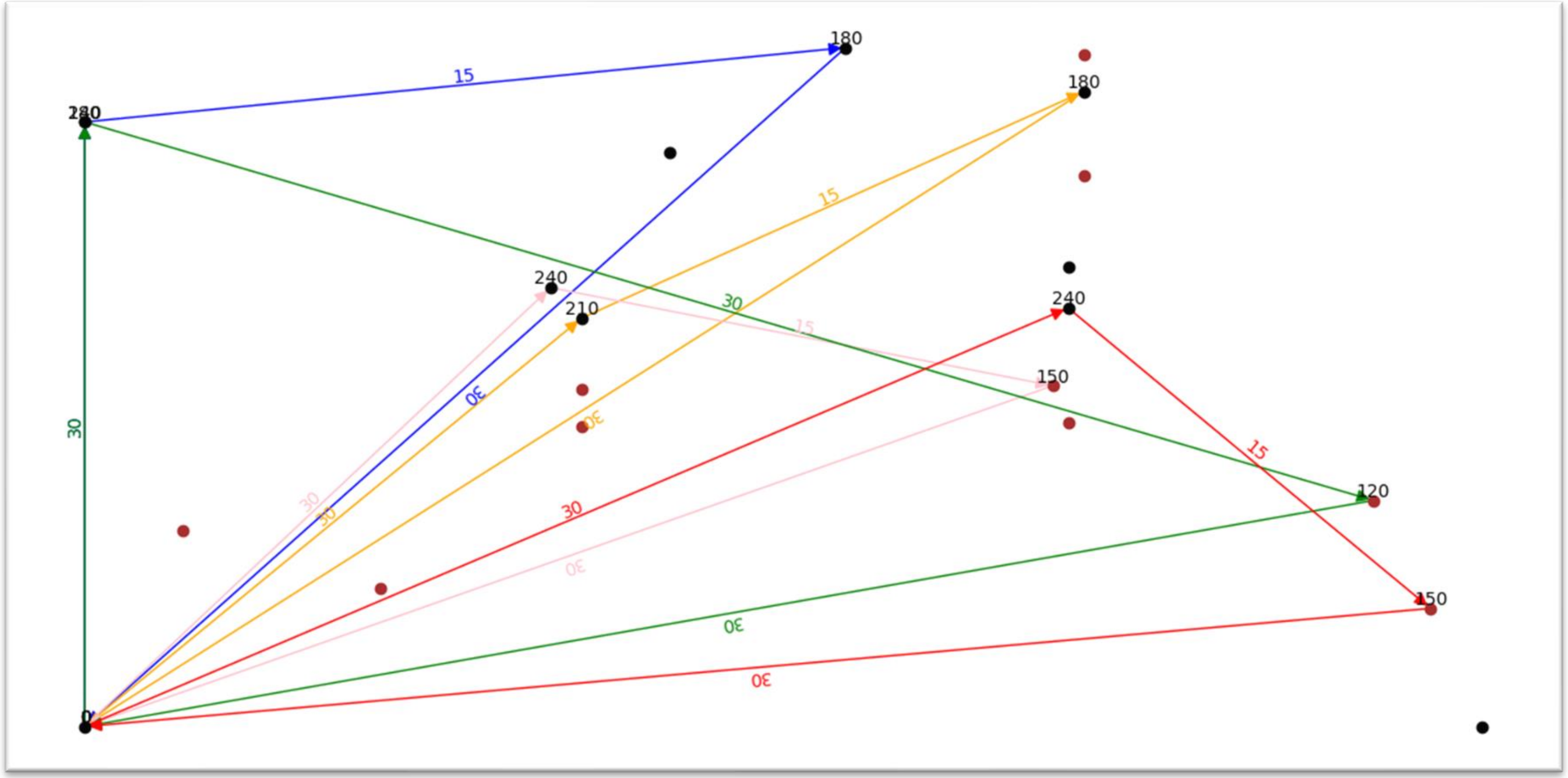

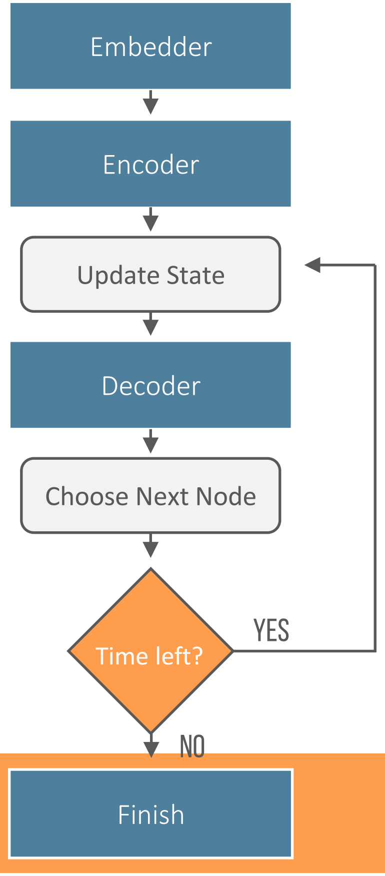

MONDAY, TUESDAY, WEDNESDAY…

ARCHITECTURE

[PDF] **Attention is all you need**

A Vaswani - Advances in Neural Information Processing Systems, 2017 - docalysis.com

Attention is **all you need Attention** is **all you need** ...

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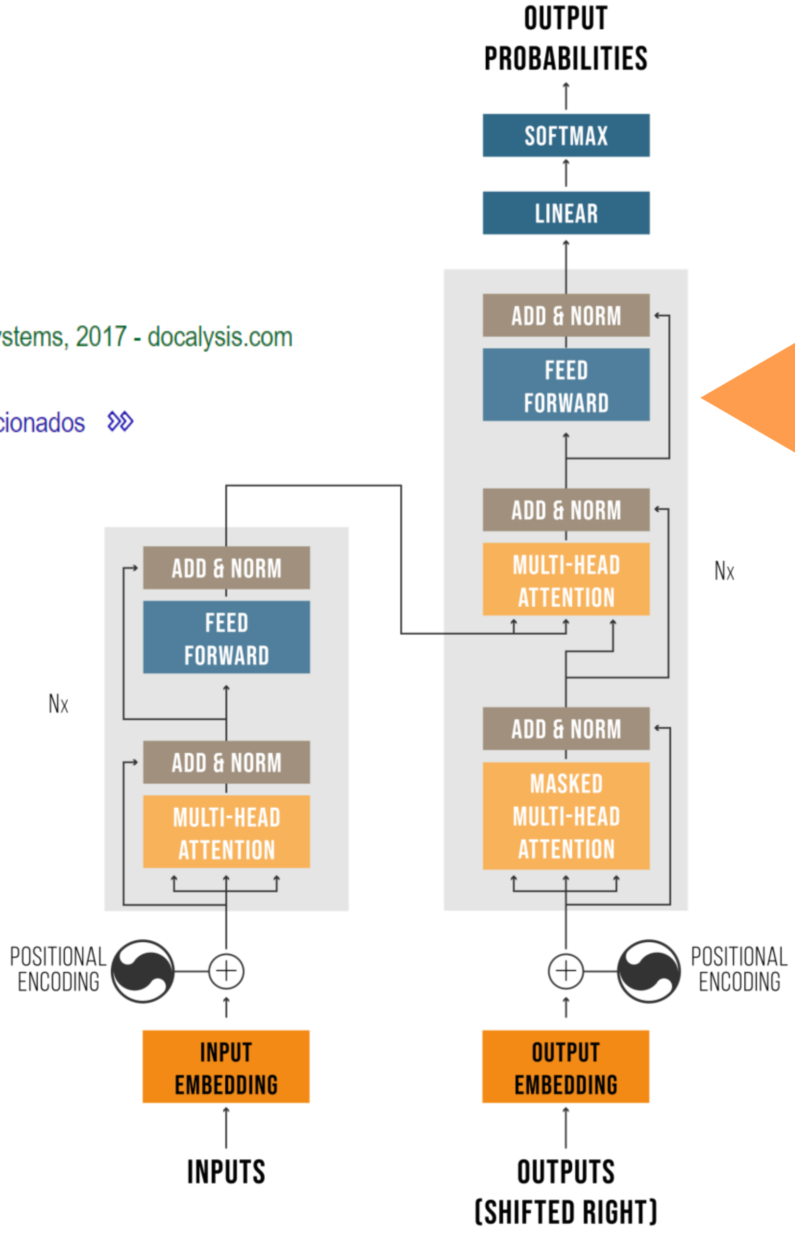

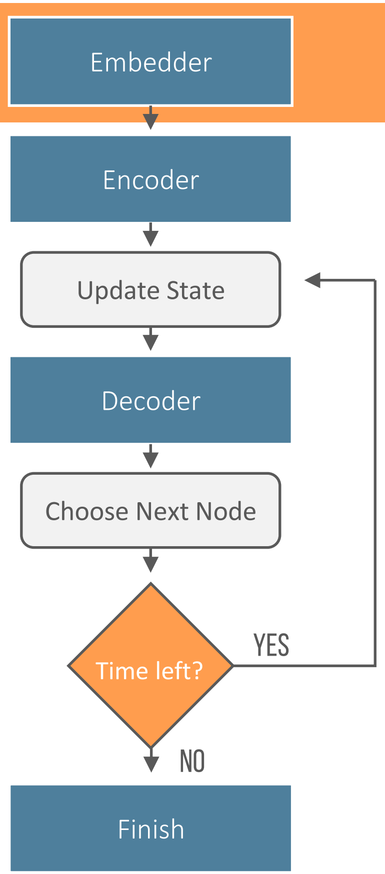

ARCHITECTURE

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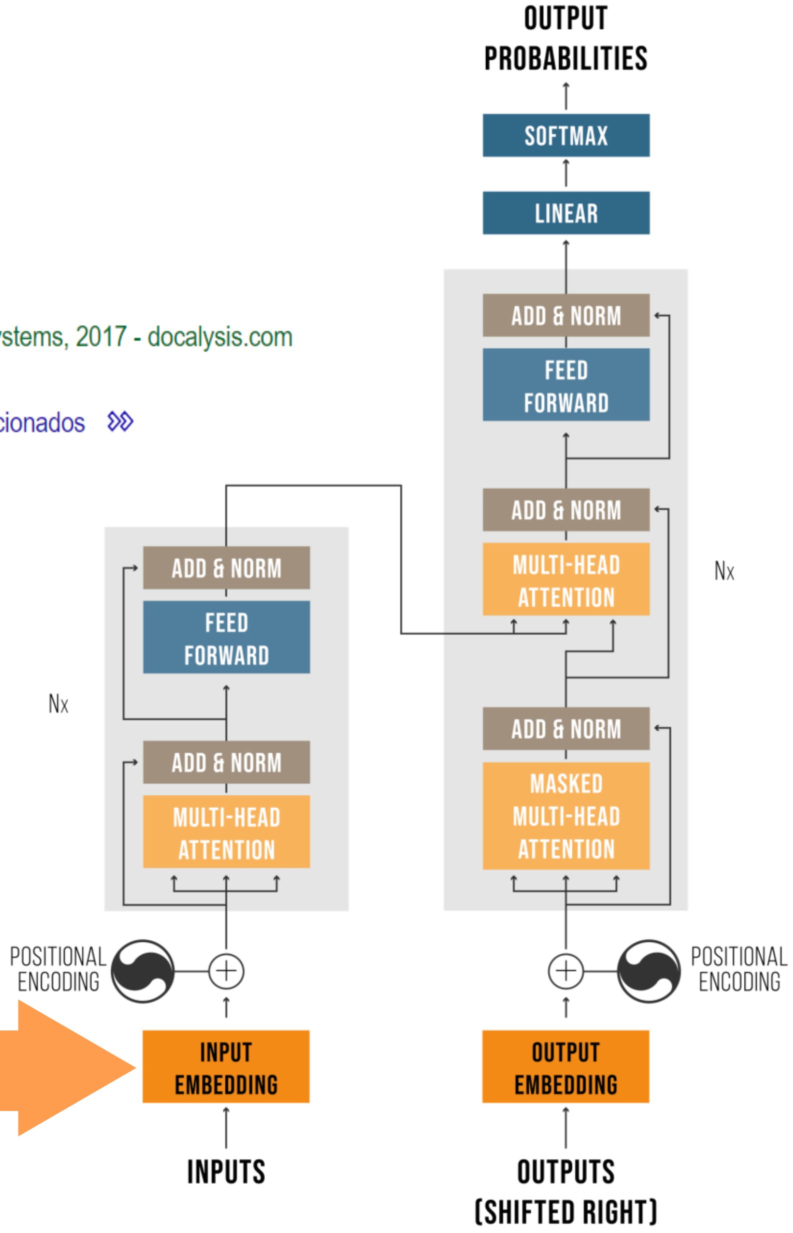

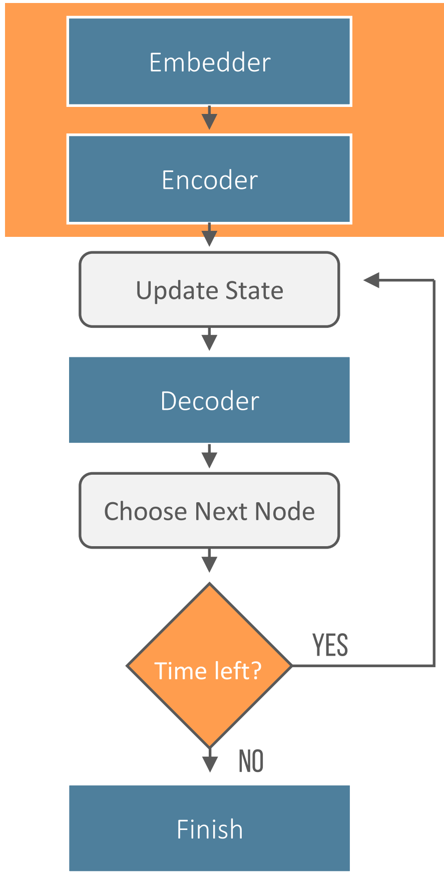

ARCHITECTURE

[PDF] **Attention** is **all you need**

A Vaswani - Advances in Neural Information Processing Systems, 2017 - docalysis.com

Attention is **all you need Attention** is **all you need** ...

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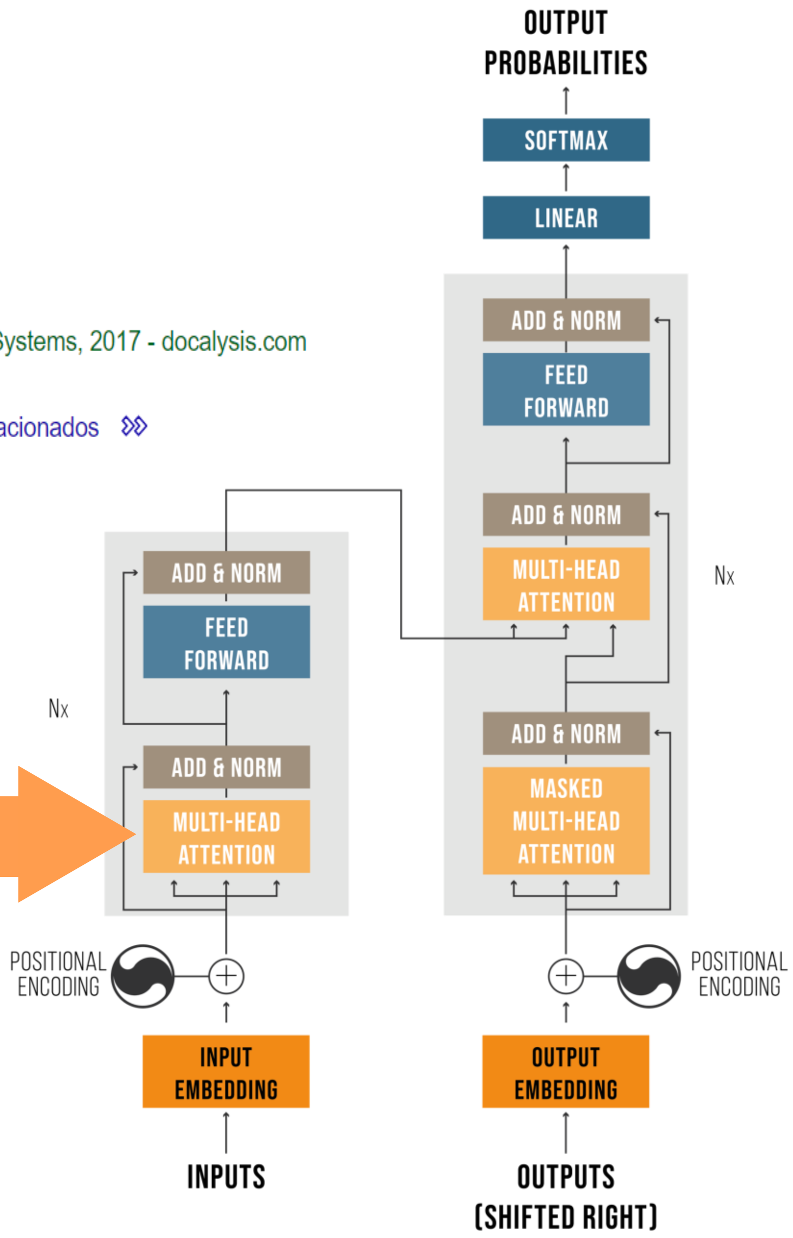
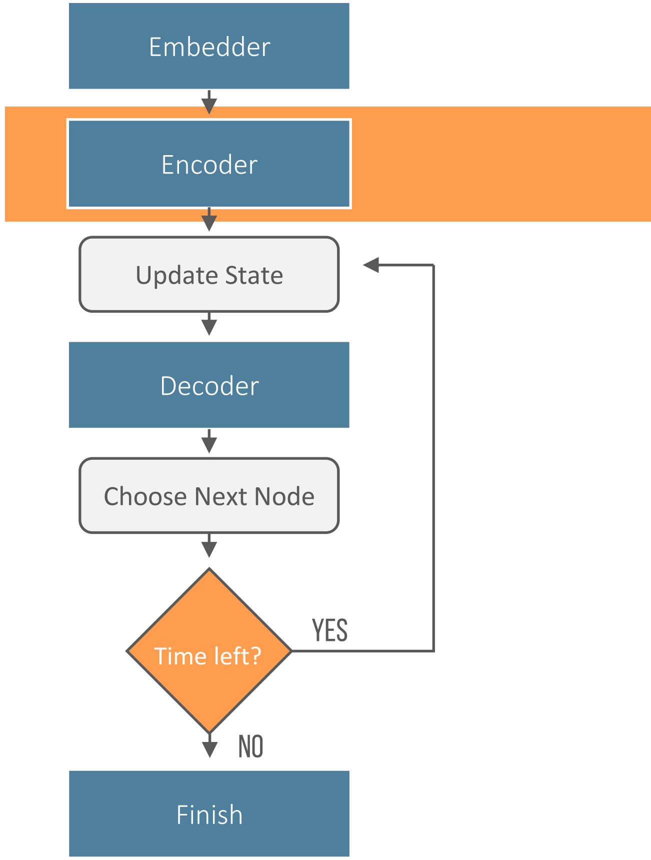
MULTI – HEAD ATTENTION





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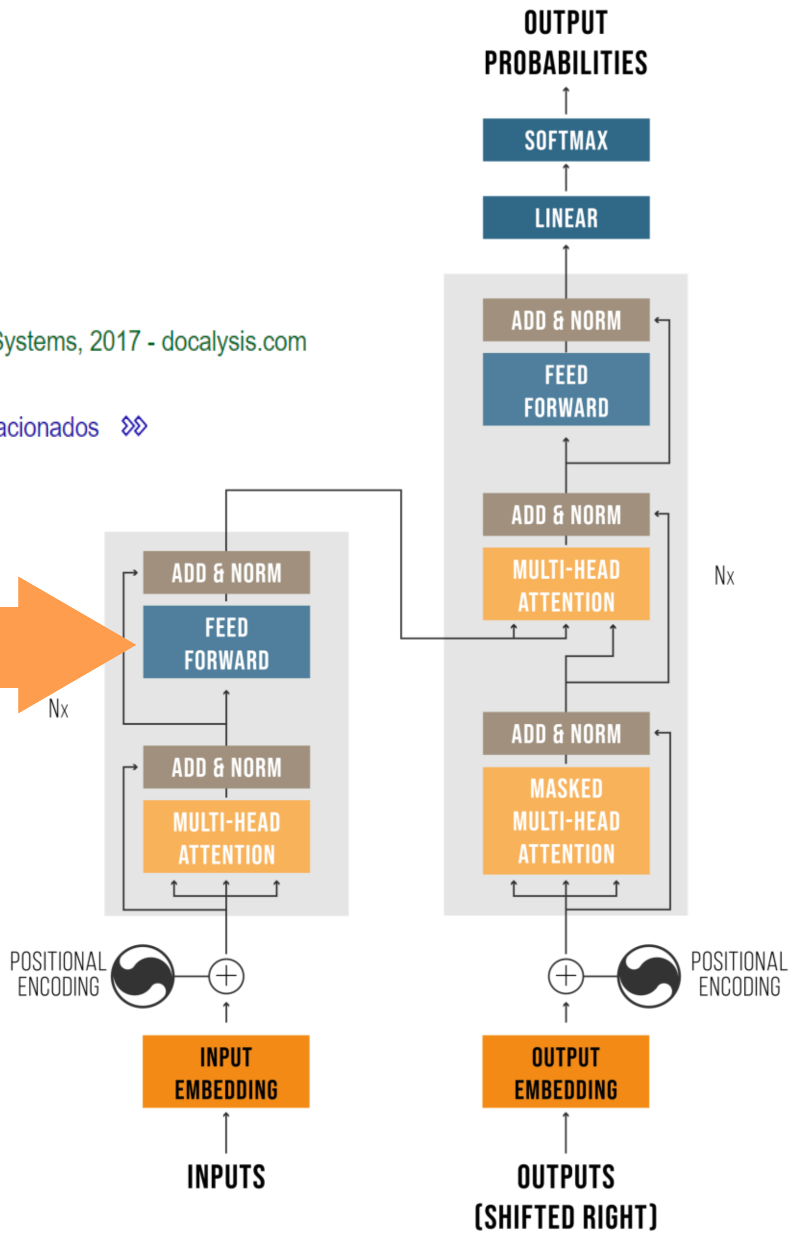
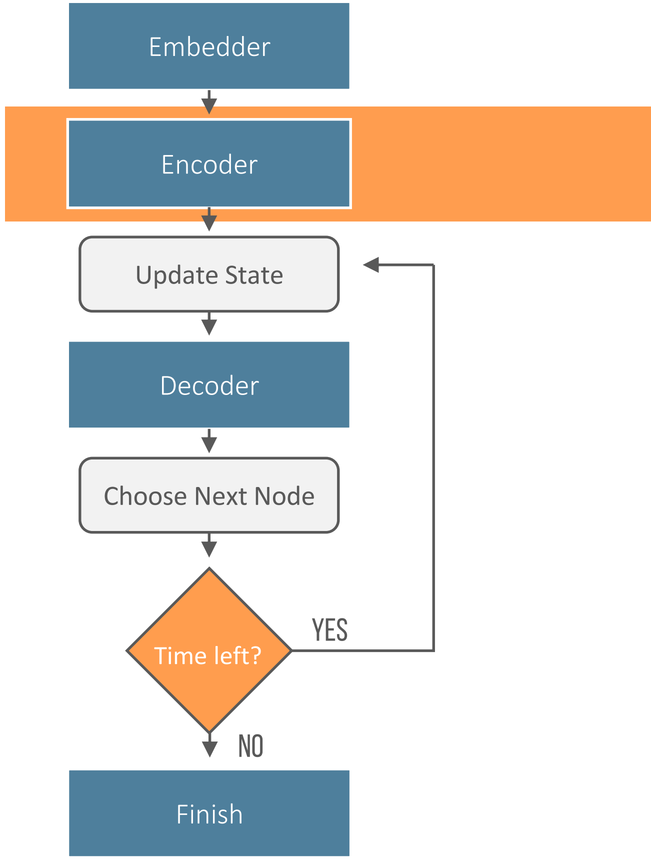
FEED FORWARD

1. Linear
2. Relu: f(x) = max (0,x)
3. Linear





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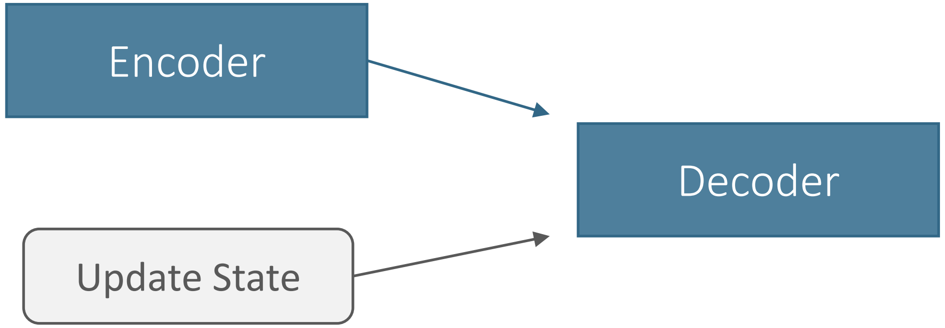
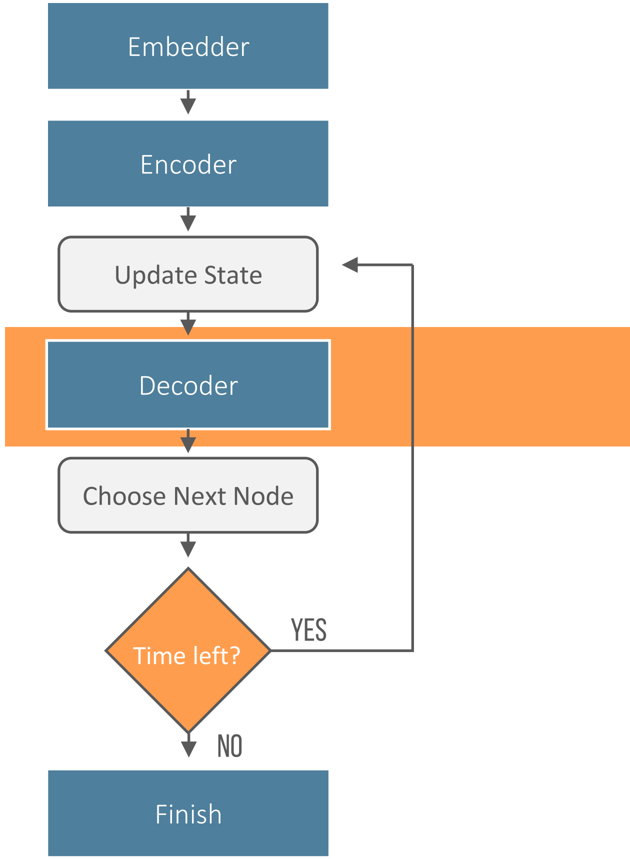
MULTI – HEAD ATTENTION LAYER: HANDLES THE STATE CONTEXT





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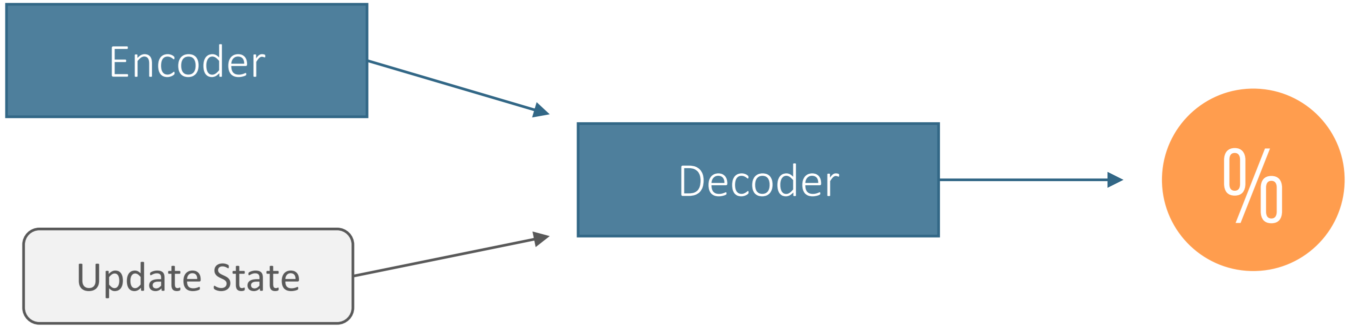
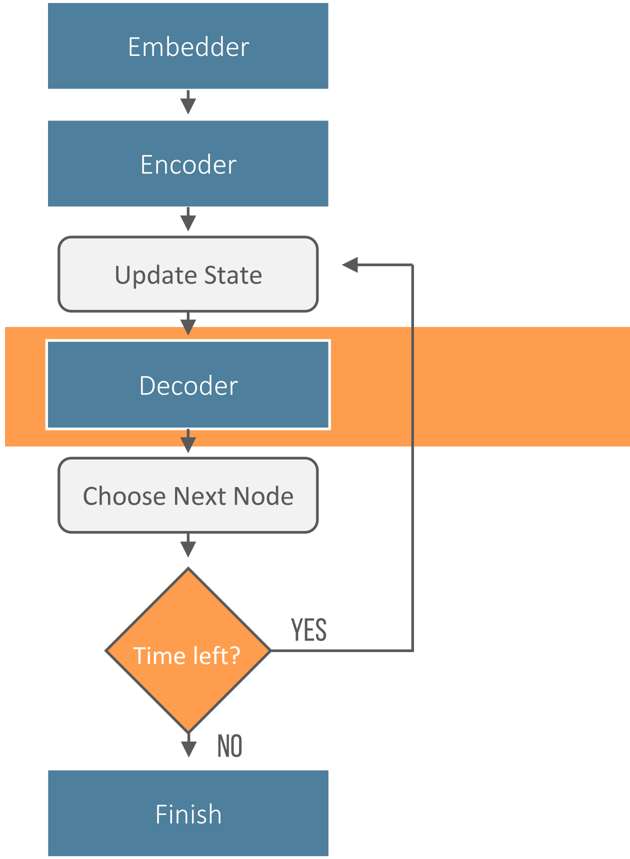


SOFTMAX: RETURNS THE PROBABILITY



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REINFORCE

TRAINING

$$\nabla_\theta J(\theta) \approx \hat{g} = \sum_{t=0} \nabla_\theta \log \pi_\theta(a_t|s_t) R(\tau)$$

Estimation of the gradient (given we use only one trajectory to estimate the gradient)

Probability of the agent to select action at from state st given our policy

Direction of the steepest increase of the (log) probability of selecting action at from state st

Cumulative return

HUGGINFACE

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MAINTENANCE ROUTE OPTIMIZATION

INDEX

1. OUR PROBLEM

Overview of the Multi-Period Team Orienteering Problem with Time Windows (TOPTW), focused on optimizing routes by considering power generators, time constraints, and team availability.

2. RL

Application of reinforcement learning algorithms to address combinatorial optimization challenges, emphasizing their adaptability compared to heuristic methods.

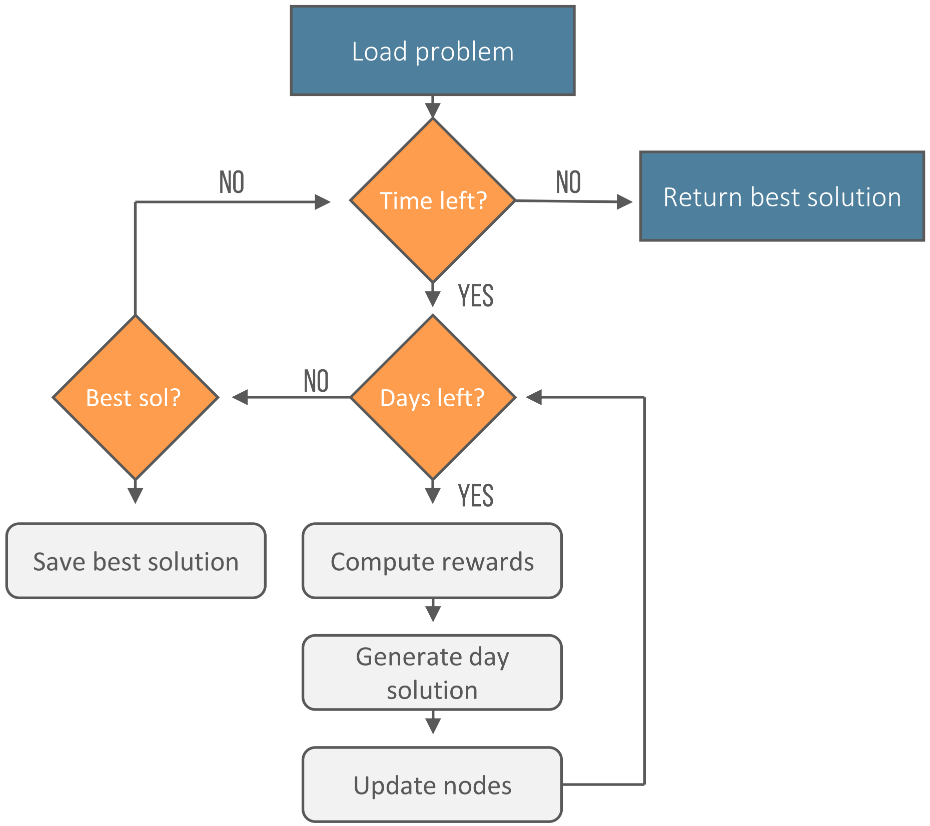
3. HEURISTIC

Development of daily updated solutions incorporating merging processes to effectively manage multi-period complexities, balancing practicality with efficiency.

4. RESULTS

Analysis of average outcomes across 256 instances, demonstrating the advantages of RL over heuristics in computational efficiency and performance under specific conditions.

METHODOLOGY:
HEURISTIC



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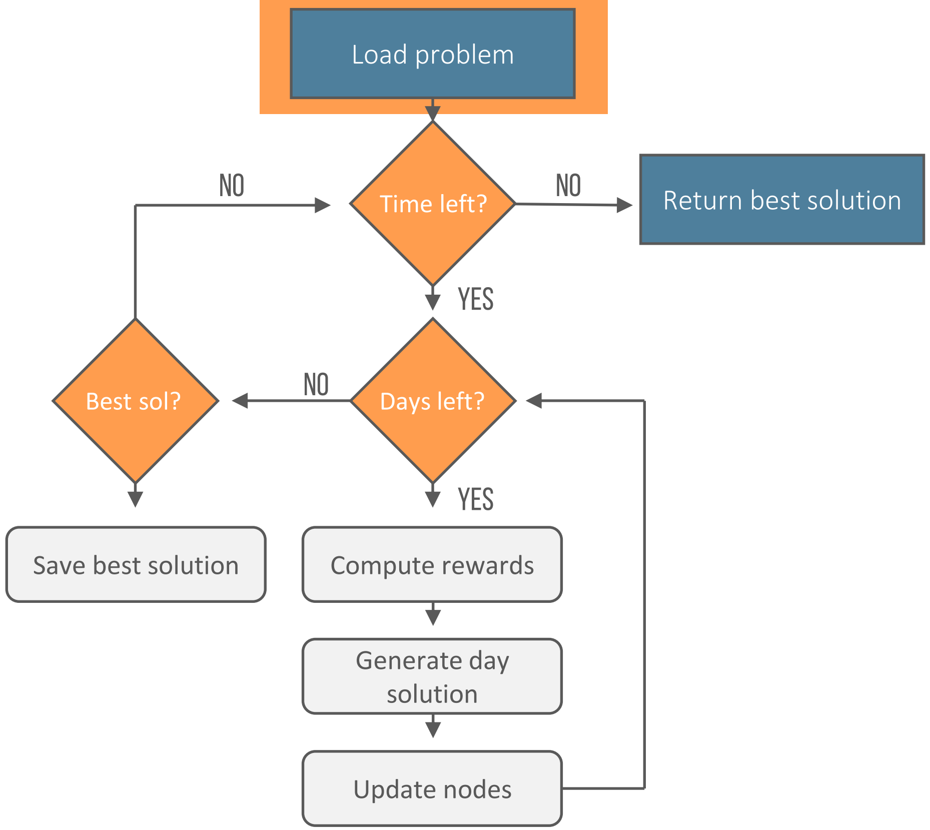
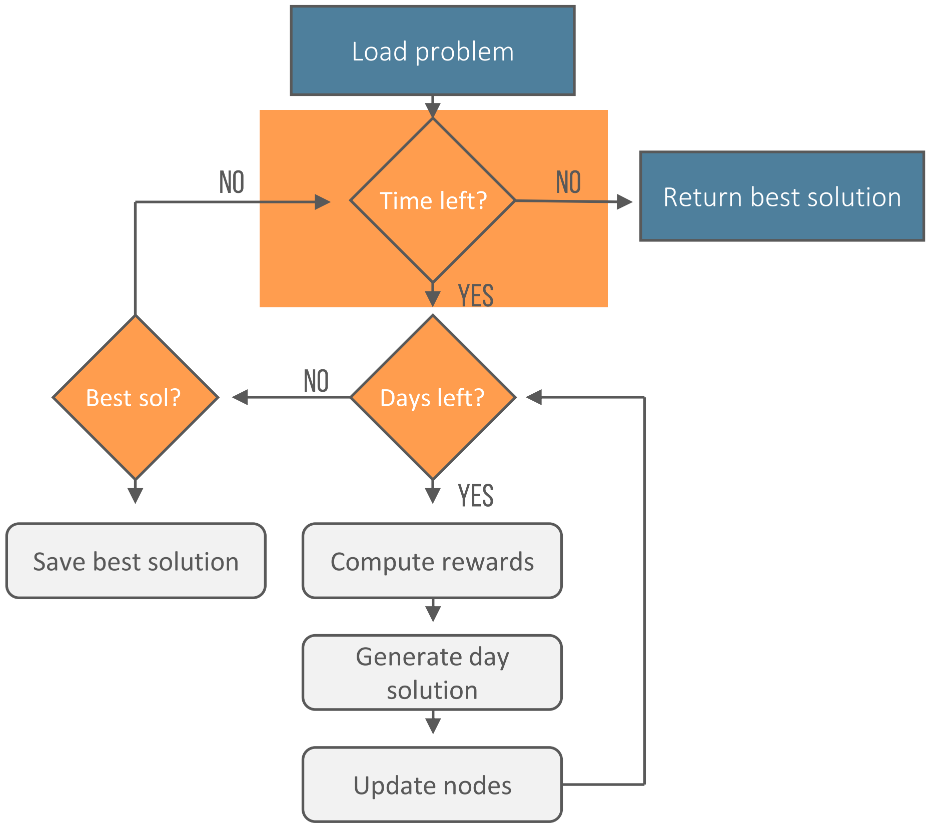


METHODOLOGY:

HEURISTIC

A maximum amount of time is given



METHODOLOGY:

HEURISTIC

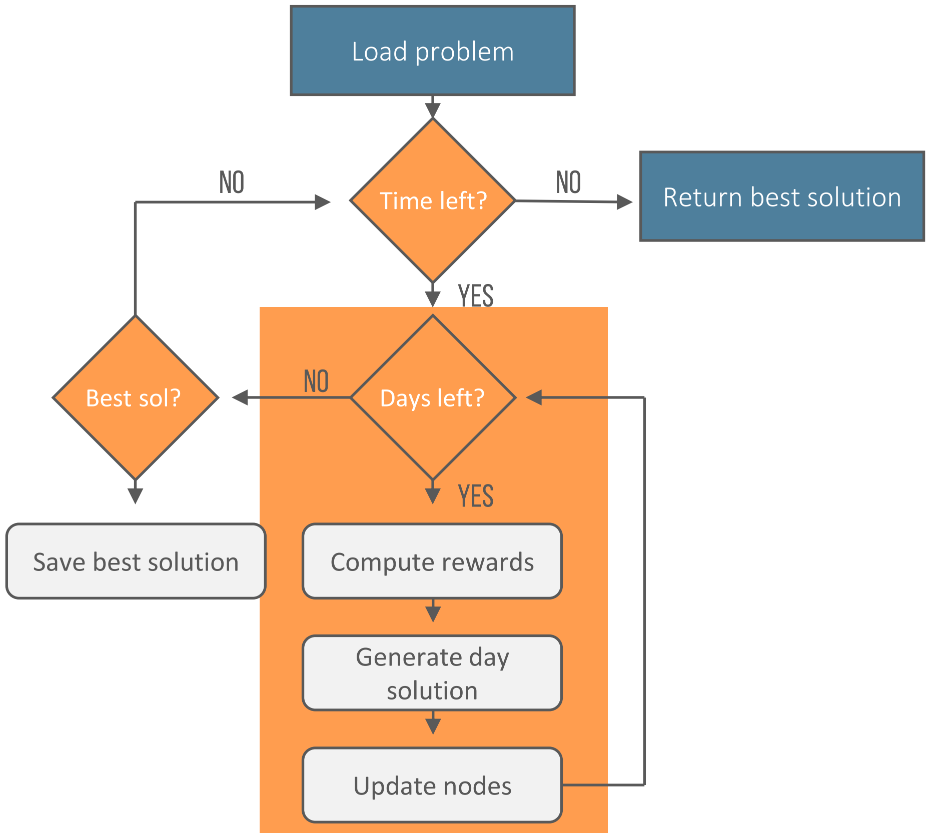
The reward varies daily.

A new solution is generated for each day.

- Dummy solution.
- BR-Merging process.

The available nodes are updated daily.

Some mechanisms are introduced to handle the multi-period aspect.



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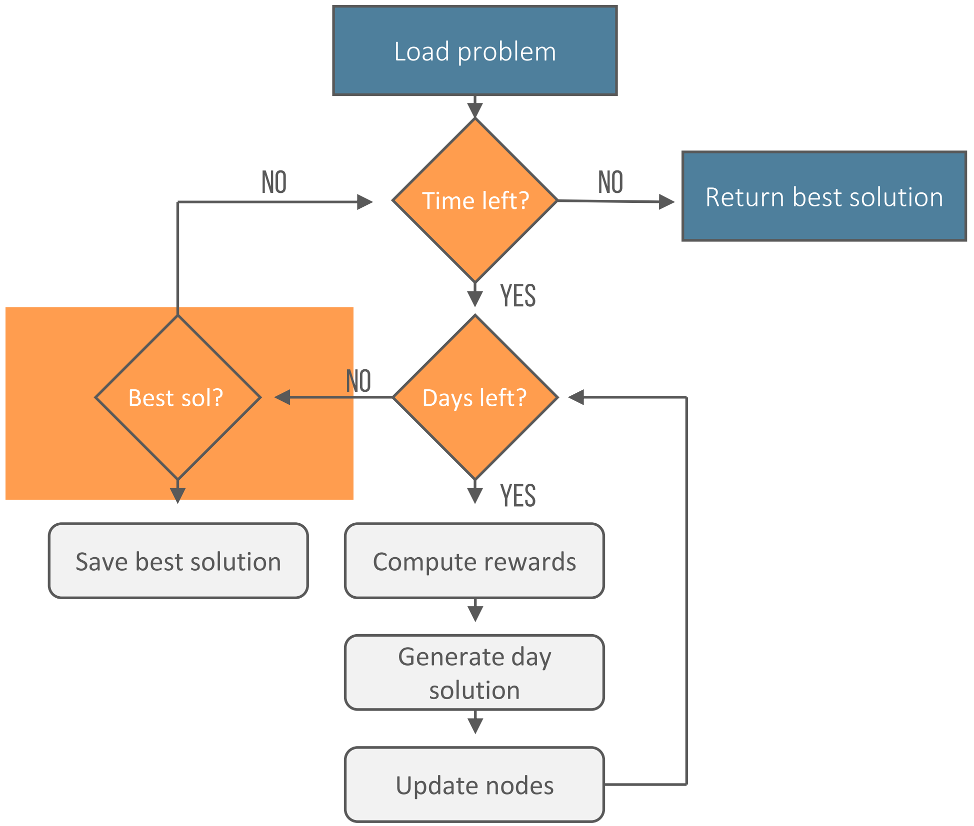

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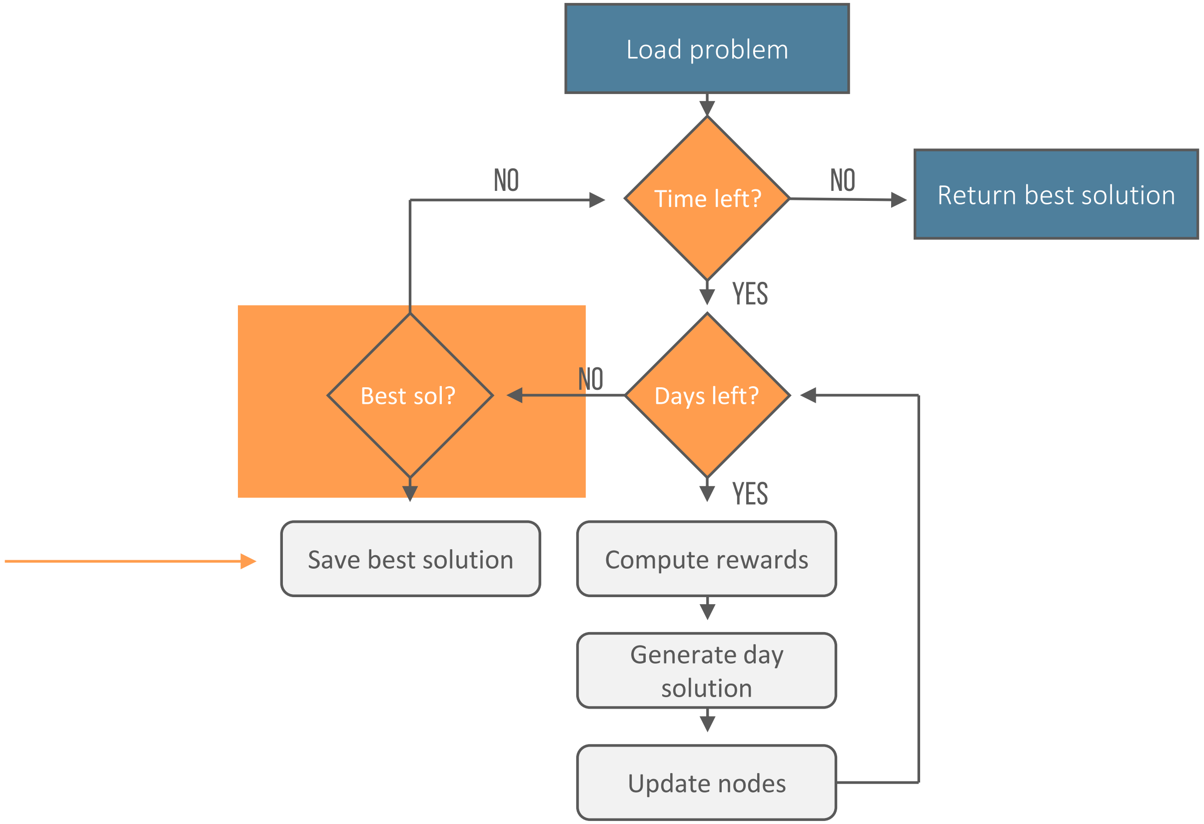

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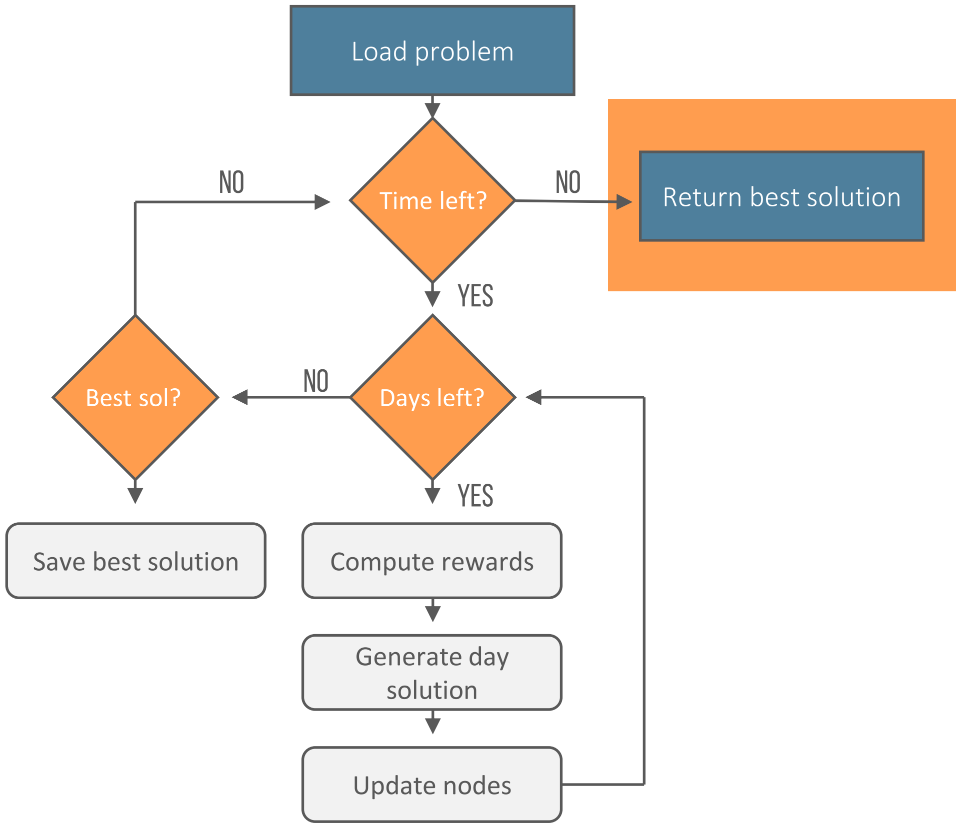

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MAINTENANCE ROUTE OPTIMIZATION

INDEX

RESULTS

		Reward	Corr. Maint. (%)	Prev. Maint. (%)
Heuristic	0.5 seconds	19.42	100%	76.04%
	2 seconds	19.55	100%	76.69%
	120 seconds	**19.65**	100%	76.43%
Reinforcement Learning Model	Greedy	19.09	100%	76.17%
	Sampling	19.43	100%	77.08%
	Augment.	19.50	100%	76.69%
	Rot. + Augment.	**19.56**	100%	76.30%

MEAN RESULTS OF 256 INSTANCES

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		2 seconds	Greedy	Sampling	Rot. + Augment.
30 Maintenances	$N = 2$ * $M = 3$ $S = 25$	**19.05**	13.35	13.87	15.22
	$N = 1$ $M = 2$ $S = 27$	**12.76**	7.60	7.84	8.47
45 Maintenances	$N = 2$ * $M = 3$ $S = 40$	19.55	19.09	19.43	**19.56**
	$N = 3$ $M = 3$ $S = 39$	**21.68**	19.62	20.61	21.06

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ACT. 4.24 OPTIMIZACIÓN DE RUTAS DE INSPECCIÓN DE MANTENIMIENTO

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Programa Misiones de I+D en Inteligencia Artificial 2021, en el marco de la Agenda España Digital 2025 y de la Estrategia Nacional de Inteligencia Artificial, Proyecto IA4TES financiado por el Plan de Recuperación, Transformación y Resiliencia.

Número de expediente TSI-100408-2021-0