

# Tutorial: Setting up a Reinforcement Learning pipeline for a Telco Core Network (part 2)

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# Installing the Gym environment and pipeline

Operating System	Linux	macOS	Windows
Repository access	Git command or download zip from GitHub		
Package installer and dependency management	pip , Miniconda or Anaconda		
Virtual environment	venv or Poetry		
Interpreter	CPython 3.9+		

A possible alternative is to use [Google Colab](#), but you would miss the fun animation of the examples.



# Installing the Gym environment and pipeline

Requires around 10GB to install and compile all dependencies

Installation, follow instructions from README.md

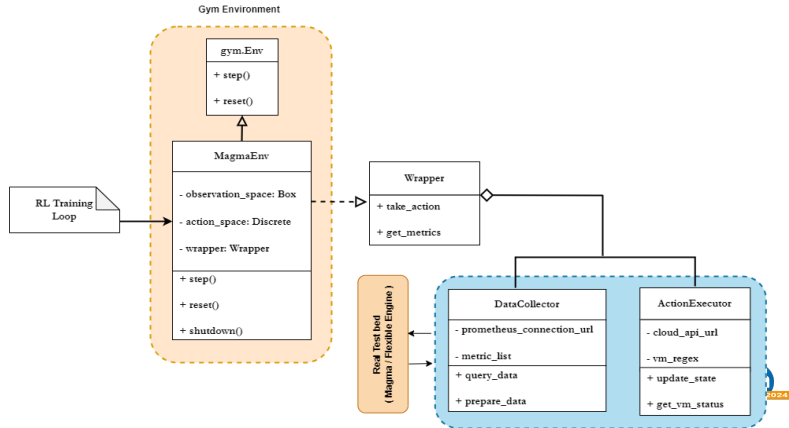
- `git clone https://github.com/gfraysse/icin2024_tutorial.git`
- `python -m venv <your virtual env>`
- `source <your virtual env>/bin/activate`
- `pip install -r requirements.txt`



# Environment Definition (Gym like/compliant)

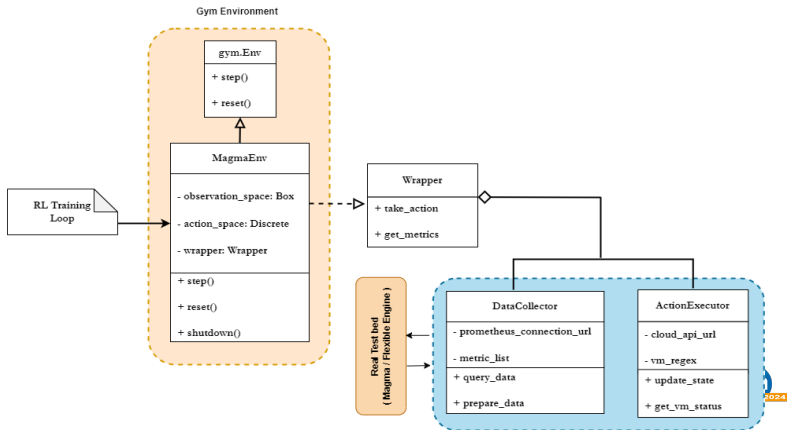
**Role:** provides standard interface for RL algorithms to interact with actual environment

- **Gymnasium:** Open-source python library for developing & comparing reinforcement learning algorithms
  - Provides standard API for learning algorithms and environment to communicate
  - Set of environments. E.g. Classic Control, Atari, MuJoCo etc.
  - Drop-in replacement of OpenAI Gym since 2021



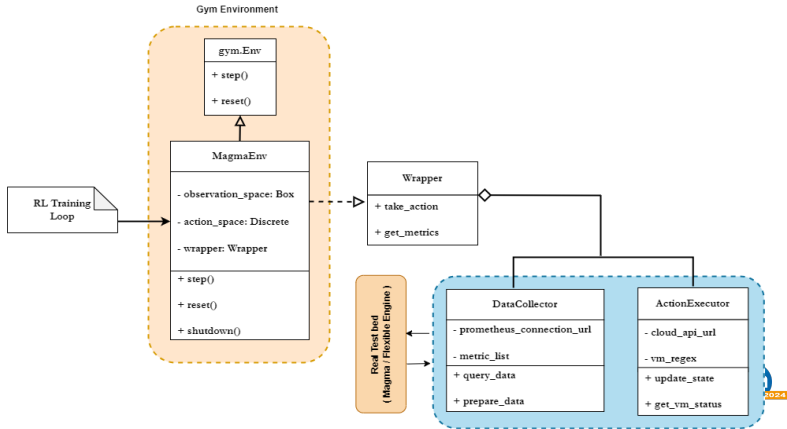
# Environment Definition (Gym like/compliant)

- **MagmaEnv**: Environment definition complying with Gym
  - a way to manage the environment while adhering to MDP
  - helps the learning algorithm to control the environment
  - implements the crucial methods like ***step()*** and ***reset()***



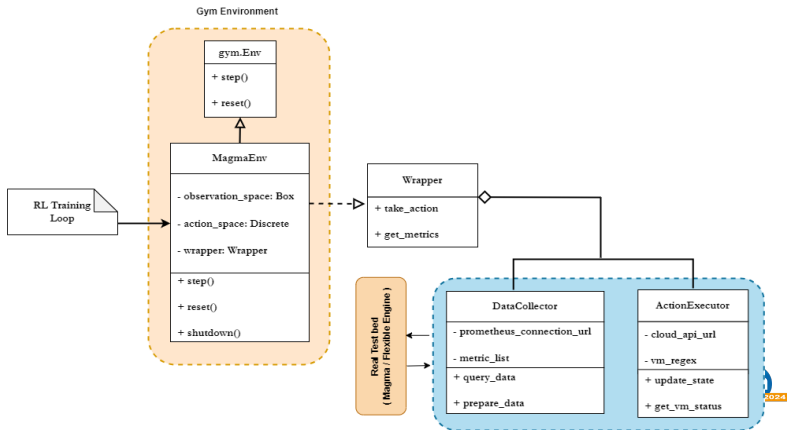
# Environment Definition (Gym like/compliant)

- **step():** accepts an 'action' and transitions the environment to a new state. It then returns:
  - a new state: in which agent finds itself after executing the action
  - reward: feedback for taking the action
  - terminated: indicates whether environment reached terminal state.
  - info: general info about environment
- **reset():** Moves the environment to an initial state.



# Environment Definition (Gym like/compliant)

- **TelcoCoreScalingEnv:**  
simulation environment  
mimicking Magma



# Finilizing the installation the Gym environment and pipeline

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# Running an experiment

## Adjust the configuration

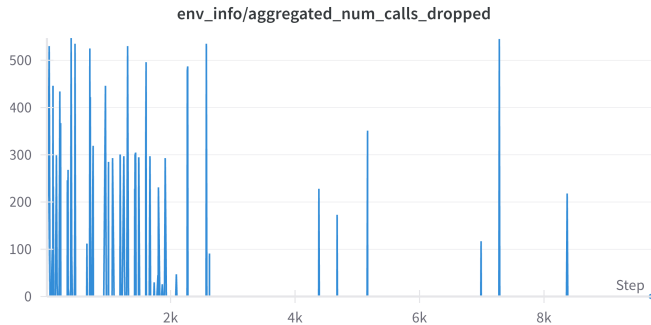
- Configuration of the pipeline *config\_per.yaml*
- Configuration of the environment *telco\_core\_scaling/envs/config/config\_env.yaml*

## Run an experiment

- `python pipeline-exp_d3qn_per_sim.py`



# Analyzing the results



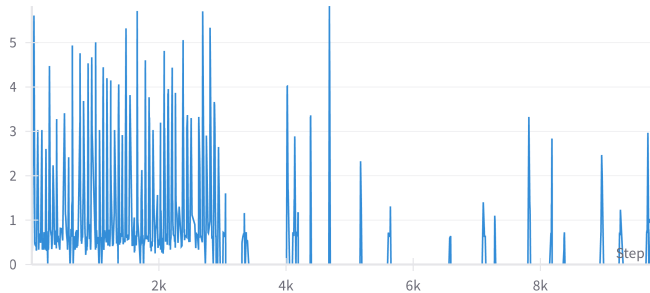
Number of calls dropped:

- Computed by the pipeline
- Measures the number of sessions that could not be initiated



# Analyzing the results

env\_info/avg\_ue\_attach\_rate



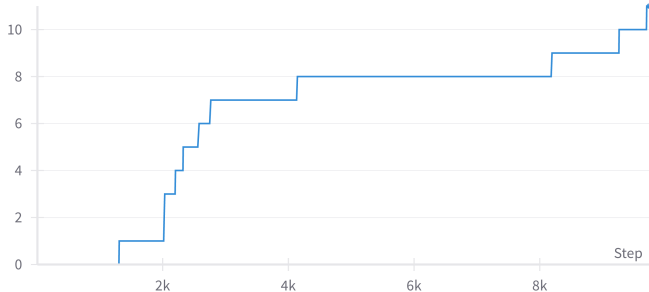
UE attach rate:

- Metric collected from Magma NMS
- Attach rate of the User Equipments (UEs) connecting to the Access Gateways (AGWs)



# Analyzing the results

env\_info/crash\_count

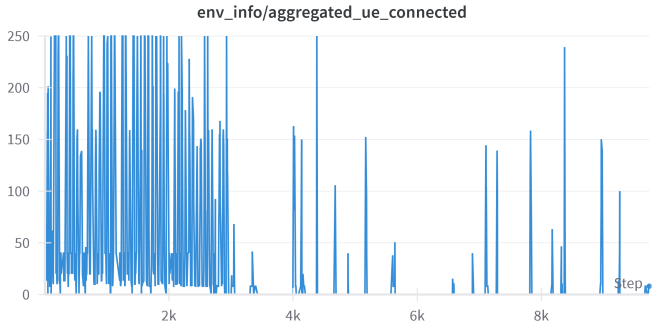


## Crash count:

- Measured by the pipeline
- Detect when something is wrong with the environment during the training (usually a crash, or an issue when starting a new instance)
- Initiate a reset



# Analyzing the results

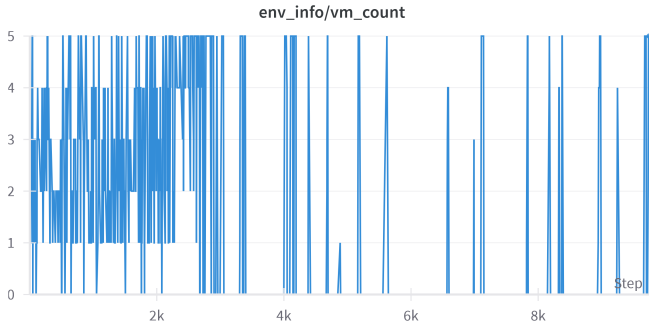


UEs connected:

- Metric collected from Magma NMS
- Number of UEs connected on all the AGWs currently running
- Different from Normalized UEs connected metric



# Analyzing the results



VM count:

- Metric collected from Magma NMS
- Measure the number of active instances of AGW(s)



## Reward function

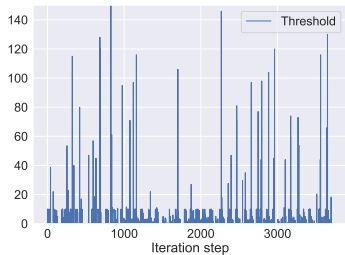
Metric	Definition
$U$	Number of UEs connected
$M$	Memory usage, in MB
$D$	Number of dropped sessions

- Maximum reward value is 1
- Encourages the Network Functions (NFs) to use resources optimally around 70%
- Resource usage above 80% or crashes are penalized with lowest reward value  $-1$ .

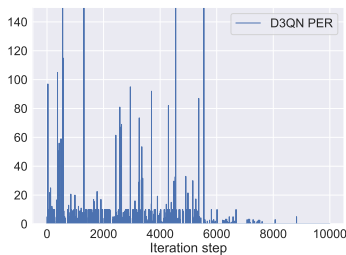
$$r = \begin{cases} 1 - (0.7 - \max(M, U) - D) & \text{if } M, U \in [0, 80] \\ \max(-\max(M, U) - 10 * D, -1) & \text{otherwise.} \end{cases}$$



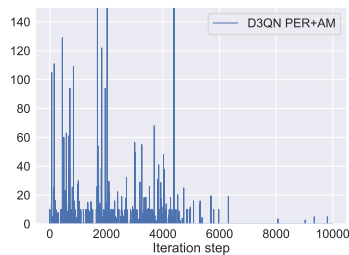
# Number of sessions dropped



(a) threshold-based scenario



(b) D3QN PER scenario



(c) D3QN PER+AM scenario

Evolution of the number  $D$  of dropped sessions, during the three experiments





## Average values of metrics during the experiments

Experiment	Steps	DUR (h)	Metric (average)				
			$U$	$M$	$P$	$C$	$D$
<b>buffer filling + <math>\epsilon</math> decay + pure exploitation</b>							
D3QN PER	10k	154	345	78	5.76	3.25	0.60
D3QN PER+AM	10k	187	368	59	4.81	3.96	0.49
<b><math>\epsilon</math> decay + pure exploitation</b>							
D3QN PER	6k	63	382	61	4.48	3.57	0.25
D3QN PER+AM	6k	76	408	41	3.11	4.63	0.12
<b>pure exploitation</b>							
D3QN PER	4k	29	407	51	3.65	3.80	0.03
D3QN PER+AM	4k	34	420	33	2.60	4.84	0.01
Threshold-based	4k	145	247	119	9.72	2.16	1.73



# Lessons learned

Reinforcement Learning (RL) is complex:

- Not your typical network or software engineer skill
- Very active area of research



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Automation of Network Core scaling:

- Development is required
- Probably better to use Infrastructure as Code framework to be IaaS-independent



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Automation of Network Core scaling:

- Development is required
- Probably better to use Infrastructure as Code framework to be IaaS-independent

Load generation is always tricky:

- Commercial products exist
- Lack of open source tools to generate traffic in a consistent way for a long time
- Traffic needs to be balanced across all instances



- Any questions left ?