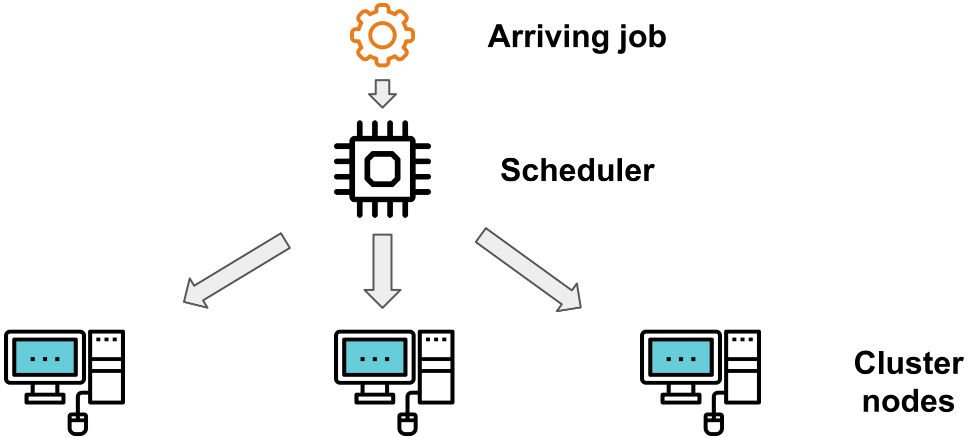
Telemetry data for machine learning based scheduling

Telemetry data for machine learning based scheduling

- Data generated in distributed systems and computing clusters:
  - Memory and CPU usage
  - Network parameters (latency, distance, etc)
  - Affinities between jobs and nodes

Telemetry data for machine learning based scheduling

- Scheduling involves deciding where to allocate arriving jobs in the cluster
- Use of telemetry data to optimize scheduling and other tasks, such as cluster workload estimation



Telemetry data for machine learning based scheduling

- Use of Machine Learning to optimize scheduling
    - Deep Reinforcement Learning (DRL)

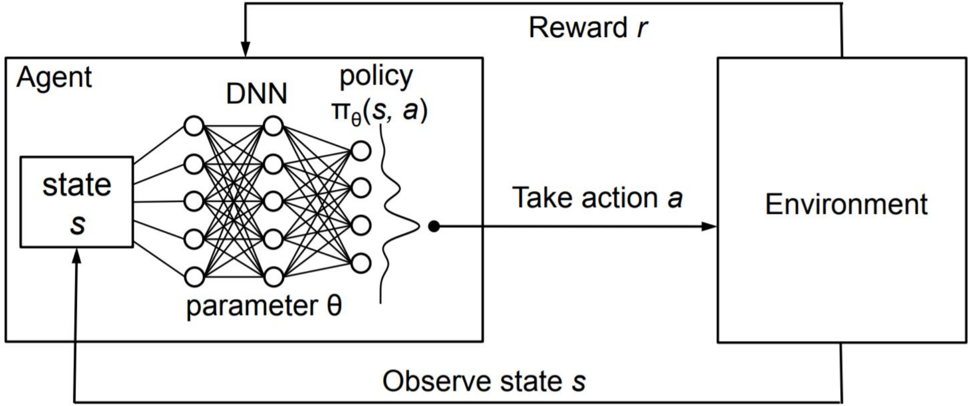
Research questions

- Is it beneficial to use telemetry data as an input to a Machine Learning model to perform scheduling decisions?

- Can telemetry data be used to predict the future workload in a node and to avoid system failures?

DRL scheduling - Methodology

- Why Reinforcement Learning?



DRL scheduling - Methodology

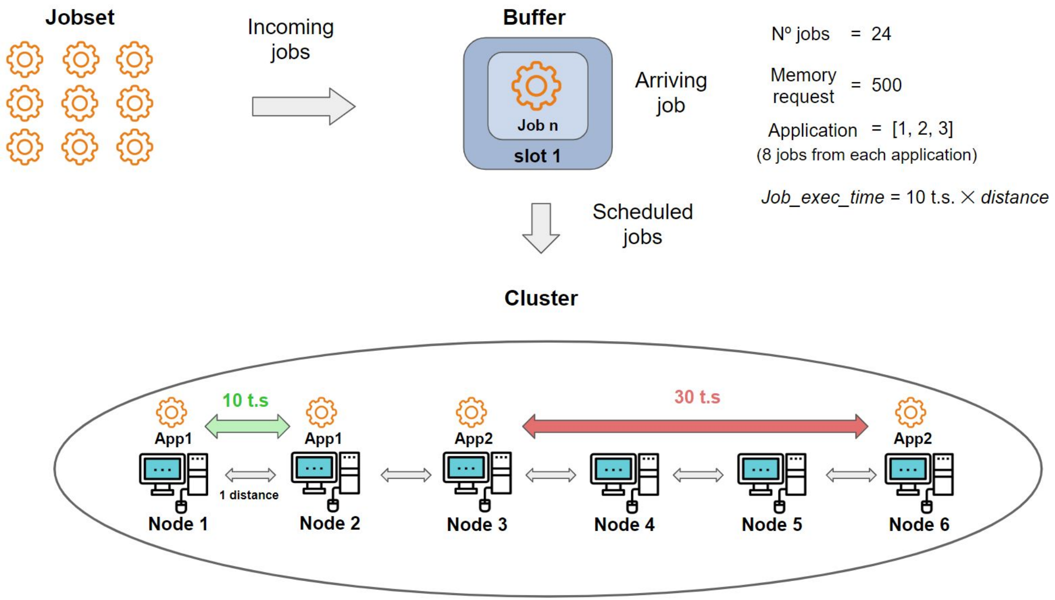
- **Policy gradient algorithm**

$$\theta = \theta + \alpha \sum_{t}^{\infty} \nabla_\theta \log \pi_\theta(s_t, a_t) * (v_t - b_t)$$

- **Experiment in simulated cluster**
  - Distance based scheduling

DRL scheduling - Distance based scheduling

- Goal
  - Minimize job duration, but how?
  - By learning from interaction and experience the distances between the nodes
- Implementation



Objective: Average job duration

$$\overline{d} = \frac{1}{N}\sum_{j=0}^{N} d_j$$

where $\overline{d}$ is the average job duration, N is the total number of jobs in the episode and d_j is the duration of the job j.

Reward

$$R_t = \sum_{j \in J_s} -1$$

where R_t is the reward at the current time-step and J_s is the set is jobs that are currently in the system.

State

- Input to DRL scheduler
  - Memory available in nodes
  - Memory request of waiting jobs in buffer
  - Affinity preference of waiting jobs in buffer

	Node 1 Memory available	Node 2 Memory available	Job 1 Memory request	Job 1 Affinity preference	Job 2 Memory request	Job 2 Affinity preference
Categorical data	500	1000	750	1	250	2
One-hot encoded data	001000	000100	0001	010	0100	001

Scheduler actions

Action	Description
0	Do not schedule any job
1	job 1: schedule to node 1 job 2: remain in buffer
2	job 1: remain in buffer job 2: schedule to node 1
3	job 1: schedule to node 1 job 2: schedule to node 1
4	job 1: schedule to node 2 job 2: remain in buffer
5	job 1: remain in buffer job 2: schedule to node 2
6	job 1: schedule to node 2 job 2: schedule to node 2
7	job 1: schedule to node 1 job 2: schedule to node 2
8	job 1: schedule to node 2 job 2: schedule to node 1

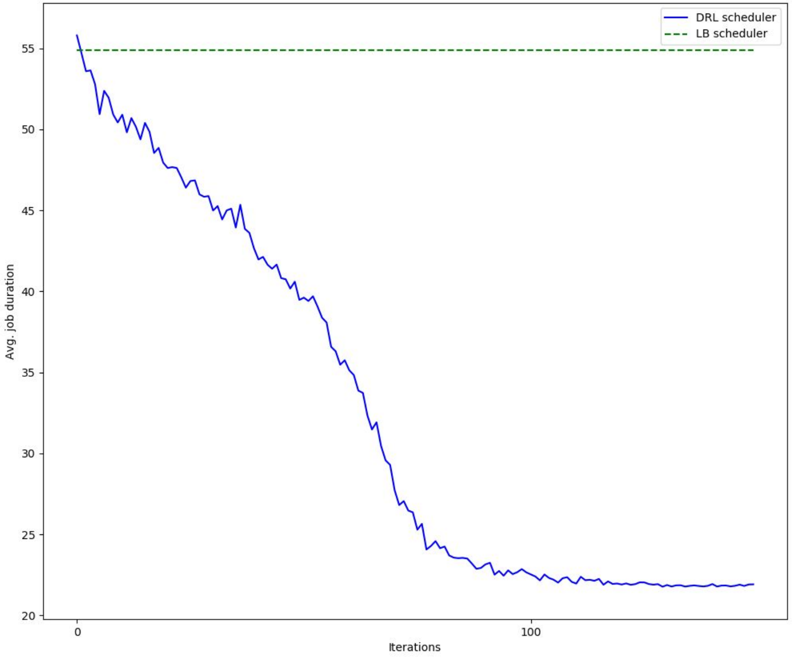
Objective: Average job duration

$$\overline{d} = \frac{1}{N}\sum_{j=0}^{N} d_j$$

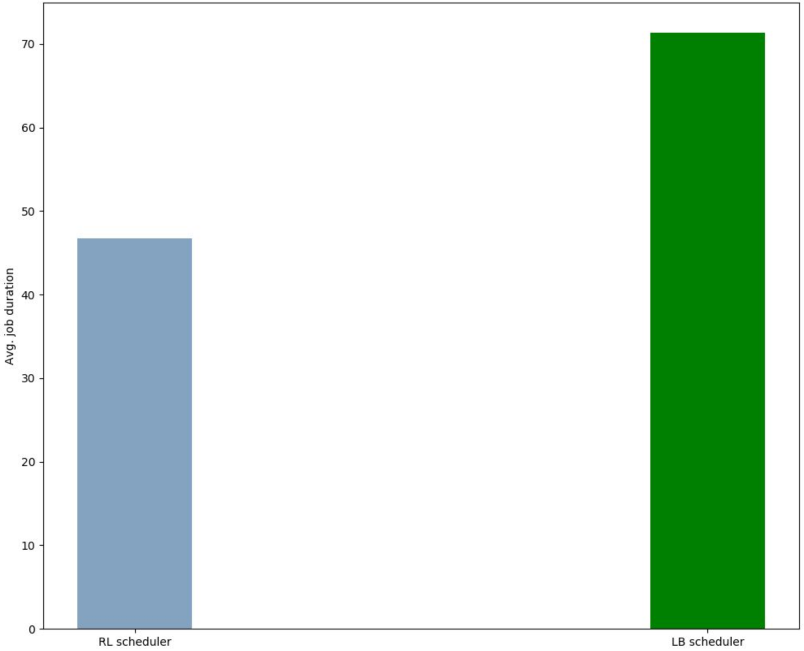
where $\overline{d}$ is the average job duration, N is the total number of jobs in the episode and d_j is the duration of the job j.

DRL scheduling - Distance based scheduling

- Results

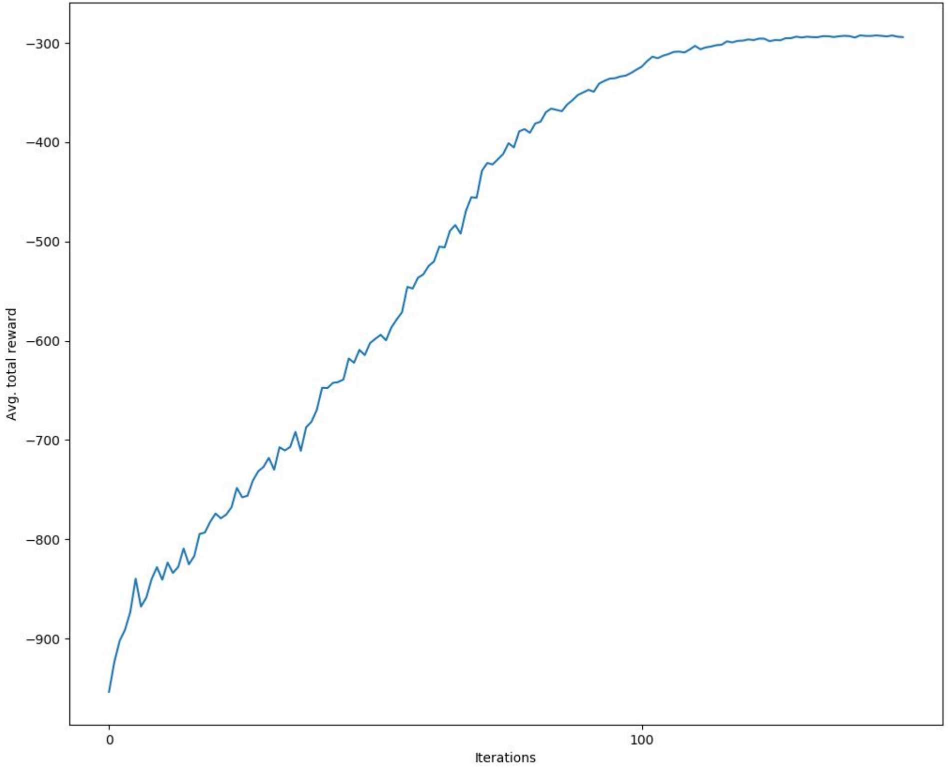


Average job duration evolution over training iterations



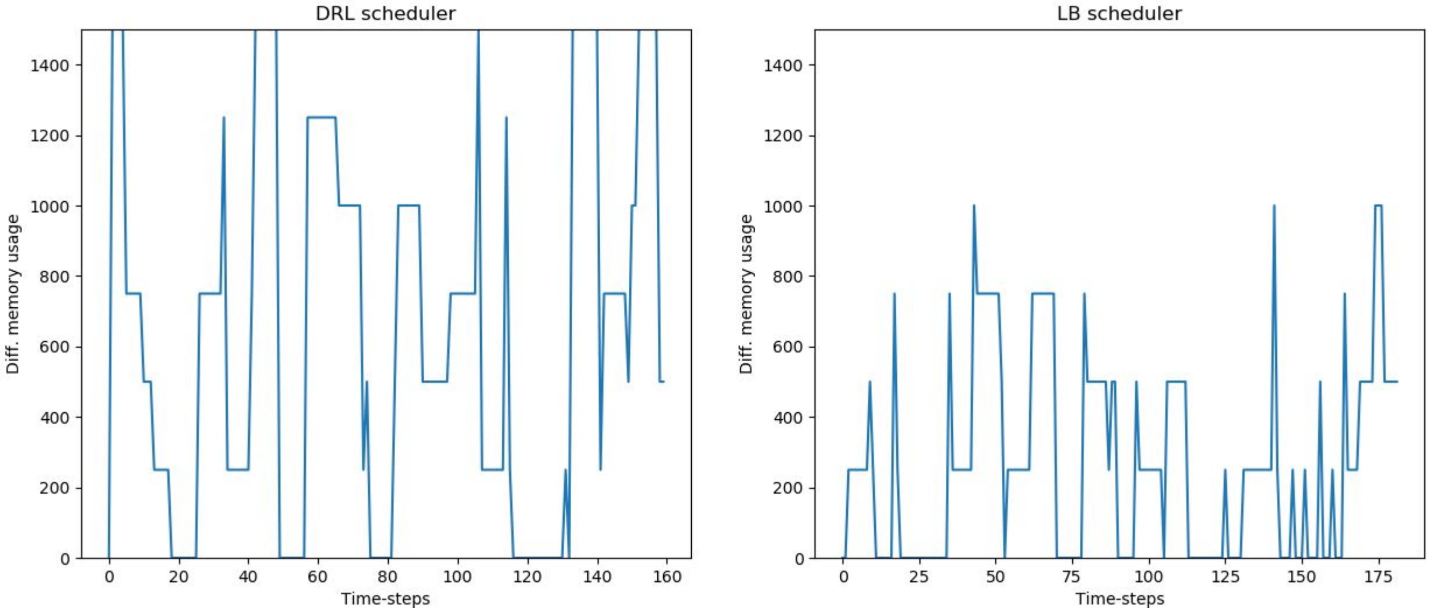
Average job duration of DRL and LB schedulers on test jobset

- Results



Average total reward evolution over training iterations

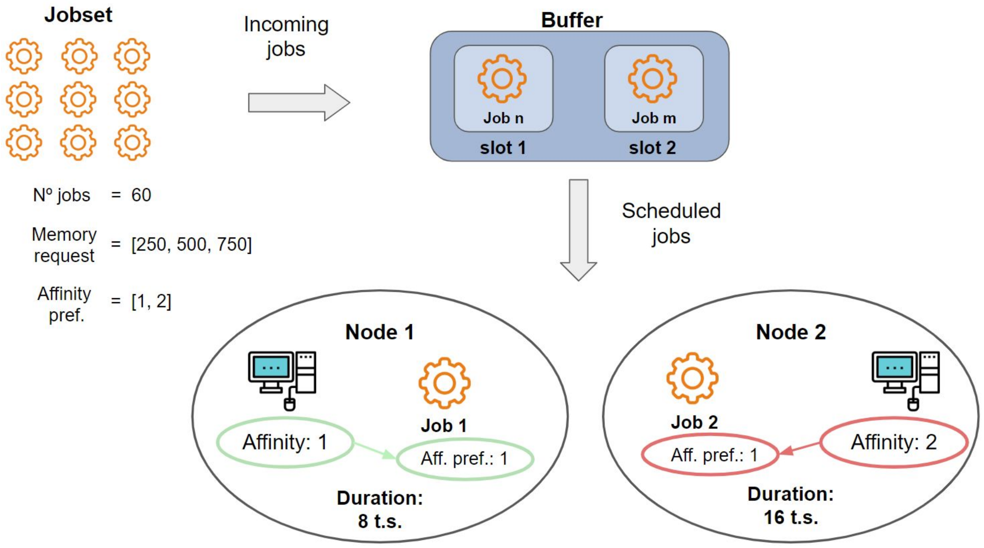
- Results



Difference of memory usage between nodes for DRL and LB schedulers

DRL scheduling - Affinity based scheduling

- Goal
  - Minimize job duration, but how?
  - Is DRL scheduling capable of learning the affinities of the nodes to reduce job duration?
- Implementation



State

- Input to DRL scheduler
  - App of Jobs in Nodes
  - App of buffer jobs
  - App of three next jobs

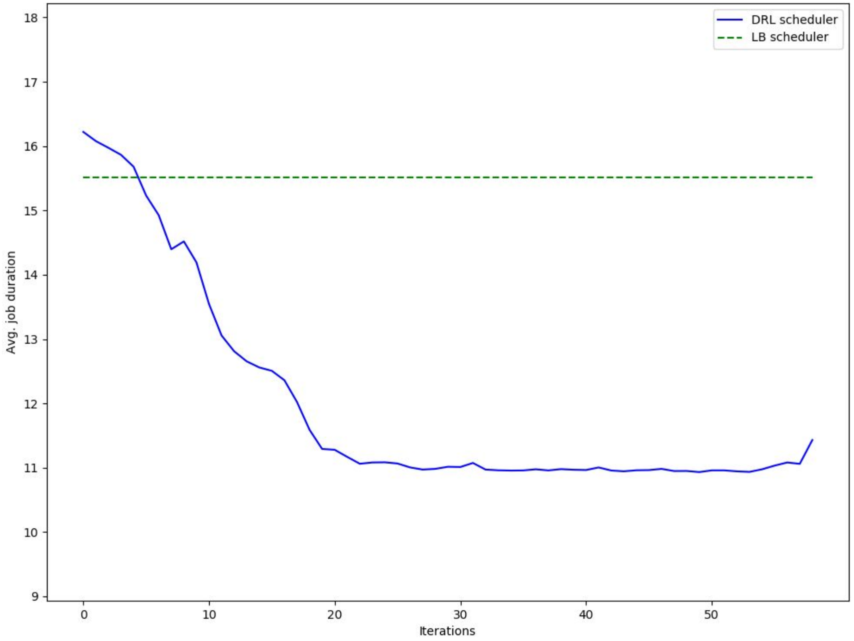
	Node 1 App	...	Node 6 App	Buffer App	Job + 1 App	Job + 2 App	Job + 3 App
Categorical data	1	...	0	2	3	1	0
One-hot encoded data	0010	...	0001	0100	1000	0010	0001

Scheduler actions

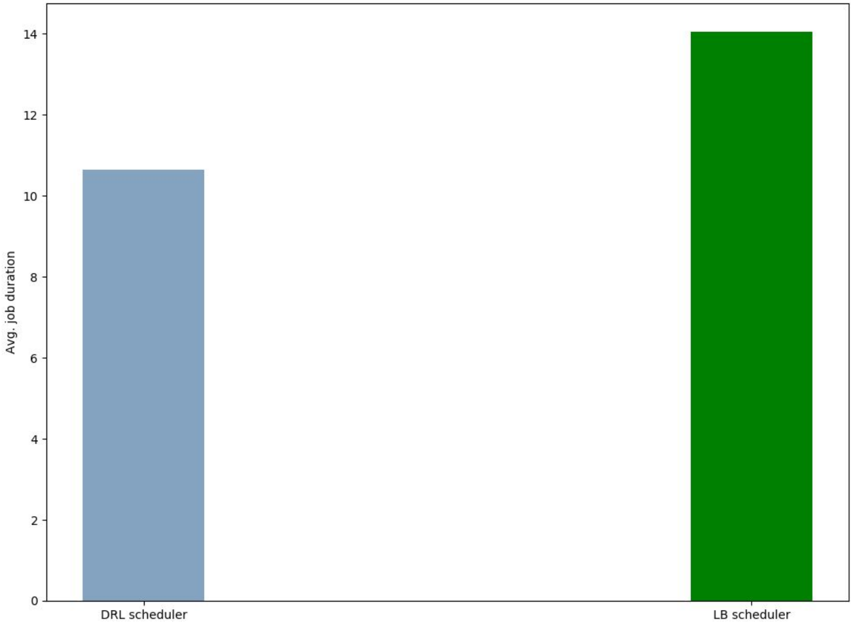
Action	Description
0	Do not schedule the job
1	Schedule the job to Node 1
2	Schedule the job to Node 2
3	Schedule the job to Node 3
4	Schedule the job to Node 4
5	Schedule the job to Node 5
6	Schedule the job to Node 6

DRL scheduling - Affinity based scheduling

- Results

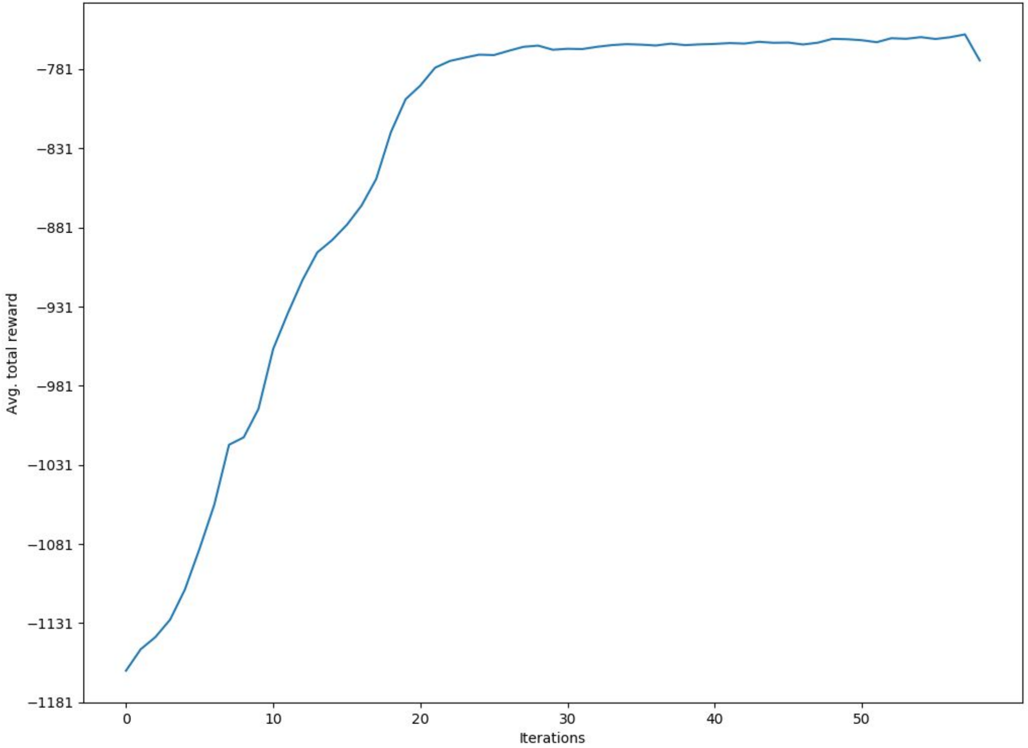


Average job duration evolution over training iterations



Average job duration of DRL and LB schedulers on test jobset

- **Results**



Average total reward evolution over training iterations