Raven: Scheduling Virtual Machine Migration during Data Center Upgrades with Reinforcement Learning

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TODAY'S AGENDA

1. Background & Context
2. Brief Deep RL Summary
3. Raven: The Scheduler
4. Results
5. Conclusions
6. How does this relate?

BACKGROUND & CONTEXT

- common for modern data centers to require maintenance upgrades for physical machines(PMs)
  - migrate virtual machines (VMs)
  - reduce downtime and/or disruptions
  - migrating images takes the longest
- must carefully select destination PM and schedule the VM migration
- Not much related works or within 'normal' situations
  - network topology and link capacities would be initially unknown

BRIEF DEEP REINFORCEMENT LEARNING SUMMARY

Extra features

- Fully connected neural network
  - adjustable policy $\pi(a|s;\theta)$ and parameters
- Cross-Entropy method is used in calculations to find optimal policy $\pi(a|s;\theta^*)$

Parameter for -> sampling (3)

$$\hat{v} = \arg\max_{v} \frac{1}{N} \sum_{n\in[N]} \mathbf{1}_{\{R(x_n)\geq\xi\}} \frac{f(x_n;u)}{f(x_n;w)} \log f(x_n;v), \quad (3)$$

$$\hat{\theta}_k = \arg\max_{\theta_k} \sum_{n\in[N]} \mathbf{1}_{\{R(x_n)\geq\xi_k\}} \left(\sum_{a_t,s_t\in x_n} \pi(a_t|s_t;\theta_k) \right), \quad (4)$$

<- Parameter estimator at iteration 'k' (4)

It's reinforcement learning with a few extra features..

RAVEN?

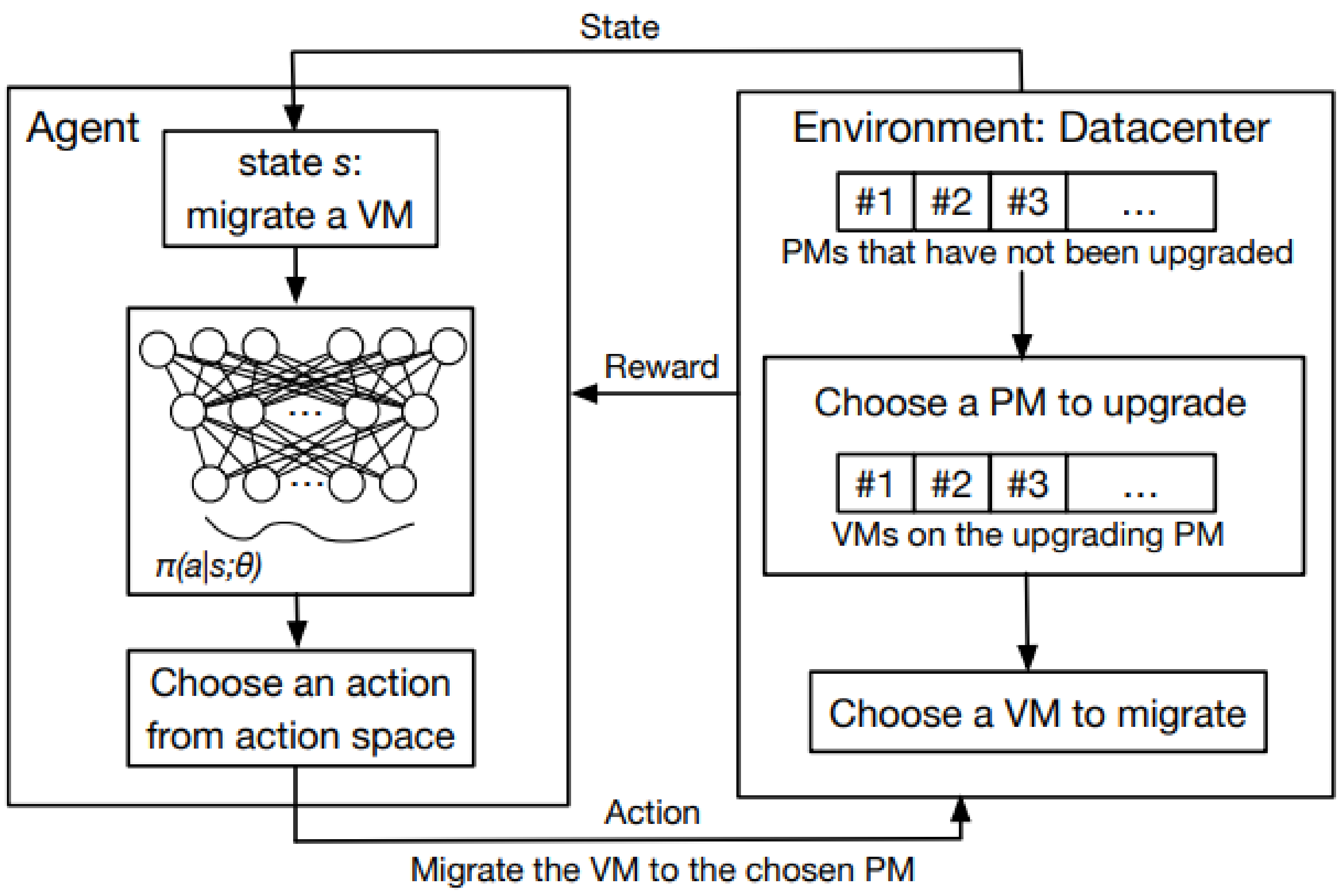


Fig. 4: The architecture of *Raven*.

Start: Pick PM that needs to be upgraded

Per timestep: VM is migrated

Episode: Finish upgrading all PMs Time step

Action: destination PM index

State Space: $s_{tj} = \{s_{tj}^{\text{status}}, s_{tj}^{\text{total cpu}}, s_{tj}^{\text{total mem}}, s_{tj}^{\text{used cpu}}, s_{tj}^{\text{used mem}}\},$

Reward: lower total migration time

RESULTS

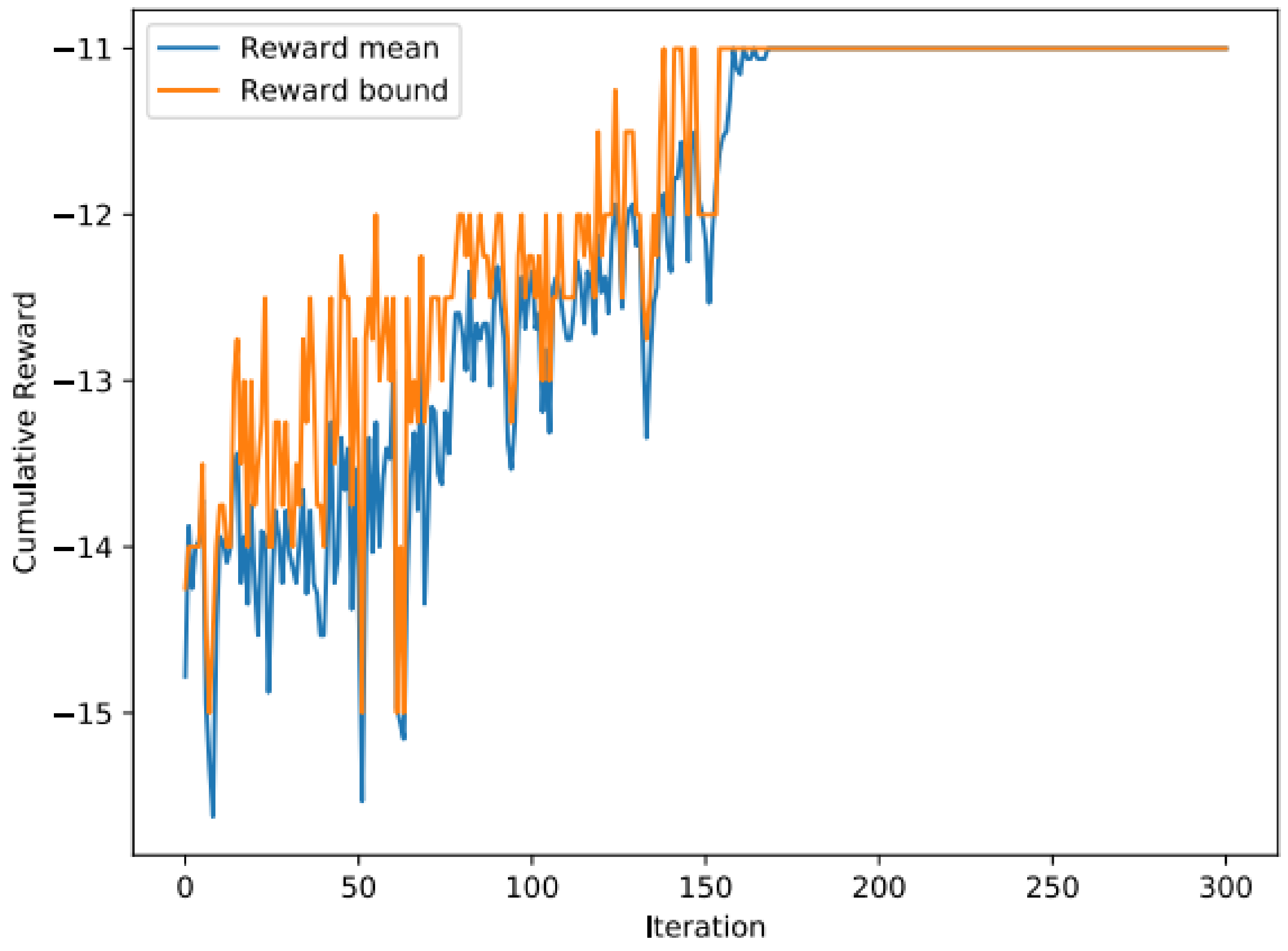


Fig. 5: The learning curve of *Raven* in datacenter with 9 physical machines and 30 virtual machines.

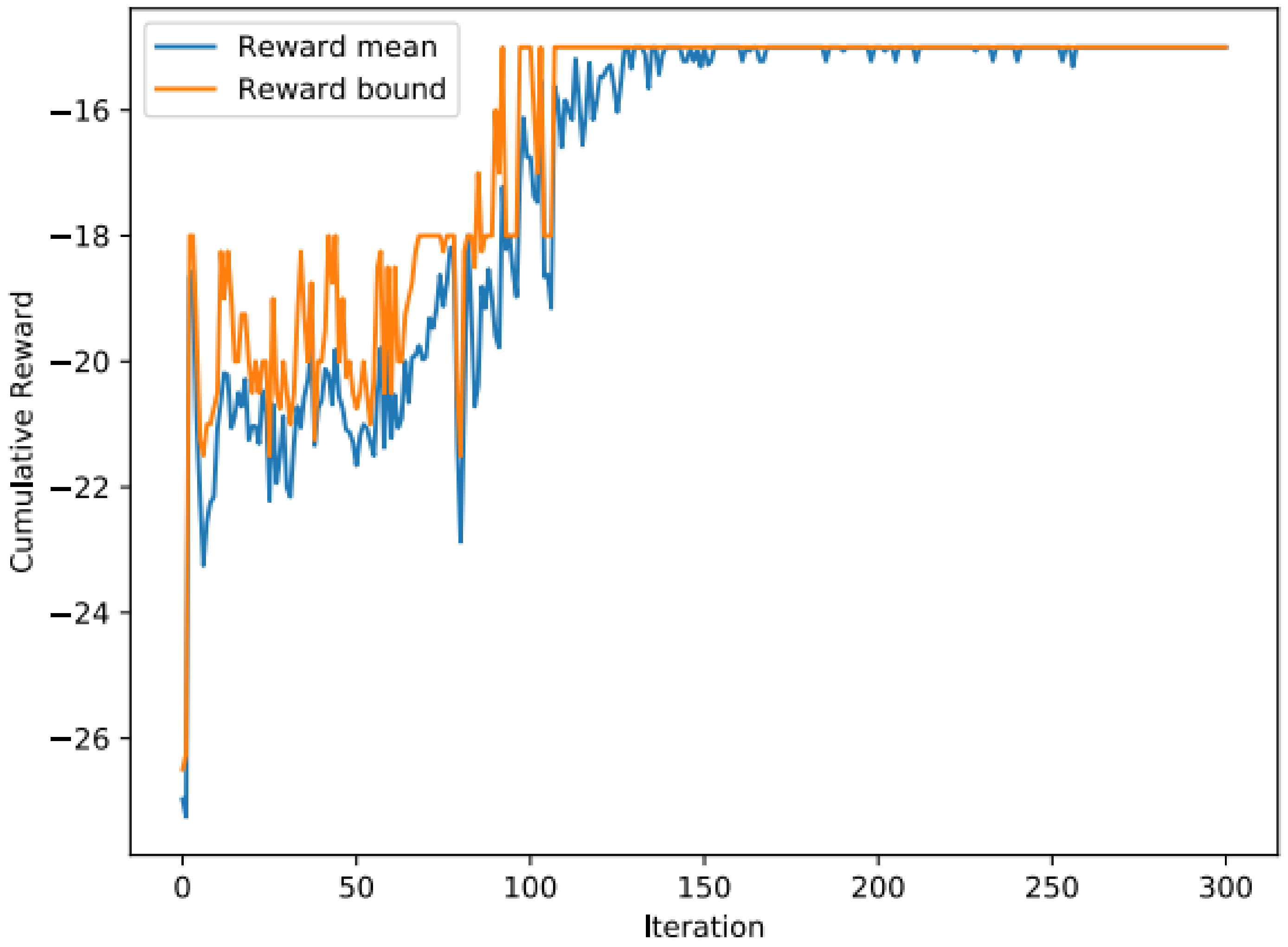


Fig. 6: The learning curve of *Raven* in datacenter with 10 physical machines and 40 virtual machines.

RESULTS CTD

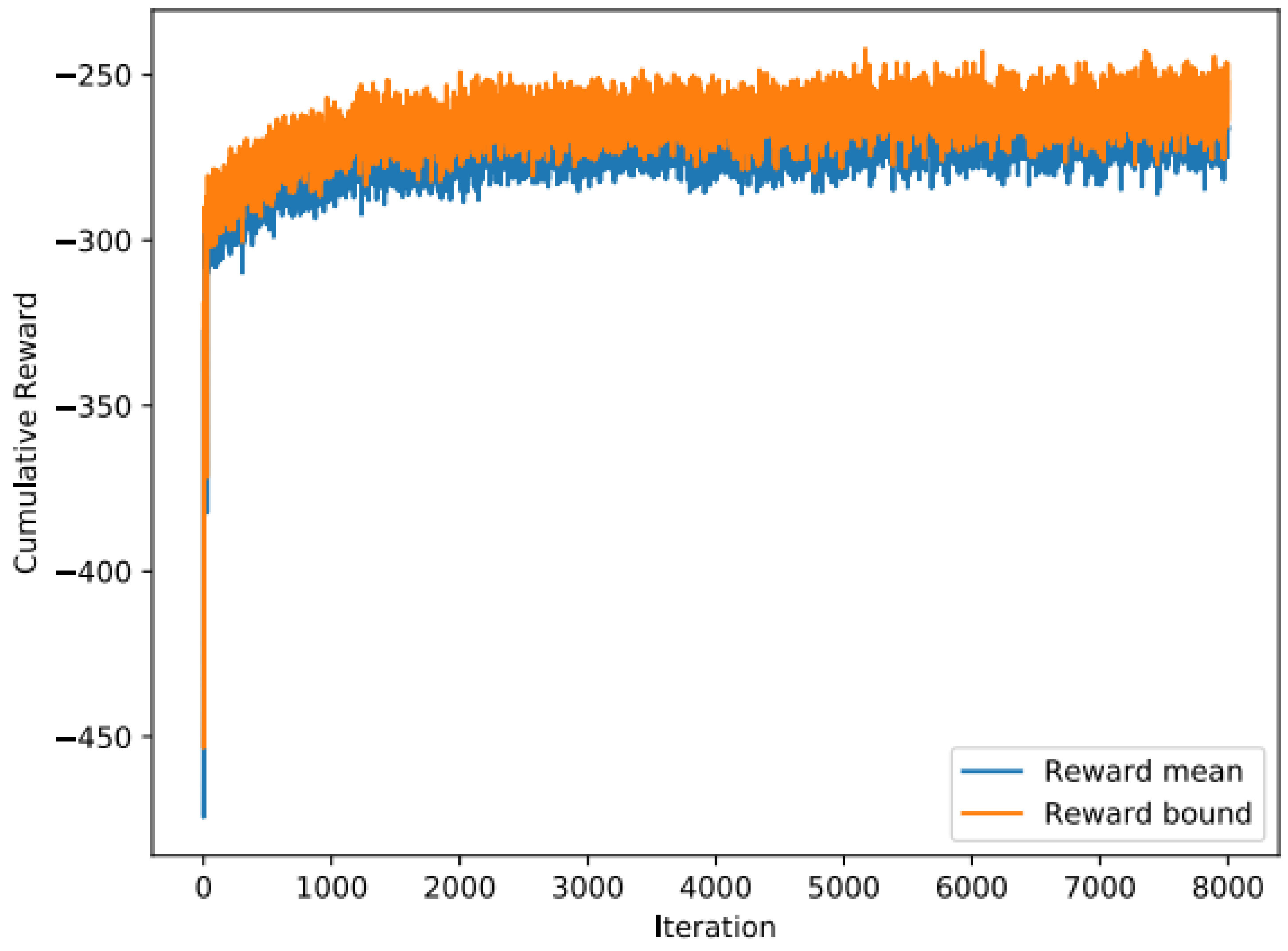


Fig. 8: The learning curve of *Raven* in datacenter with 260 physical machines and 520 virtual machines.

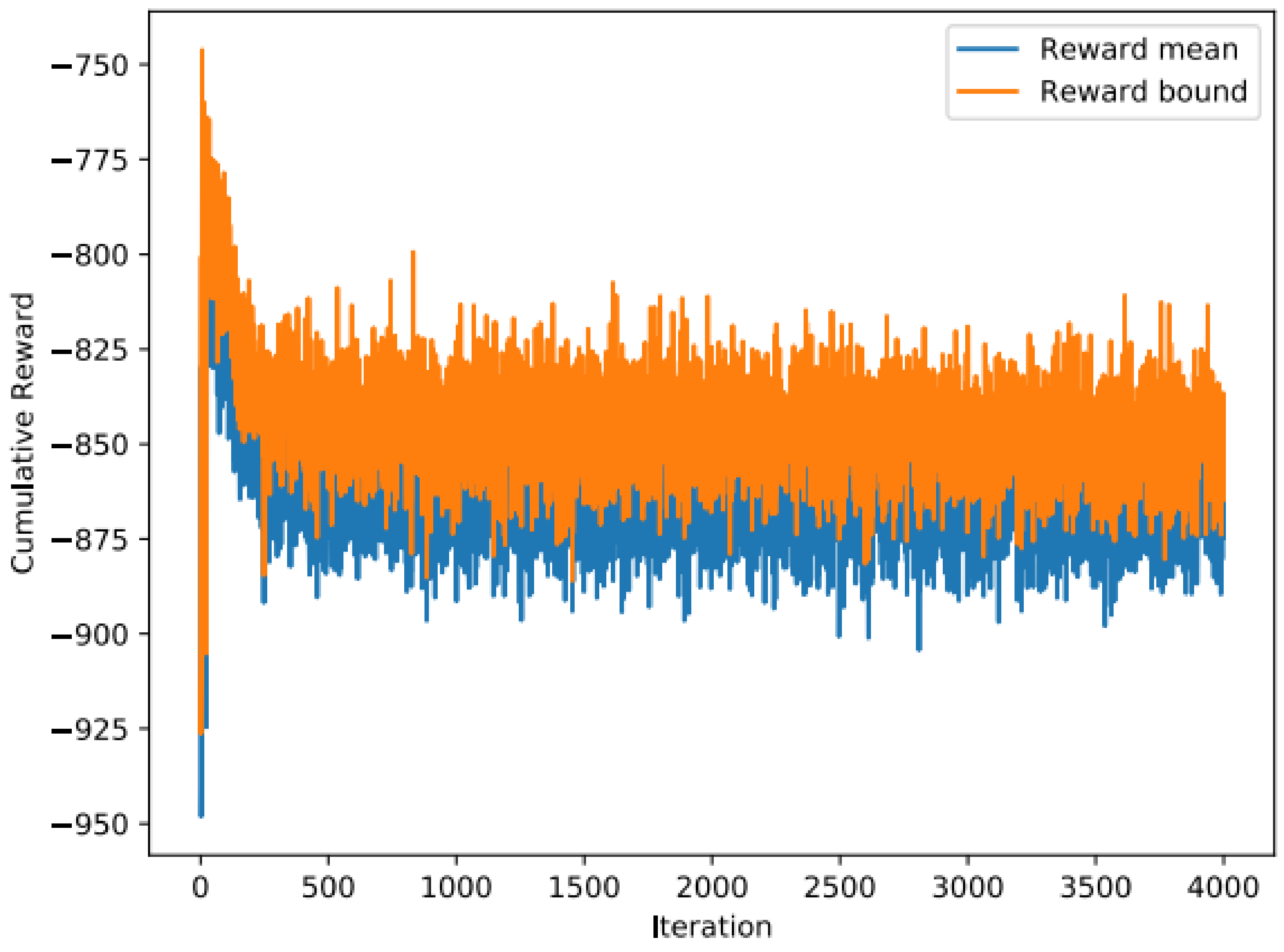


Fig. 9: The learning curve of *Raven* in datacenter with 260 physical machines and 1158 virtual machines.

RESULTS CTD

Table 1: Total migration time within different datacenters.

Datacenter Setting			Total Migration Time		
Number of PMs	Number of VMs	Number of Aggregation Switches	Min-DIFF	Heuristic	*Raven*
50	100	0	35.56 (11%)	57.50 (45%)	31.50
50	100	2	130.5 (27%)	110.0 (14%)	94.00
50	150	0	55.50 (31%)	103.00 (63%)	38.00
50	150	2	168.00 (16%)	159.00 (11%)	140.50
100	200	0	43.50 (28%)	91.50 (66%)	31.00
100	200	2	227.00 (35%)	221.50 (34%)	146.00
100	300	0	65.50 (2%)	192.50 (66%)	63.99
100	300	2	339.00 (15%)	378.00 (24%)	286.00
260	520	6	791.00 (58%)	510.00 (34%)	332.14
260	520	7	681.00 (35%)	445.78 (1%)	440.15
260	520	8	651.25 (58%)	440.00 (39%)	268.00
260	1158	6	944.31 (7%)	924.42 (5%)	869.97
260	1158	7	903.00 (10%)	910.50 (11%)	805.85
260	1158	8	918.50 (15%)	870.95 (11%)	774.23

RESULTS CTD

Table 2: Average total migration time within different datacenter.

Datacenter Setting			Average Total Migration Time		
Number of PMs	Number of VMs	Number of Aggregation Switches	Min-DIFF	Heuristic	*Raven*
50	100	0	36.20 (0%)	57.55 (36%)	36.39
50	100	2	117.00 (1%)	107.38 (-7%)	115.13
50	150	0	47.25 (-1%)	94.50 (49%)	47.94
50	150	2	172.95 (9%)	165.83 (5%)	157.00
100	200	0	53.05 (17%)	100.16 (56%)	43.54
100	200	2	248.24 (15%)	214.80 (2%)	209.14
100	300	0	66.80 (7%)	156.65 (60%)	61.96
100	300	2	335.95 (12%)	299.65 (1%)	296.32
260	520	6	725.55 (46%)	451.52 (14%)	388.94
260	520	7	667.70 (35%)	465.76 (7%)	433.17
260	520	8	622.65 (45%)	420.08 (19%)	338.65
260	1158	6	971.67 (12%)	1020.25 (17%)	846.06
260	1158	7	912.01 (14%)	987.62 (20%)	782.55
260	1158	8	836.54 (10%)	969.42 (22%)	748.93

CONCLUSIONS

Needed Improvements:

- consider live VM migration
- struggles to converge under certain settings

Overall

- ✓ closer to a real-life use case scenario
- ✓ does better in larger network topologies
- ✓ still has the shortest times overall compared to:
  - Min-DIFF
  - Heuristic evaluation

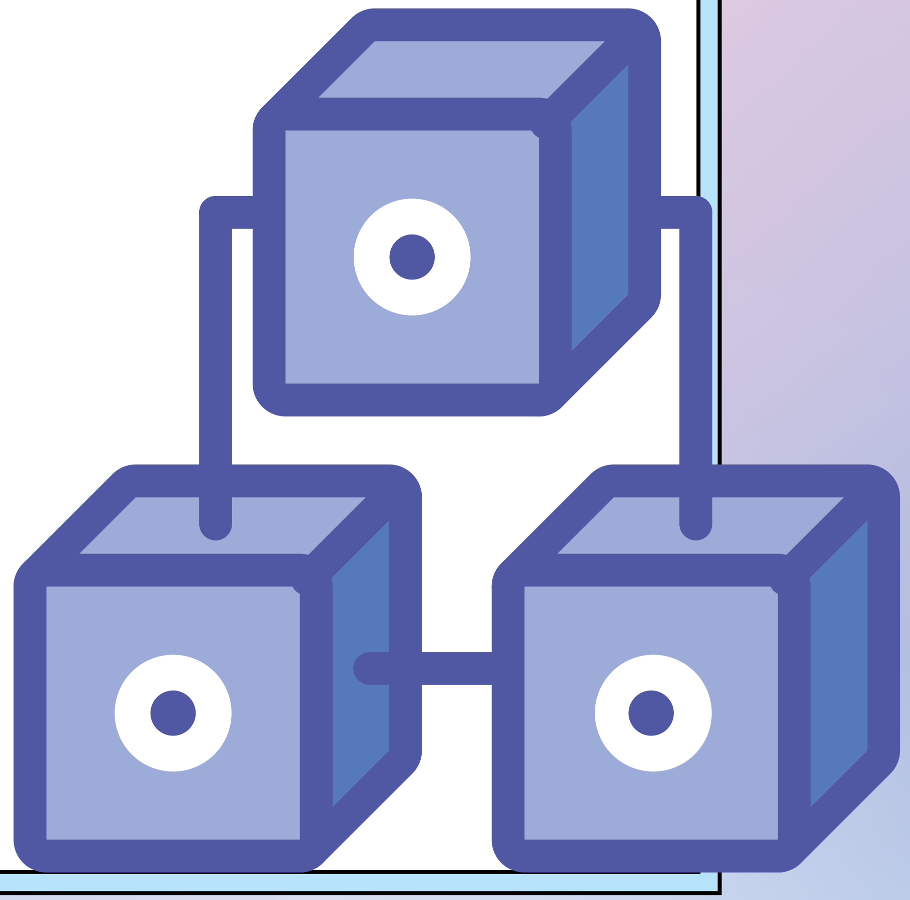
HOW DOES THIS RELATE?

Deep reinforcement learning looks more promising to pursue

- large fat tree, harder to maintain a traditional Q Table

Similar unique example, with no obvious starting event

- good example to 'translate'



Works Cited

Ying, C., Li, B., Xiaodi, K., & Guo, L. (2020). Raven : Scheduling Virtual Machine Migration During Datacenter Upgrades with Reinforcement Learning. *Mobile Networks and Applications*, 1-12.

Thank you!

Any questions, comments, and/or concerns?