Application of Multi-agent Reinforcement Learning in Warehouse Logistics

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Introduction to me and What I am doing here :)

Nikunj Gupta

- Final year IMTech Student @ IIIT-Bangalore
- Currently, pursuing a Master's thesis
  - Under Prof. G. Srinivasaraghavan @ IIIT-B
  - In Association with Ericsson Research
- Summer internship
  - Optimal placement of items in a warehouse

Use case scenario

Warehouse Management System

- Demand forecasting
- Placement of items in the warehouse

Overall Objective: Maximize throughput and Reduce incurred costs

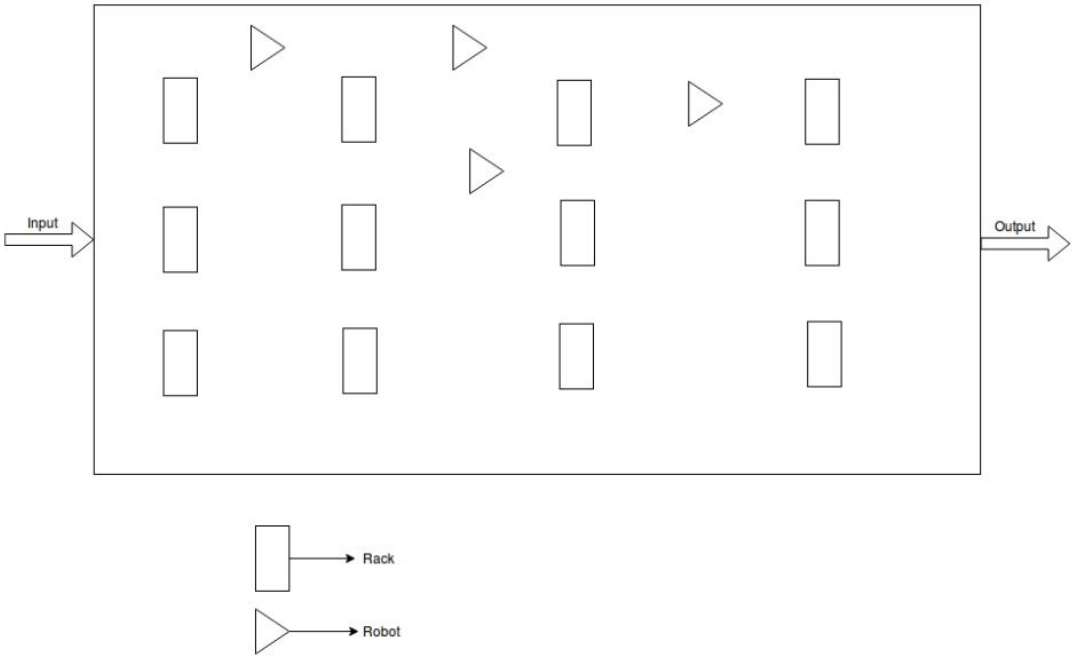


Figure 1: Warehouse (Top View)

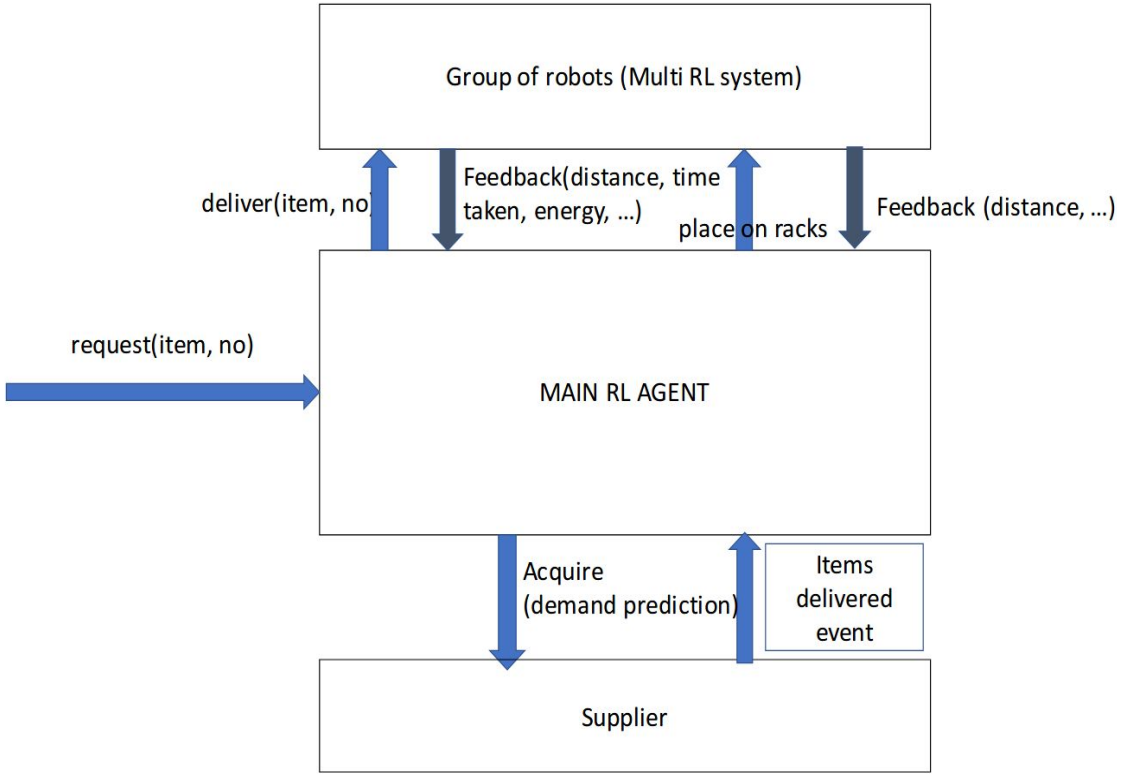
Possible Solution Approaches and Why?

- Reinforcement Learning
  - Works very well in dynamic environments
  - Complex function approximators have shown to be effectively useful in RL too (Deep Reinforcement Learning)
  - Simulations are easy to build; Possible to extend

- Multi-Agent Systems
  - Can take care of huge scale in a distributed manner.

Solution Architecture

- One agent handling the demand and acquisition
- A set of robotic agents handling placement and supply within warehouse
- Fully Cooperative Multi-Agent Environment
  - Coordination
  - Working together to achieve a bigger goal
- Reinforcement Learning
  - Rewards
  - Penalties



States, Actions and Rewards

- Work in progress
- States
  - Items in the warehouse and their locations, robots and their locations
- Actions
  - acquire(item, #), pick(item), drop(item)
- Rewards
  - throughput, profit of sale, penalty for no-stock or overshoot of stocks

Current Work

Implementing simplistic case of only the demand and acquisition.

- A Storage of maximum 50 bags of type T, say wheat bags
- Demand: Sampled from Poisson Distribution
  - Different means for each day (to maintain a weekly pattern)
- Feedback:
  - Profit per bag
  - Penalty for ordering bags more than capacity
  - Penalty if not being able to fulfill customer’s demand
- Question
  - Policy (how many bags to acquire in a day?)

State, actions...

- State
  - Tuple- (Number of bags present today N, WeekDay #)
- Action
  - Number of bags (say A) to be ordered from Supplier
- Next State: N - M + A
  - where M is the Number of bags sold that day

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State:  (18, 6)    Action:  9    Demand:  13    NextState:  (14, 7)
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State:  (36, 7)    Action:  16    Demand:  19    NextState:  (33, 1)
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Model-free Q-table construction

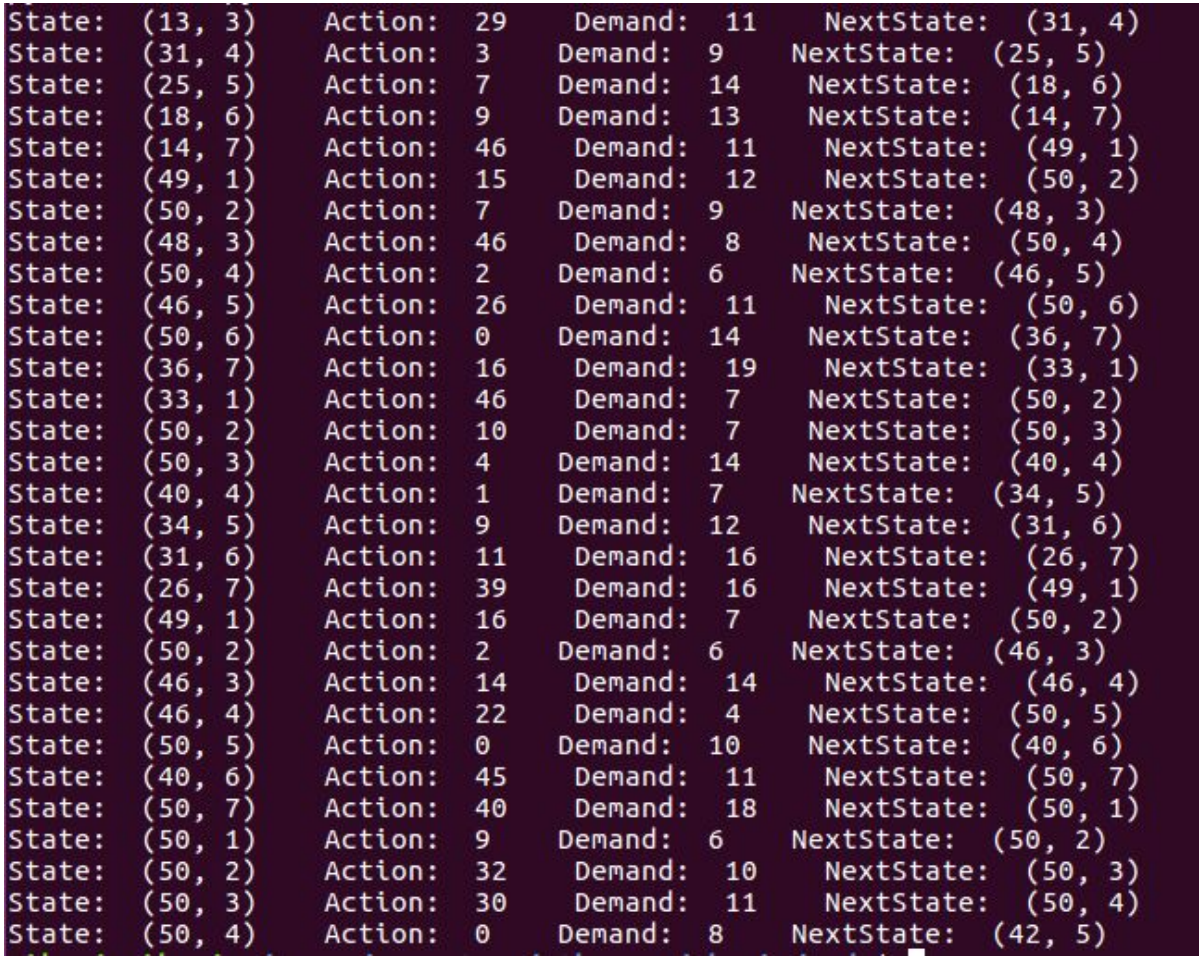
- Q-table
  - Matrix of all possible States vs Actions
- States
  - (0-50, 1-7)
- Actions
  - 0-50
- Basically, 18207 entries

$$Q(s,a) = r + \gamma \max_{a'} Q(s',a')$$

Action / State	0	1	2	3	..	..	..	49	50
(0,1)									
(0,2)									
(0,3)									
..					...				
(25,3)									
(25,4)									
..									
..									
(50,7)									

Results

- Demand is always met.
- Next State is generally having close to 50 Bags.
- Agent seems to have learnt to keep the warehouse fully packed.



Extending it with robots

TBD

Thank You