

Internship report

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1 Introduction

1.1 Institut de Recherche en Informatique de Toulouse (IRIT)

1.1.1 About the institut

The Institut de Recherche en Informatique de Toulouse (IRIT), created in 1990, is a Joint Research Unit (UMR 5505) of the Centre National de la Recherche Scientifique (CNRS), the Institut National Polytechnique de Toulouse (INP), the Université Paul Sabatier Toulouse3 (UT3), the Université Toulouse1 Capitole (UT1) and the Université de Toulouse Jean Jaurès (UT2J).

IRIT is one of the largest UMR at the national level, is one of the pillars of research in Occitanie with its 600 members, permanent and non-permanent, and about 100 external collaborators. Due to its multi-tutorial nature (CNRS, Toulouse Universities), its scientific impact and its interactions with other fields, the laboratory constitutes one of the structuring forces of the IT landscape and its applications in the digital world, both at regional and national level.

Through its cutting-edge work and dynamics, our unit has been able to define its identity and acquire undeniable visibility, while positioning itself at the heart of changes in local structures: University of Toulouse, as well as the various mechanisms resulting from future investments (LabEx CIMI, IRT Saint-Exupéry, SAT TTT, 3IA ANITI).

IRIT has focused its research on five major scientific issues and six strategic application areas.

- Health, Autonomy, Living, Well-being
- Smart City
- Aerospace and Transportation
- Social Media, Digital Social Ecosystems
- e-Education for learning and teaching
- Heritage and People Safety

As well as strategic action:

- Scientific Computing, Big Data and AI

1.1.2 Organization

The 24 research groups of the laboratory are dispatched in seven scientific departments:

- Dpt ASR : Architecture, Systems, Networks
- Dpt CISO : HPC, Simulation, Optimization
- Dpt FSL : Reliability of Systems and Software
- Dpt GD : Data Management
- Dpt ICI : Interaction, Collective Intelligence
- Dpt IA : Artificial Intelligence
- Dpt SI : Signals, Images

1.2 The internship

Markov decisions processes (MDPs) and their model free counterpart in reinforcement learning (RL) have known a large success in the last two decades. Although research in these two areas has been taking place for more than fifty years, the field gained momentum only recently following the advent of powerful hardware and algorithms with which suprahuman performance were obtained in games like Chess or Go.

However, these impressive successes often rely on quite exceptional hardware possibilities and cannot be applied in many "usual" contexts, where, for instance, the volume of data available or the amount of computing power is more restricted. To define the next generation of more "democratic" and widely applicable algorithms, such methods still need to deal with very demanding exploration issues as soon as the state/action spaces are not small. One way around this is to use underlying knowledge and structure present in many MDPs. This is especially true for problems related to scheduling and resources sharing in among others server farms, clouds, and cellular wireless networks. The internships will revolve around this theme of improving the efficiency of learning algorithms by leveraging the structure of the underlying problem and focus mainly on model-free approach.

2 Problem settings

Two type of systems are studied in this internship: queuing system and load-balancing system.

2.1 Queuing system

2.1.1 Describe

We have n classes of queue C_1, \dots, C_n . For each class of queue, its behavior is fully controlled by which environment it is in. An environment can be in one of the states m_1, \dots, m_m . And the environment of class C_i is a random variable, denoted by M_i , which is in one of the states m_1, \dots, m_m . For each environment, C_i has their own holding cost $c_{i,j}$ (the cost of one unfinished unit of work on the queue), arrival rate $\lambda_{i,j}$ (the rate of one more unit of work arriving to the queue) and departure rate $\mu_{i,j}$ (the rate of one unit of work on the queue has finished). Furthermore, the environment M_i can change from m_j and m_k with the rate of $\xi_{i,j,k}$. A table summarizing all parameters is shown below.

Table 1: Queuing system parameters

		m_1	...	m_m
C_1	Holding cost	$c_{1,1}$	...	$c_{1,m}$
	Arrival rate	$\lambda_{1,1}$	...	$\lambda_{1,m}$
	Departure rate	$\mu_{1,1}$	...	$\mu_{1,m}$
\vdots				
C_n	Holding cost	$c_{n,1}$	...	$c_{n,m}$
	Arrival rate	$\lambda_{n,1}$	...	$\lambda_{n,m}$
	Departure rate	$\mu_{n,1}$	...	$\mu_{n,m}$

For each C_i , we have a matrix transition as below.

Table 2: Matrix transition of the environment of C_i

	m_1	...	m_m
m_1	$\xi_{i,1,1}$	...	$\xi_{i,1,m}$
m_m	$\xi_{i,m,1}$	...	$\xi_{i,m,m}$

The agent will decide which queues should be activated. Only works on activating queues can be processed and finished. In more generic problems, the agent is allowed to activate / deactivate multiple queues at the same time based on some conditions. However, in this internship, the agent can only activate one queue at a time.

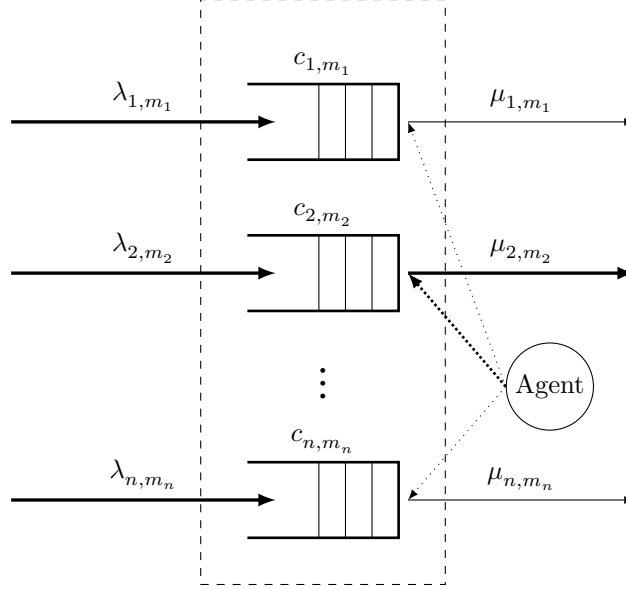


Figure 1: Visualization of the queueing system when the agent activates queue 2, the bold lines represent the flow of works inside the system.

The state of the system is represented by two vectors:

- $S = (X_1, \dots, X_n)$ where X_i is a random variable represents the current number of works of class C_i and is observable.
- $E = (M_1, \dots, M_n)$ and this vector is not observable.