Formal Approaches to Decision-Making under Uncertainty

Lecture 2-3: Modest Tools for MDPs

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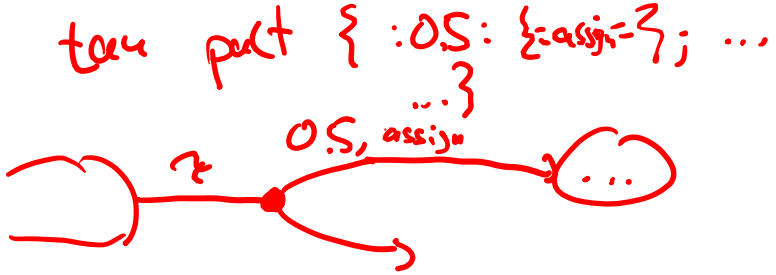
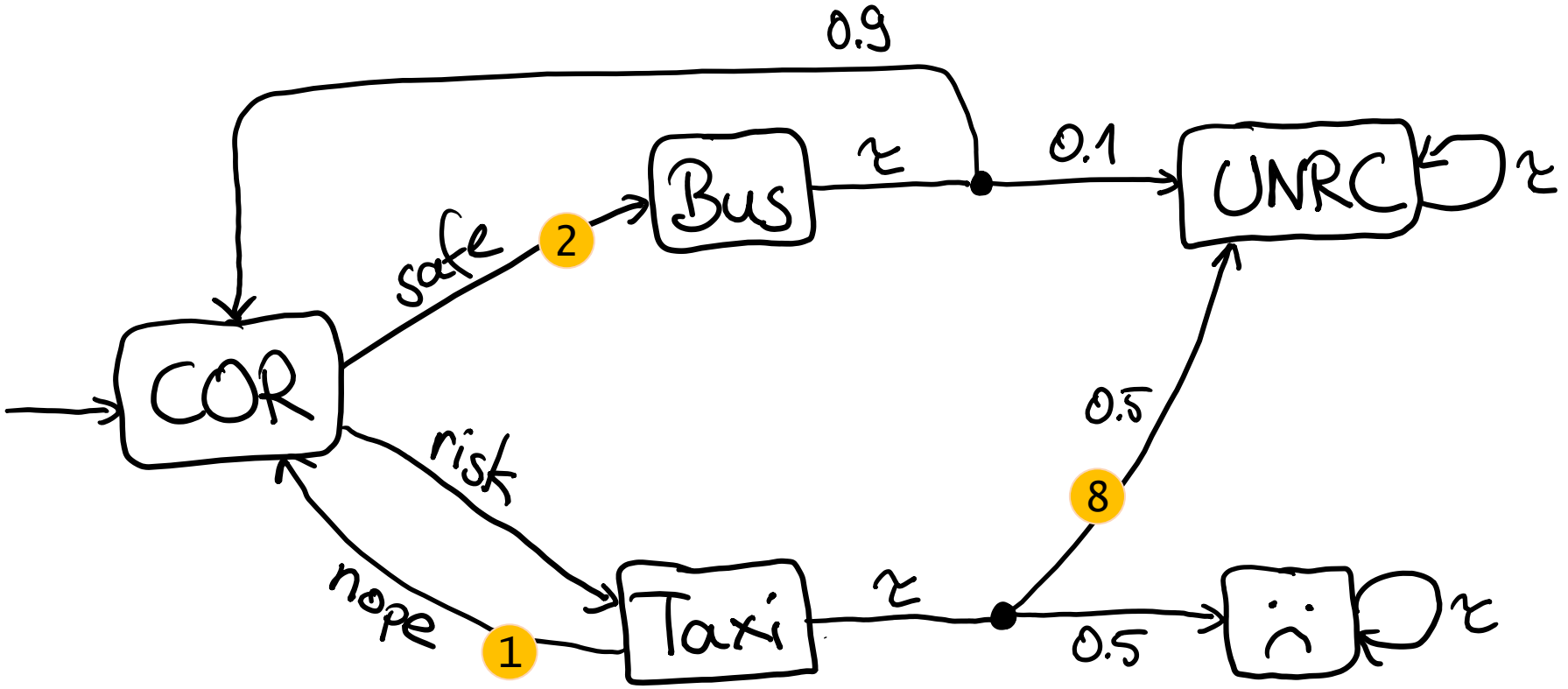
Markov Decision Processes

A Markov decision process **MDP**
from Córdoba airport to Rio Cuarto:





Lots of MDP Models

Quantitative verification benchmark set at `qcomp.org/benchmarks`:

collection of case studies and benchmark models with probabilities

Models

Model	Name	Type	Original	Params	States	Properties	Notes
beb	Bounded Exponential...	MDP	Modest	3 (2/1)	4.53 k - 362 T	2 (2 × P)	(made for parti...
bitcoin-...	Andresen Attack on ...	MA	Modest	2 (0/2)	252	2 (1 × Pb, 1 × E)	(optimal strate...
blocksw...	Blocksworld	MDP	PPDDL	1 (1/0)	1.13 k	1 (1 × P)	(IPPC 2008 ben...
bluetoo...	Bluetooth Device Dis...	DTMC	PRISM	1 (0/1)	3.41 G - 55.3 G	1 (1 × E)	(PRISM benchm...
boxworld	Boxworld	MDP	PPDDL	2 (2/0)		1 (1 × P)	(IPPC 2008 ben...
breakd...	Queueing System wit...	MA	Modest	1 (0/1)	20.6 k - 242 k	2 (2 × P)	(nondeterminis...
brp	Bounded Retransmis...	DTMC	PRISM	2 (0/2)	677 - 5.19 k	3 (3 × P)	(PRISM benchm...
brp-pta	Bounded Retransmis...	PTA	Modest	4 (0/4)	3.96 k - 56.8 M	14 (10 × P, 2 × Pb, 2...	(scalable in mul...
cabinets	Railway cabinets	MA	Galileo	3 (3/0)	28.3 k	2 (1 × Pb, 1 × S)	(rare event, sm...
cdrive	City Driving	MDP	PPDDL	1 (1/0)	38 - 2.19 k	1 (1 × P)	(IPPC 2006 ben...
cluster	Workstation Cluster	CTMC	PRISM	3 (0/3)	276 - 9.47 M	8 (4 × Pb, 2 × Eb, ...	(PRISM benchm...
consen...	Randomized Consens...	MDP	PRISM	2 (1/1)	272 - 2.76 G	5 (3 × P, 2 × E)	(PRISM benchm...
coupon	Coupon Collectors	DTMC	PGCL	3 (2/1)	5.40 k - 17.5 G	3 (1 × P, 1 × Pb, 1 ×...	(classic probabi...
crowds	Crowds Protocol	DTMC	PRISM	2 (0/2)	1.15 k - 10.6 M	1 (1 × P)	(PRISM benchm...
csma	IEEE 802.3 CSMA/CD ...	MDP	PRISM	2 (2/0)	1.04 k - 39.1 G	5 (3 × P, 2 × E)	(PRISM benchm...
csma-pta	IEEE 802.3 CSMA/CD ...	PTA	PRISM	2 (0/2)		1 (1 × P)	(PRISM benchm...
csma_a...	IEEE 802.3 CSMA/CD ...	PTA	PRISM	2 (0/2)		3 (1 × P, 2 × Pb)	(PRISM benchm...
dpm	Dynamic Power Man...	MA	Modest	3 (0/3)	34.6 k - 5.67 G	7 (4 × P, 1 × Pb, 1 ...	(scalable nonde...
eajs	Energy-aware job sc...	MDP	PRISM	3 (1/2)	12.8 k - 7.90 M	2 (1 × Pb, 1 × E)	(reward-bound...
echoring	EchoRing	MDP	Modest	1 (0/1)	110 k - 4.74 M	7 (7 × P)	(industrial prot...
egl	Probabilistic Contrac...	DTMC	PRISM	2 (0/2)	33.8 k - 663 T	4 (2 × P, 2 × E)	(PRISM benchm...
elevators	Elevators	MDP	PPDDL	3 (3/0)	909 - 539 k	1 (1 × P)	(IPPC 2006 ben...
embed...	Embedded Control S...	CTMC	PRISM	2 (0/2)	3.48 k - 8.55 k	14 (4 × P, 5 × Pb, 2 ...	(PRISM benchm...

Exercise I

Game of 4 dice with different sides:

A: 0 0 4 4 4 4
B: 1 1 1 5 5 5
C: 2 2 2 2 6 6
D: 3 3 3 3 3 3

Rules:
1. Player 1 chooses a die,
2. player 2 chooses one of the remaining dice,
3. both players roll their dice,
4. the player with the higher number wins.

Q: What is the probability of winning?
What is the best strategy for each player?

how much of this can you answer with MDPs?

Exercise II

Let's play… "Obstgarten"

6-sided die: blue, green, yellow, red, basket, crow

4 baskets – blue, green, yellow, red – with 0 to 4 fruits (initially 4)

Crow at position 0..4, initially 0

Exercise II

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4 baskets – blue, green, yellow, red – with 0 to 4 fruits (initially 4)

Crow at position 0..4, initially 0

Turn-based 1.5-player game:

In each turn, you roll the die. Possible outcomes:

→ colour c: eat 1 fruit from the c-coloured basket (nop if empty)

→ basket: *choose* one basket to eat a fruit from (nop if all empty)

→ crow: move crow one position forward

All fruits eaten = you win. | Crow at position 4 = crow wins.

Exercise II

Let's play… "Obstgarten"

What the kids want to know:

1. What is the maximum probability that I win?
2. How should I play to maximise my chance of winning?
3. What is the minimum/maximum number of turns until the game ends? (What if I play randomly?)
4. How do I maximise my play time?
   Is this good for winning?
5. Dinner is almost ready – I can only play n more turns.
   What is the minimum probability that I finish the game?
   How do I maximise the probability to finish in time?

Homework

First step to pass this course:

Finish the 4-dice and Obstgarten game modelling,
answer the queries with mcsta,
summarise your results in a short text file,
and send everything to Arnd by email:

- file `four-dice.modest`,
- file `obstgarten.modest`,
- file `models-readme.txt`

Try to get as far as you can.

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