Digital World (2018)

Week 9, S1: State Machines

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WHAT WAS IT?

"lunch today was exquisite!"

it

"the weather was atrocious"

it

"I just watched Stephen King's IT"

it

State machines

- state machines model systems for which the output depends on their history of inputs

- idea: find a set of states that capture the essential properties of the history of inputs

  => *use them to determine the current output…*

  => *…as well as the next state*

- state machines perform a transduction from a stream of inputs to a stream of outputs

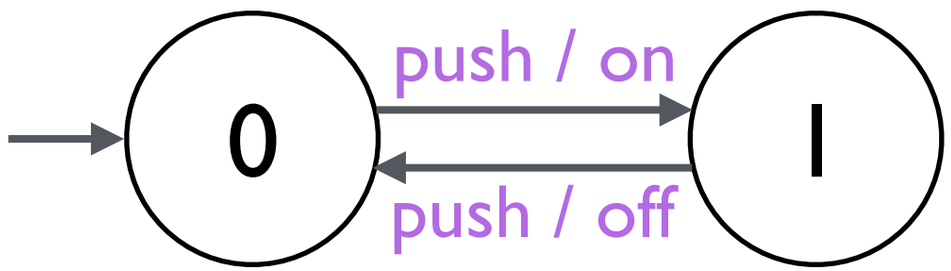
Abusing your torchlight

push push push push push push push push

transduce

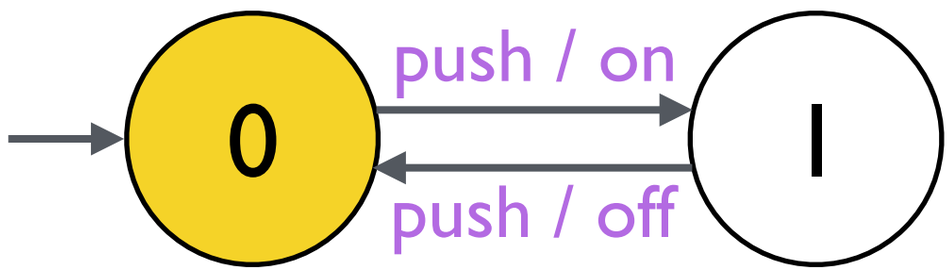
on off on off on off on

Abusing your torchlight



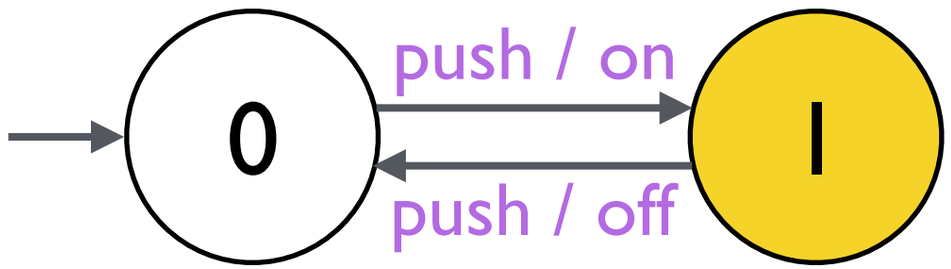
input:	*push*	*push*	*push*	*push*	*push*	*push*	*push*
output:							

Abusing your torchlight



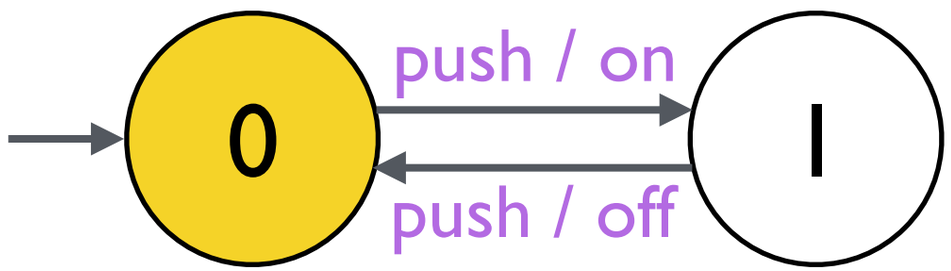
input:	*push*	*push*	*push*	*push*	*push*	*push*	*push*
output:							

Abusing your torchlight



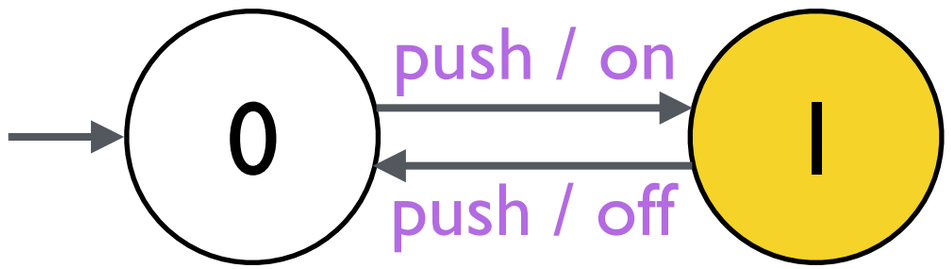
input:	*push*	*push*	*push*	*push*	*push*	*push*	*push*
output:	*on*						

Abusing your torchlight



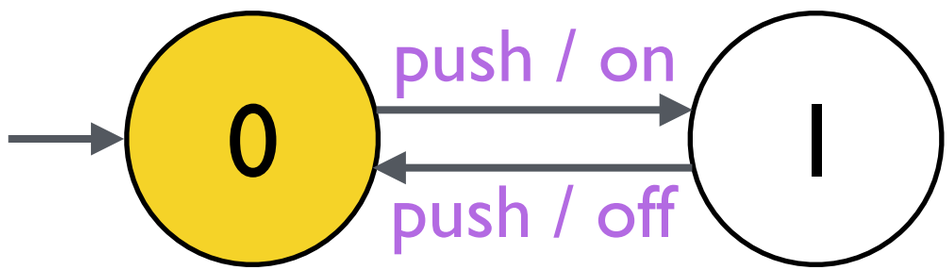
input:	*push*	*push*	*push*	*push*	*push*	*push*	*push*
output:	*on*	*off*					

Abusing your torchlight



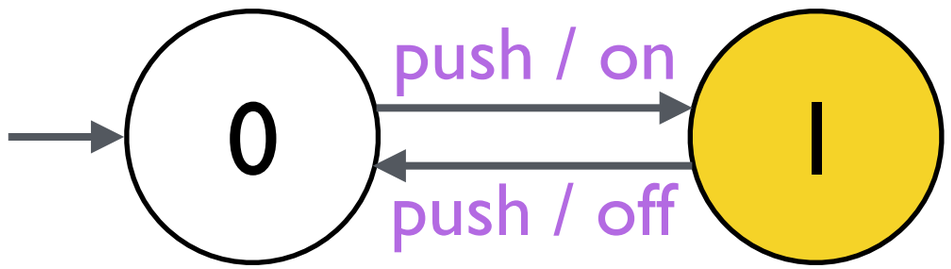
input:	*push*	*push*	*push*	*push*	*push*	*push*	*push*
output:	*on*	*off*	*on*				

Abusing your torchlight



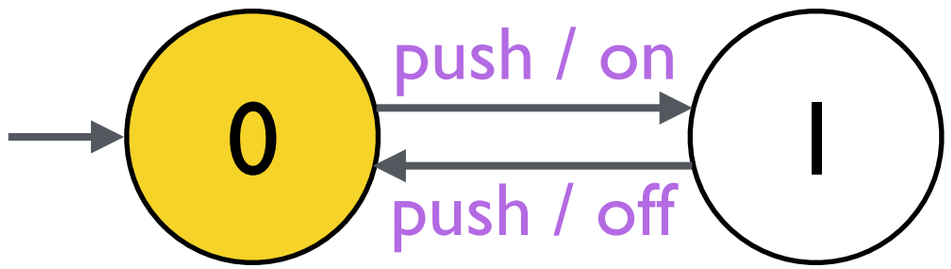
input:	*push*	*push*	*push*	*push*	*push*	*push*	*push*
output:	*on*	*off*	*on*	*off*			

Abusing your torchlight



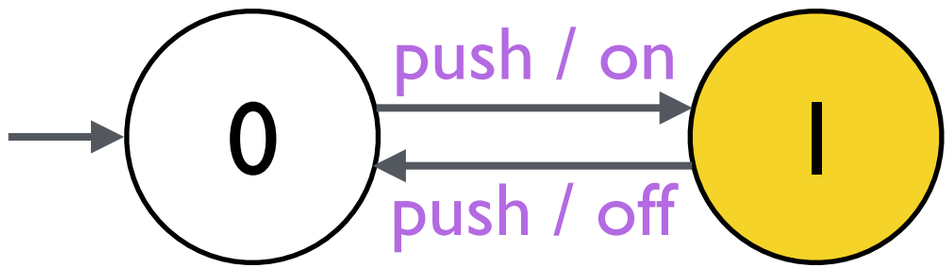
input:	*push*	*push*	*push*	*push*	*push*	*push*	*push*
output:	*on*	*off*	*on*	*off*	*on*		

Abusing your torchlight



input:	*push*	*push*	*push*	*push*	*push*	*push*	*push*
output:	*on*	*off*	*on*	*off*	*on*	*off*	

Abusing your torchlight



input:	*push*	*push*	*push*	*push*	*push*	*push*	*push*
output:	*on*	*off*	*on*	*off*	*on*	*off*	*on*

Language recogniser: *abcabcabcabc…*

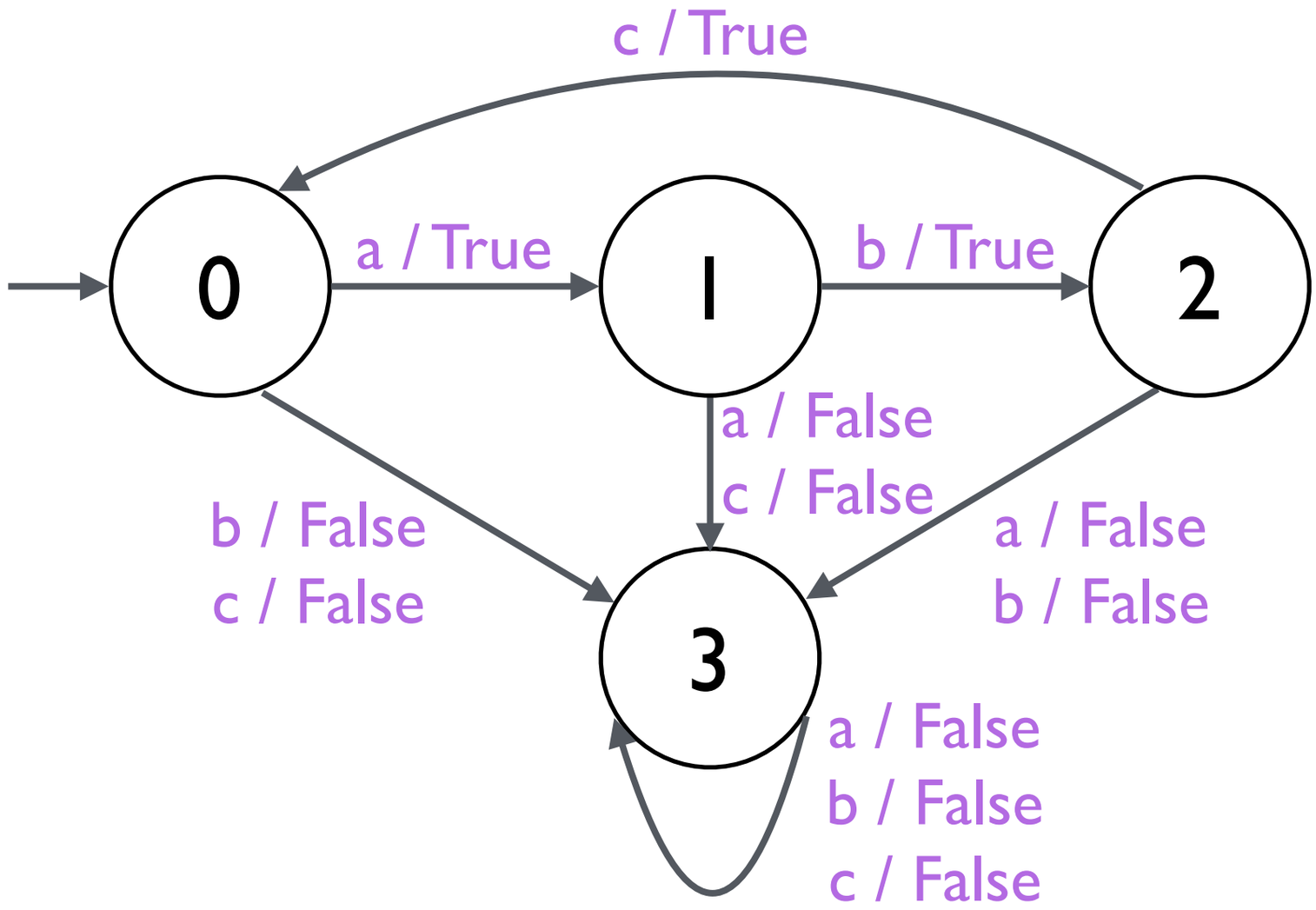
- abcabcabcabc ✓
- aabcabcabcabc X
- abcabcaaaaaaa X
- abccccccccc X

a b c c c

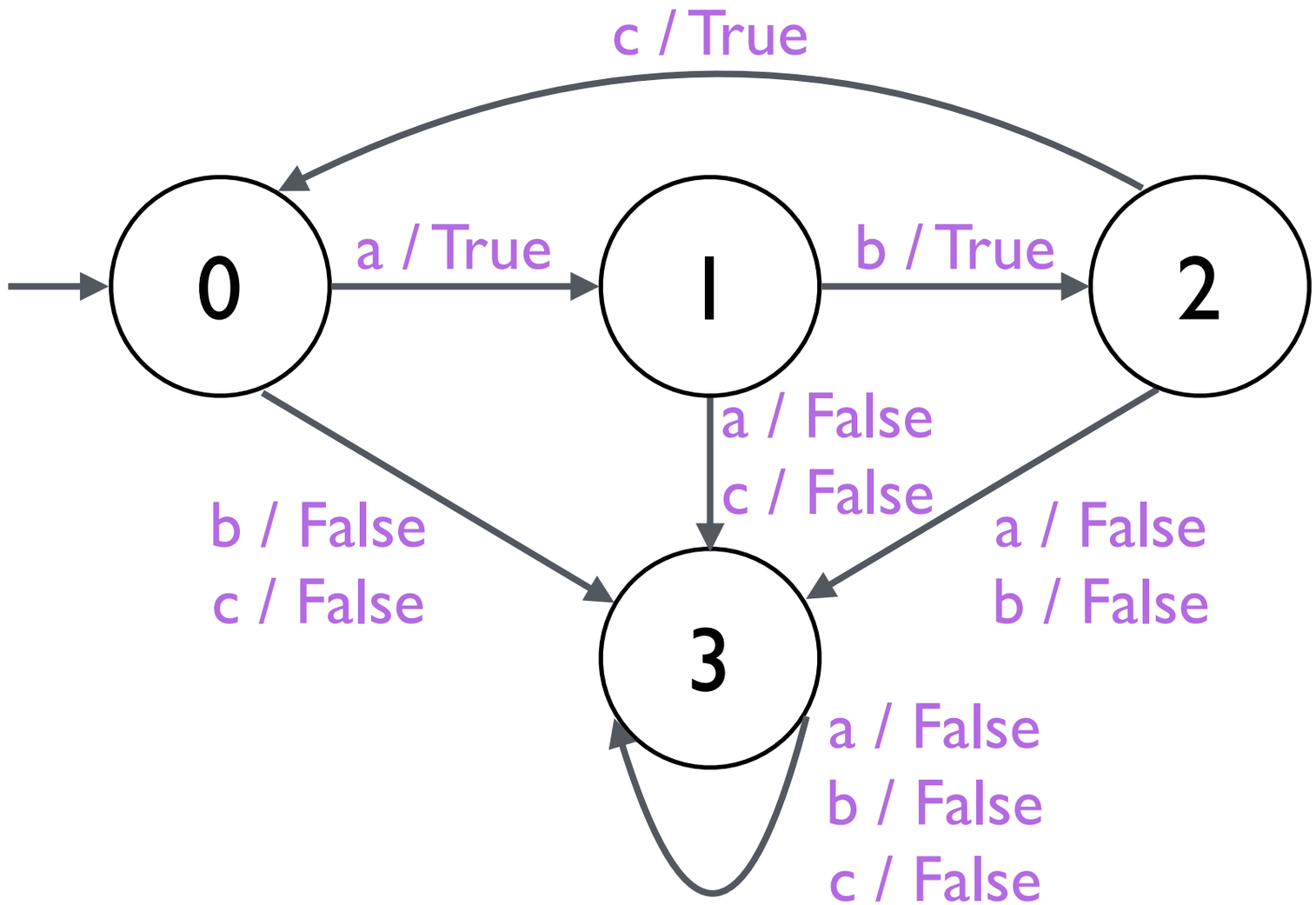
transduce

True True True False False

Language recogniser: *abcabcabcabc…*

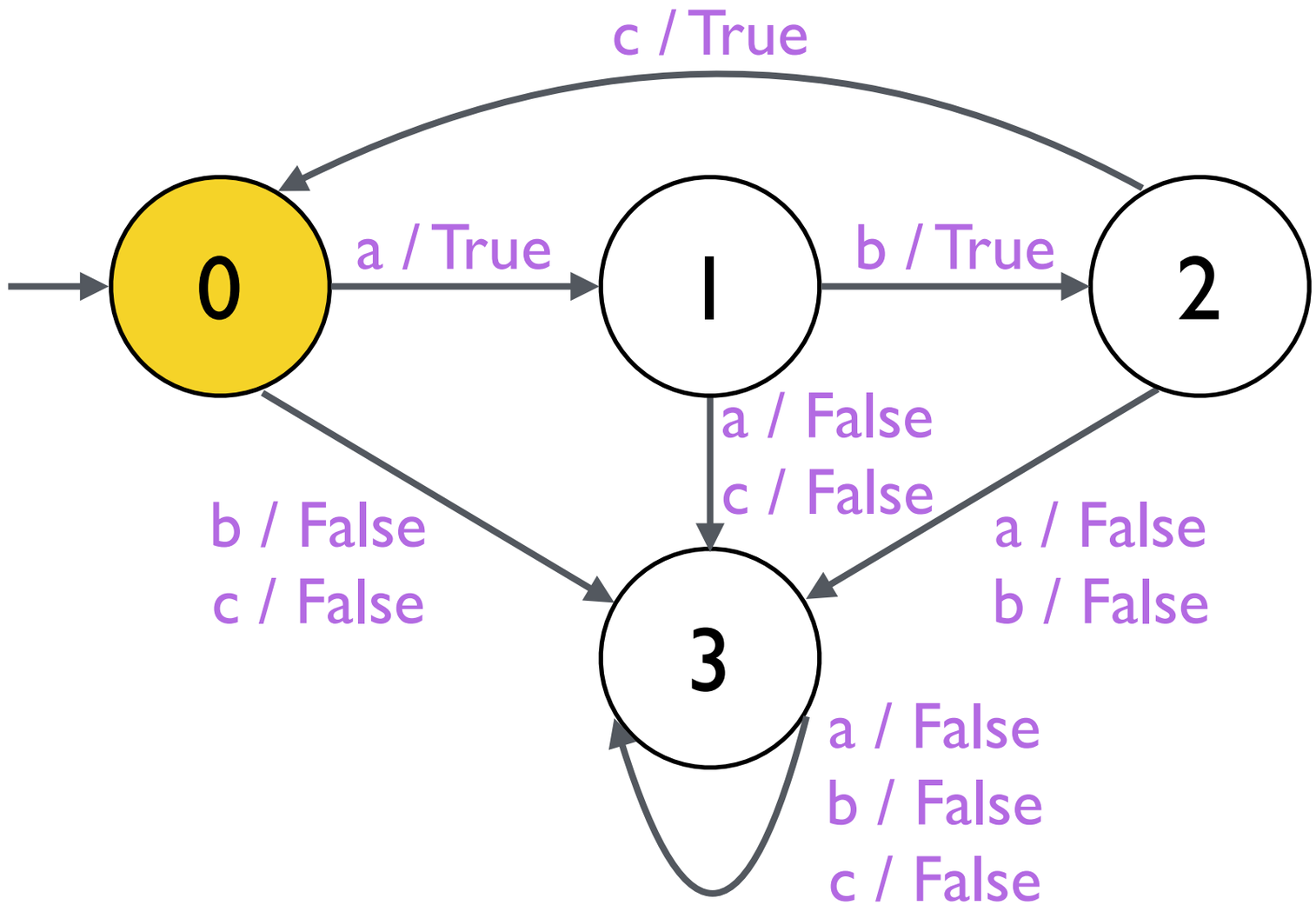


Language recogniser: *abcabcabcabc…*



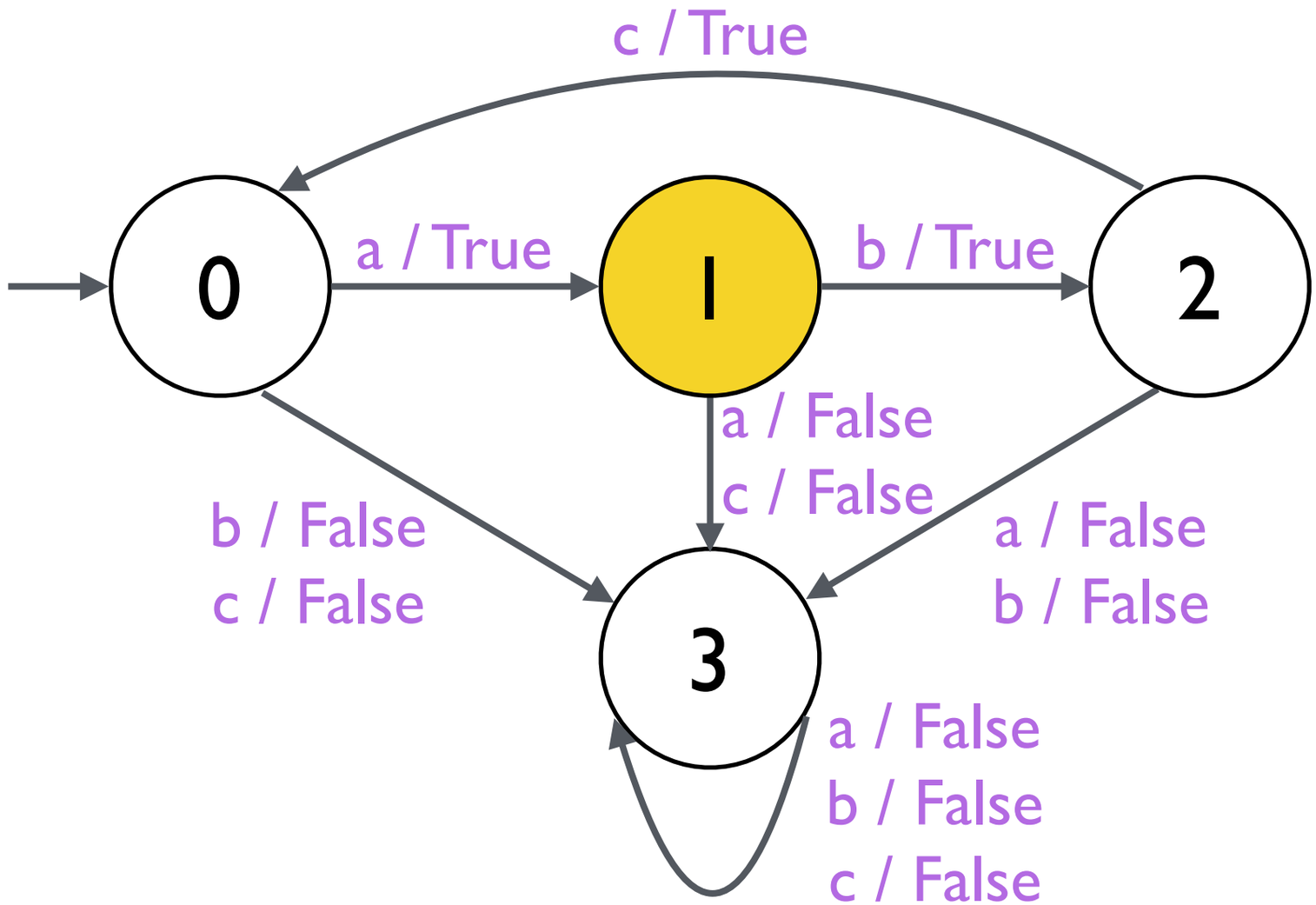
input:	*a*	*b*	*c*	*c*	*c*
output:					

Language recogniser: *abcabcabcabc…*



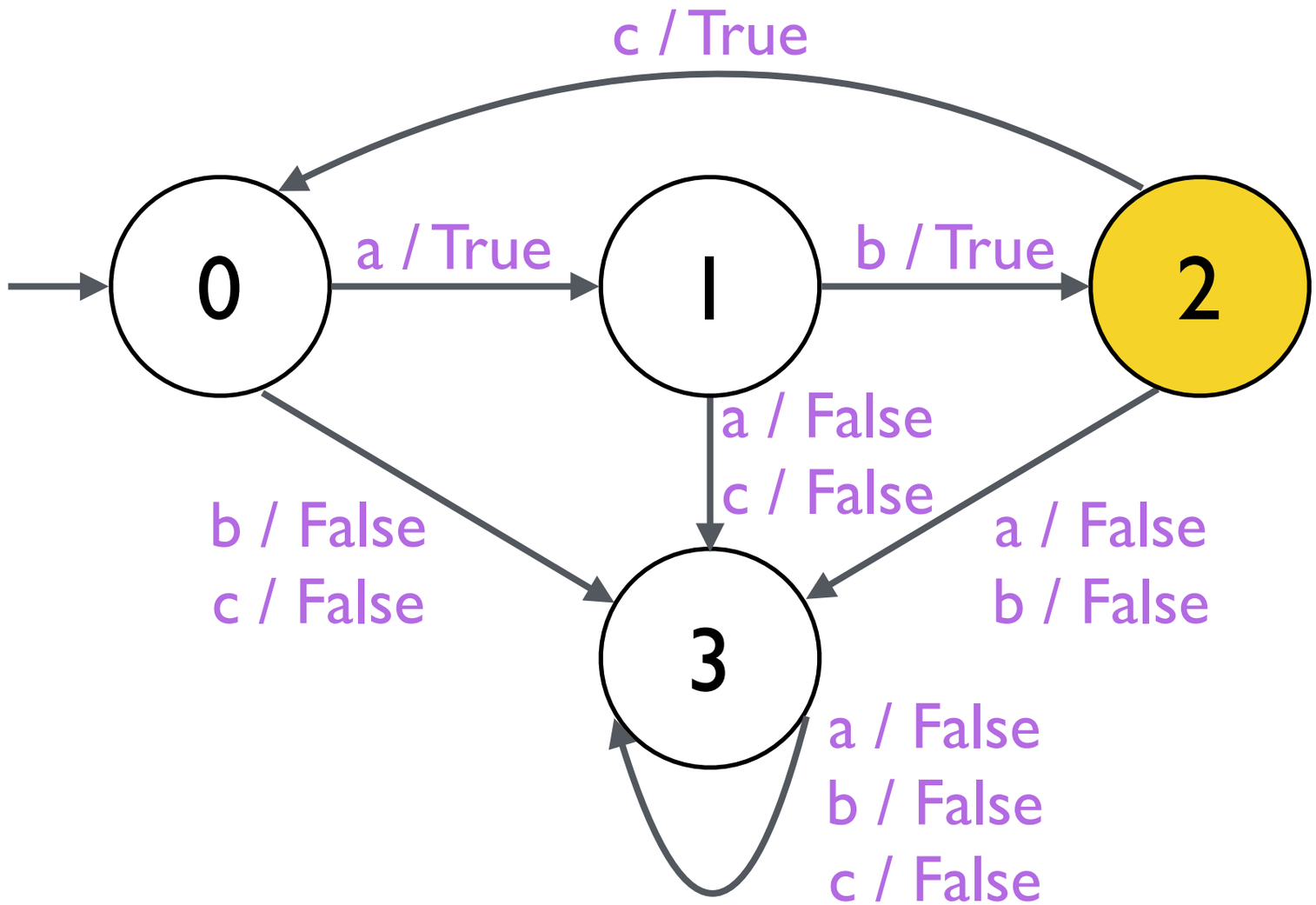
input:	*a*	*b*	*c*	*c*	*c*
output:					

Language recogniser: *abcabcabcabc…*



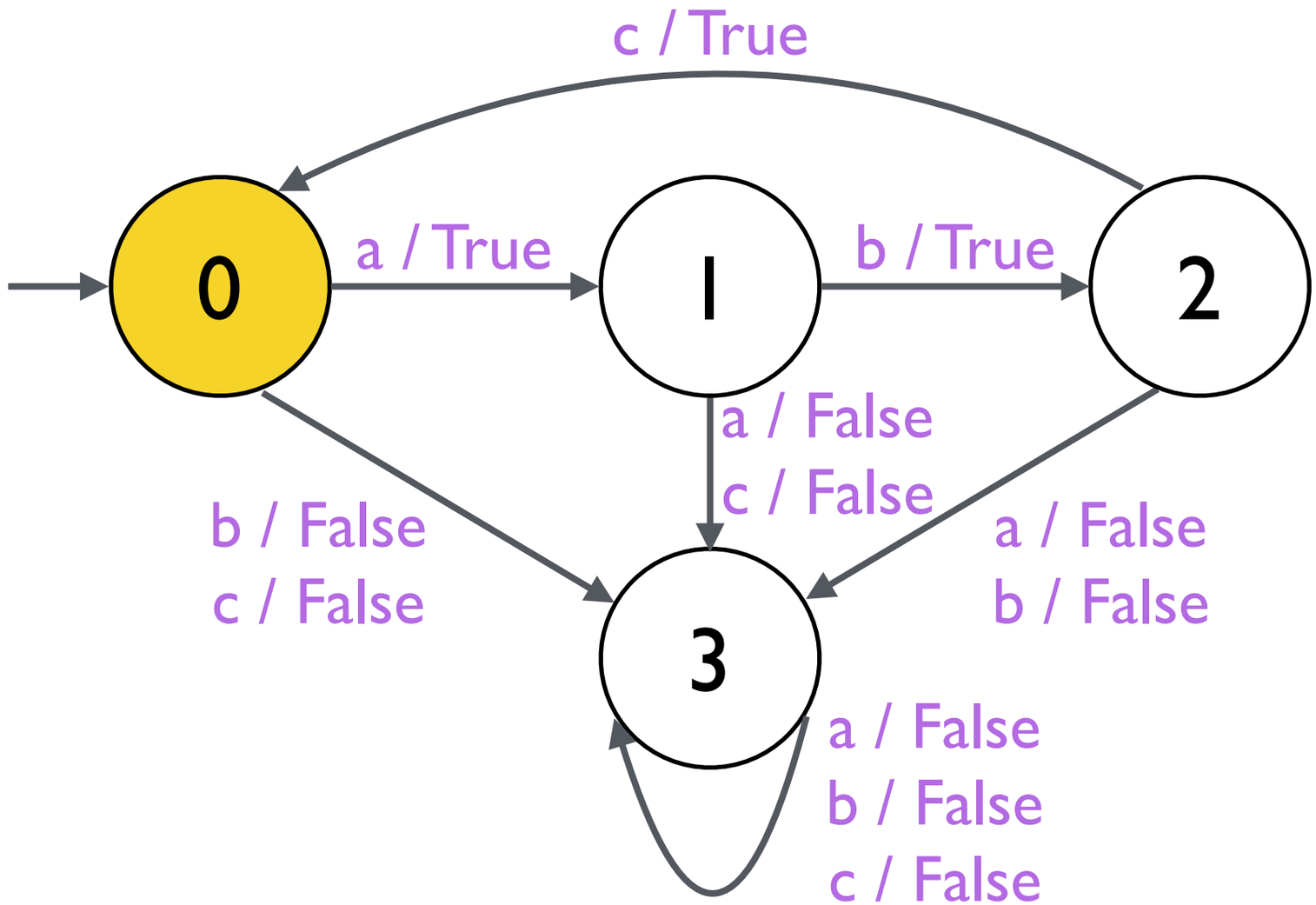
input:	*a*	*b*	*c*	*c*	*c*
output:	*True*				

Language recogniser: *abcabcabcabc…*



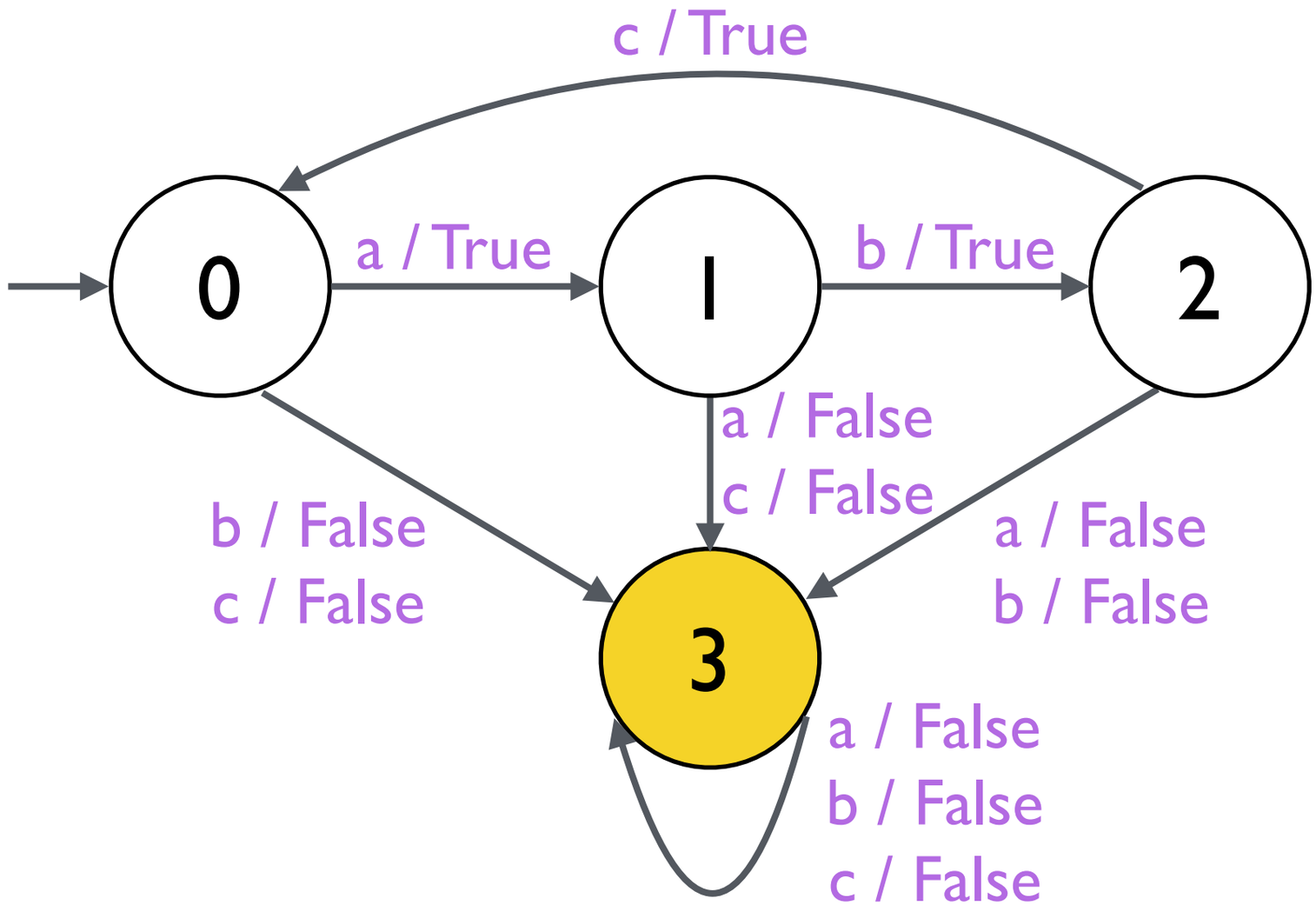
input:	*a*	*b*	*c*	*c*	*c*
output:	*True*	*True*			

Language recogniser: *abcabcabcabc…*



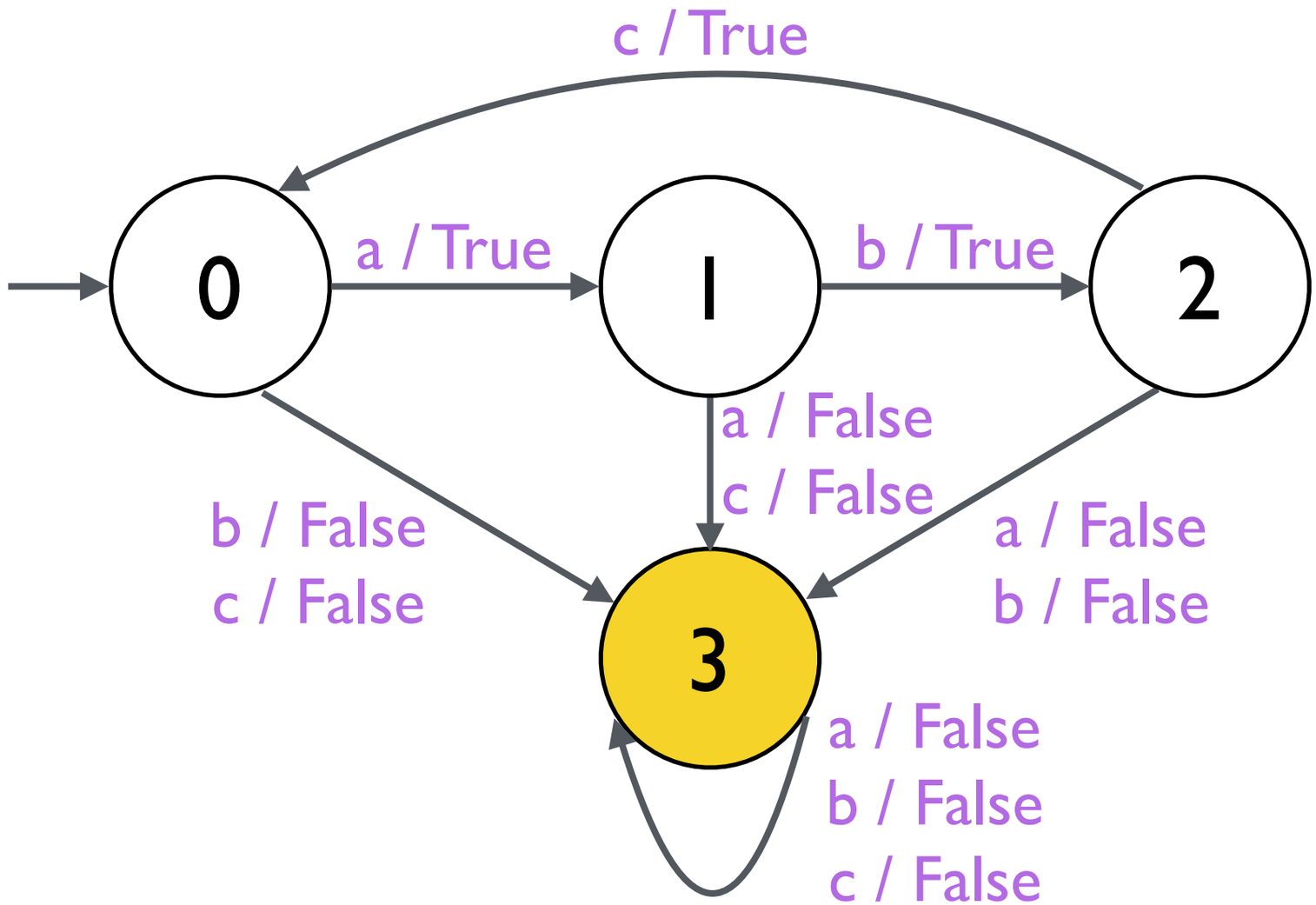
input:	*a*	*b*	*c*	*c*	*c*
output:	*True*	*True*	*True*		

Language recogniser: *abcabcabcabc…*



input:	*a*	*b*	*c*	*c*	*c*
output:	*True*	*True*	*True*	*False*	

Language recogniser: *abcabcabcabc…*



input:	*a*	*b*	*c*	*c*	*c*
output:	*True*	*True*	*True*	*False*	*False*

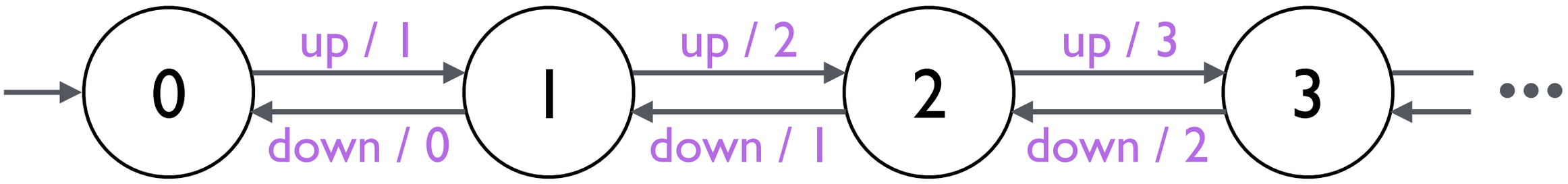
Infinite state machine: *up and down*

up down up up down

transduce

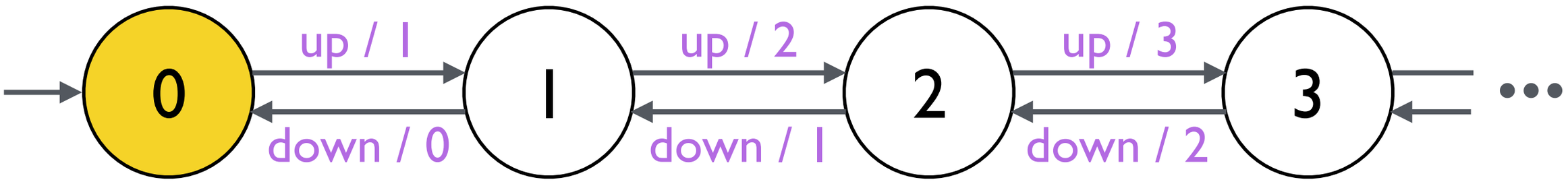
1 0 1 2 1

Infinite state machine: *up and down*



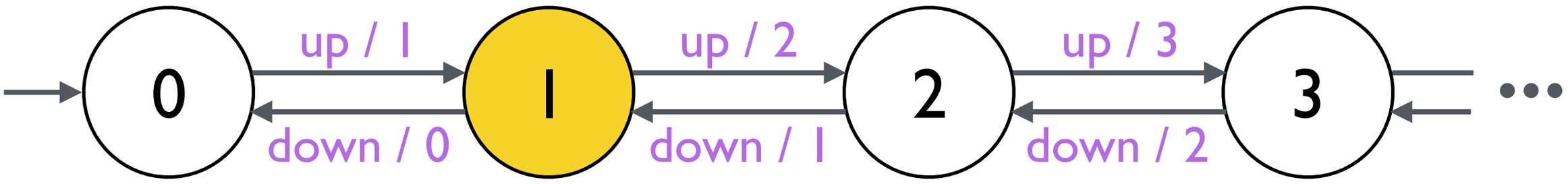
input:	*up*	*up*	*up*	*down*	*down*	*up*
output:						

Infinite state machine: *up and down*



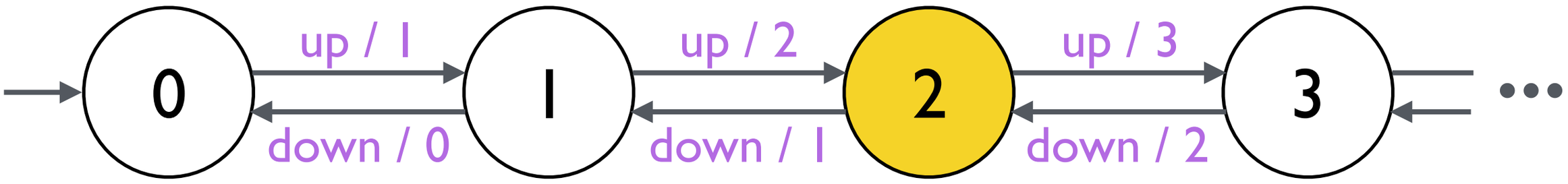
input:	*up*	*up*	*up*	*down*	*down*	*up*
output:						

Infinite state machine: *up and down*



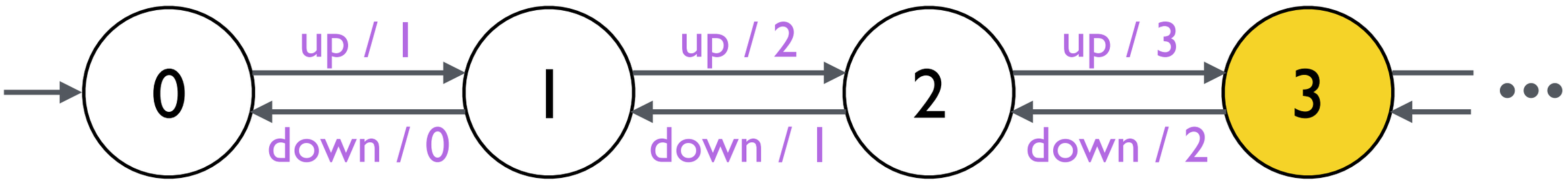
input:	*up*	*up*	*up*	*down*	*down*	*up*
output:	*1*					

Infinite state machine: *up and down*



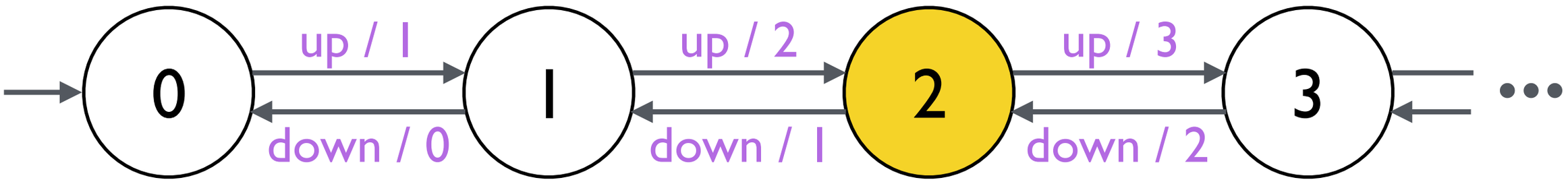
input:	*up*	*up*	*up*	*down*	*down*	*up*
output:	*1*	*2*				

Infinite state machine: *up and down*



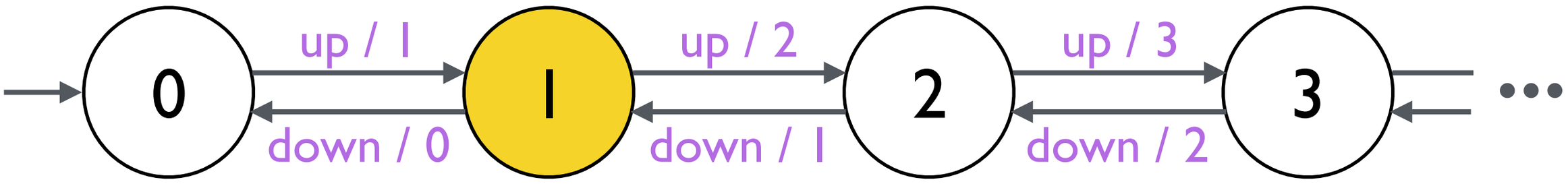
input:	*up*	*up*	*up*	*down*	*down*	*up*
output:	*1*	*2*	*3*			

Infinite state machine: *up and down*



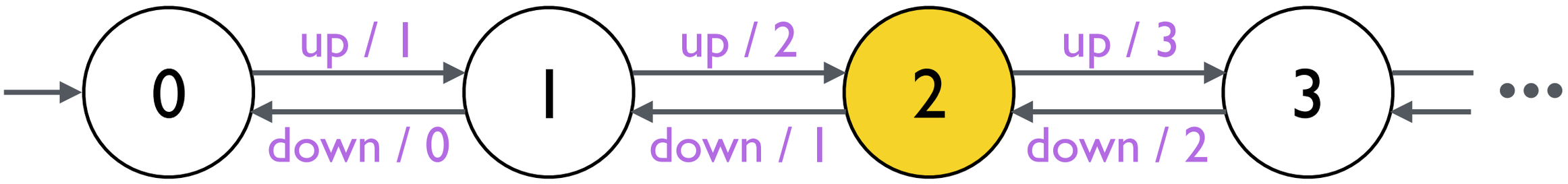
input:	*up*	*up*	*up*	*down*	*down*	*up*
output:	*1*	*2*	*3*	*2*		

Infinite state machine: *up and down*



input:	*up*	*up*	*up*	*down*	*down*	*up*
output:	*1*	*2*	*3*	*2*	*1*	

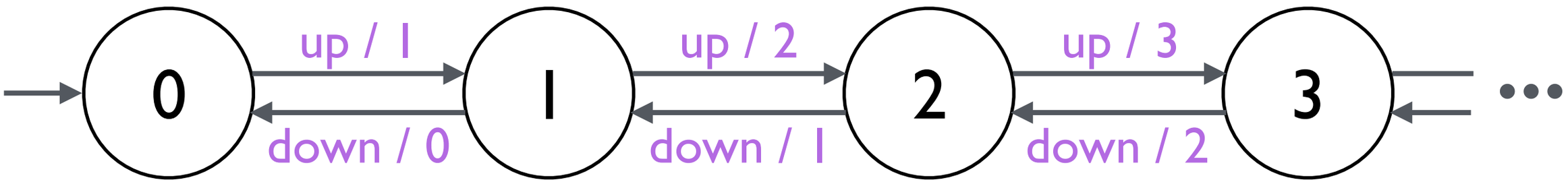
Infinite state machine: *up and down*



input:	*up*	*up*	*up*	*down*	*down*	*up*
output:	*1*	*2*	*3*	*2*	*1*	*2*

the outputs come from the transitions,
<u>not</u> the state IDs (even though they match in our model)

Infinite state machine: *up and down*



$$
\begin{aligned}
S &= \mathbb{N}_0 \\
I &= \{up, down\} \\
O &= \mathbb{N}_0 \\
n(s, i) &= \begin{cases} s+1 & \text{if } i == up \\ s-1 & \text{if } i == down \text{ and } s > 0 \end{cases} \\
o(s,i) &= n(s, i) \\
s0 &= 0
\end{aligned}
$$

State machines in Python

- we will implement state machines using the libdw library

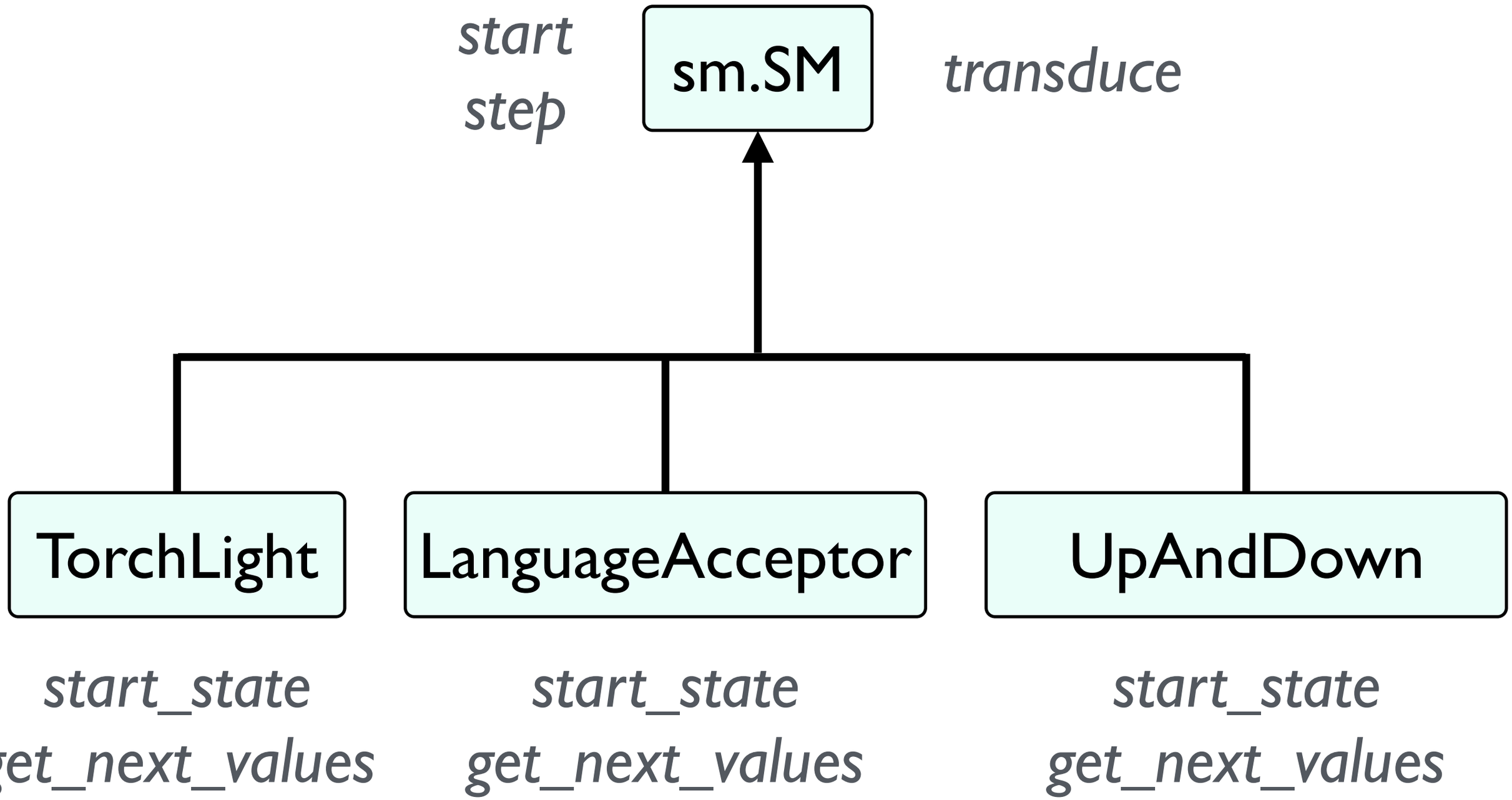
- libdw provides a class called sm.SM that we inherit from

  => *inherit several useful methods: s.start(), s.step(i), s.transduce(list)*

- we then define the start state via attribute start_state, and the transitions via query get_next_values(self, state, inp)

  => *these are used by the inherited methods (start, step, transduce, …)*
  to realise the state machine

Inheritance hierarchy for state machines



Summary

- state machines model systems for which the output depends on their history of inputs

- they perform a transduction from input streams to output streams

- we can express state machines in Python as classes that inherit from sm.SM (in the libdw library)

- we define transitions in those subclasses, inheriting general methods that fire/transduce them from sm.SM