

## Counterexample Handling

$f$  produces a 1 if number of  $a$ 's and  $b$ 's are both even, otherwise 0.

Two  $a$ -transition to states which differ on suffix  $a$ : add suffix  $aa$

	a	b	aa	"colour"
$\rightarrow \epsilon$	0	0		
$\rightarrow a$	1	0		a/0
$\rightarrow b$	0	1		
$\rightarrow ab$	0	0		
$\rightarrow aba$	0	1		a/0
$aa$	0	0		
$ba$	0	0		
$bb$	0	0		

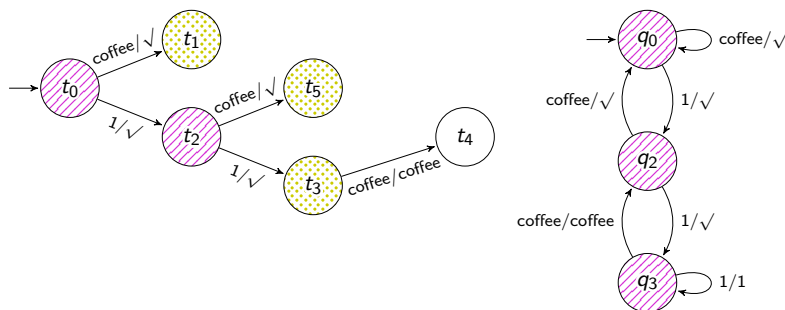
## Angluin's L\* Algorithm

- 1 Maintain a set  $\mathcal{U}$  of (marked) prefixes, initially  $\mathcal{U} = \{\epsilon\}$
- 2 Maintain a set  $\mathcal{V}$  of suffixes, initially  $\mathcal{V} = I$
- 3 Maintain an observation table with rows  $\mathcal{U} \cup \mathcal{U}I$  and columns  $\mathcal{V}$
- 4 Fill the table using output queries
- 5 Table is **closed** when every row from  $\mathcal{U}I$  is also a row from  $\mathcal{U}$ ; if table is not closed extend  $\mathcal{U}$  and go to step 4
- 6 Table is **consistent** if whenever rows  $u, v \in \mathcal{U}$  are the same, rows  $ui$  and  $vi$  are also the same, for all  $i \in I$ ; if table is not consistent extend  $\mathcal{V}$  and go to step 4
- 7 When table is both **closed** and **consistent** construct hypothesis and perform equivalence query
- 8 If reply is "no" add all prefixes of counterexample to  $\mathcal{U}$  and go to step 4

## Learning with L<sup>#</sup>

### Promotion Rule:

Move frontier state to basis if it is apart from all basis states.

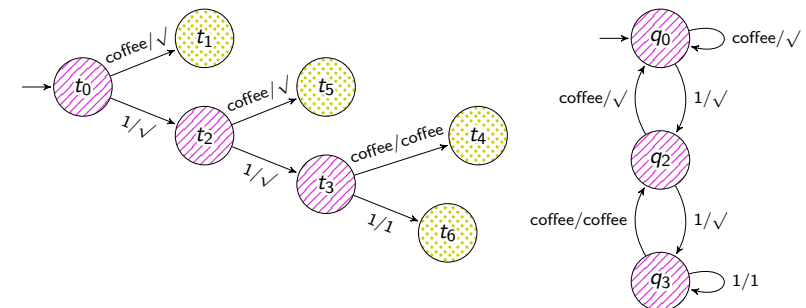


Witness: **coffee**

## Learning with L<sup>#</sup>

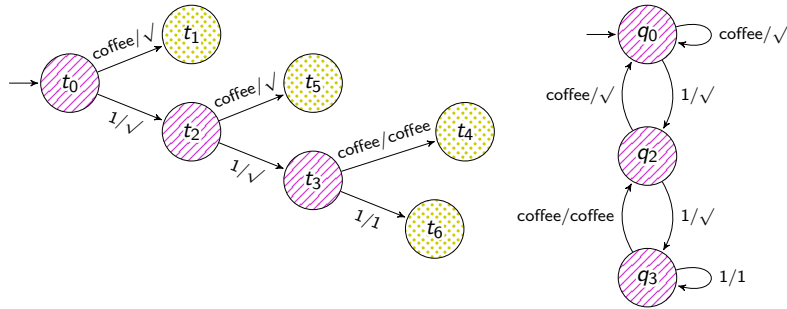
### Extension Rule:

Ensure each basis state has outgoing transition for each input.



## Learning with $L^\#$

**Identification Rule:** Identify frontier states.



Navigation icons: back, forward, search, etc.

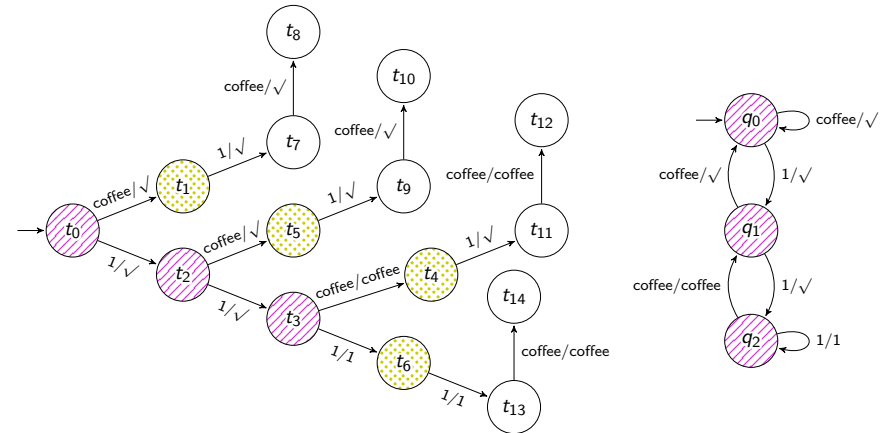
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## Learning with $L^\#$

**Equivalence Rule:**

Build hypothesis, ask equivalence query, process counterexample.

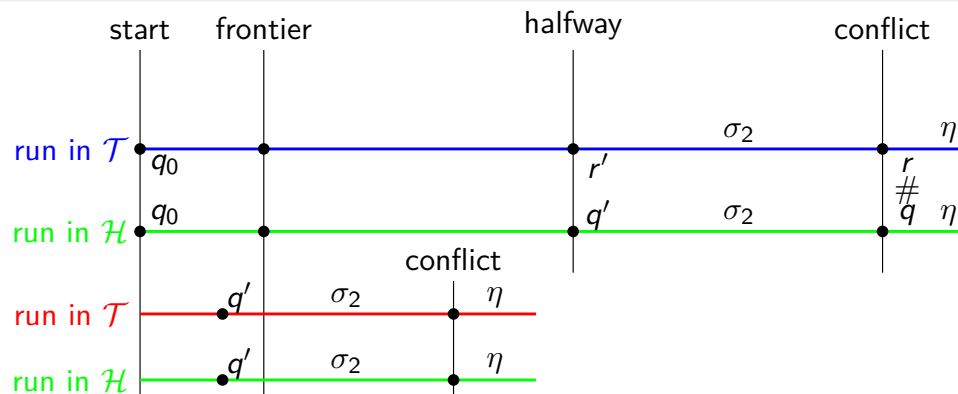


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## Counterexample Processing



Key idea: perform output query  $\text{access}(q')\sigma_2\eta$

If outputs for  $\sigma_2\eta$  from  $r'$  and  $q'$  are different in  $\mathcal{T}$  then  $r' \# q'$

Else  $\text{access}(q')\sigma_2$  leads to a conflict!

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