Reconfigurable Broadcast Networks and Asynchronous Shared-Memory Systems are Equivalent

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Two Models

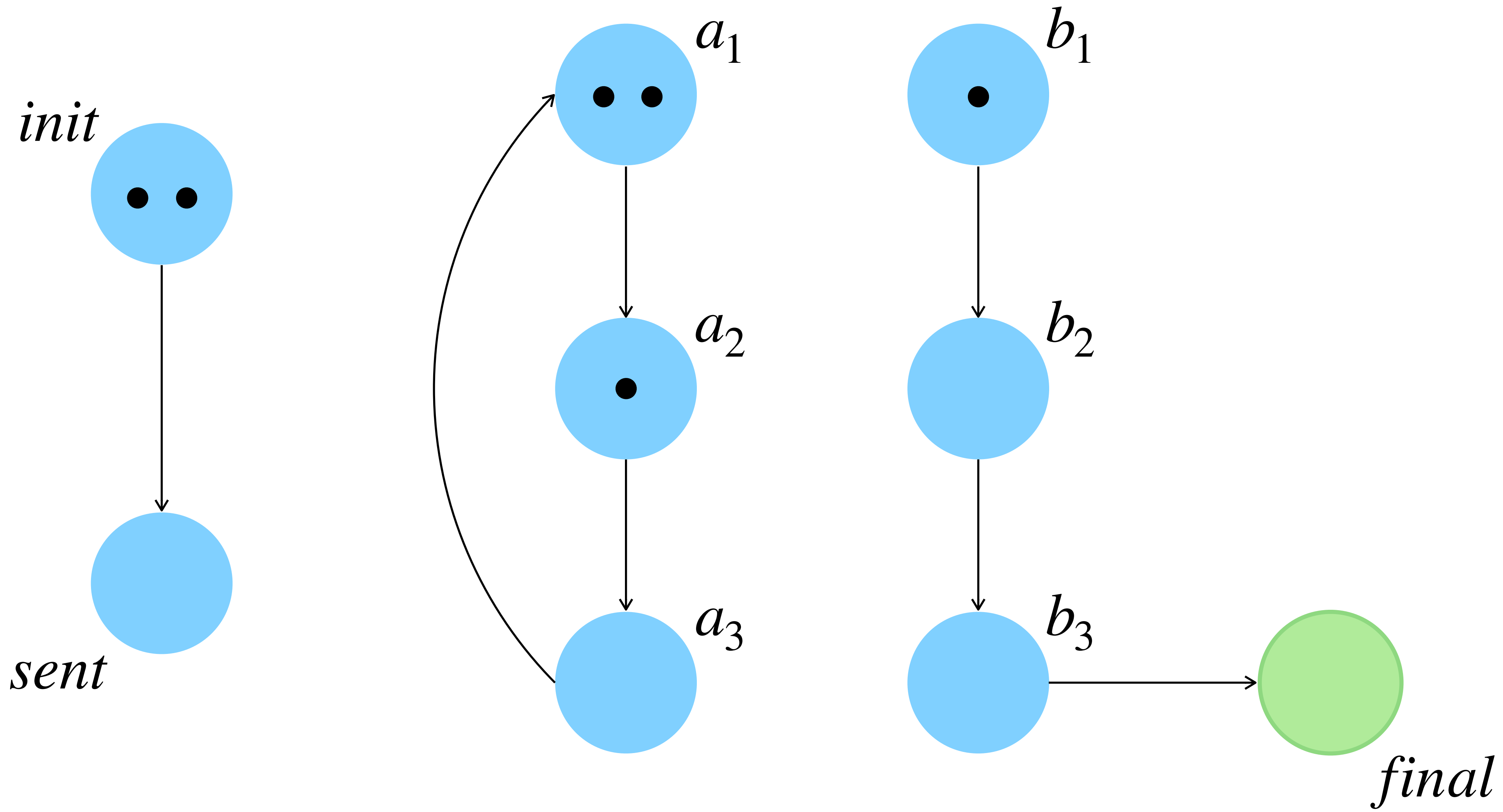
Reconfigurable Broadcast Network (RBN)

- introduced in [Delzanno, Sangnier & Zavattaro, CONCUR ’10]
- anonymous, identical processes which can communicate by selective broadcast.

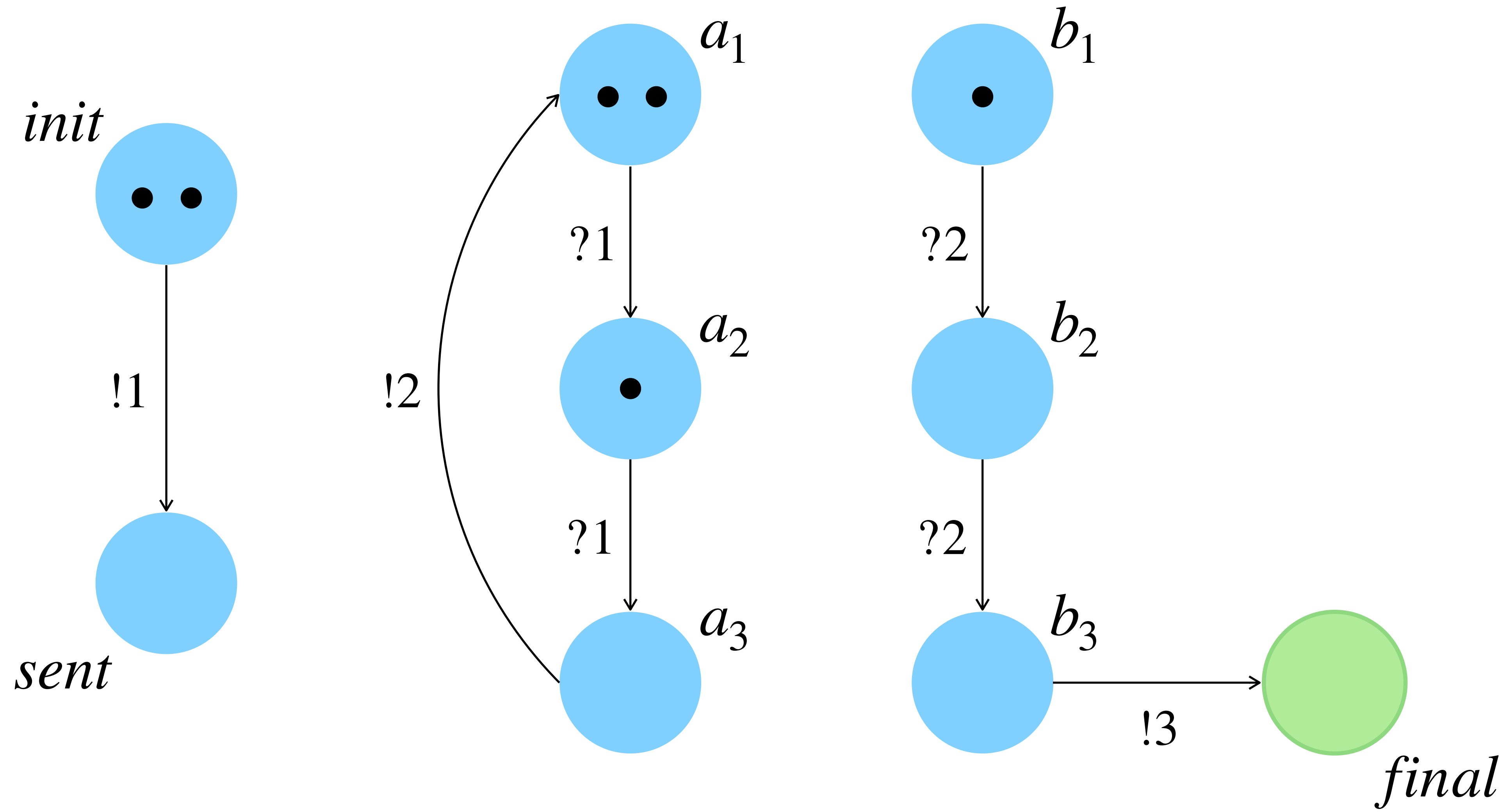
Asynchronous Shared Memory System (ASMS)

- introduced in [Esparza, Ganty & Majumdar, CAV ’13]
- anonymous, identical processes which can communicate by writing to a shared register.

RBN



RBN



RBN

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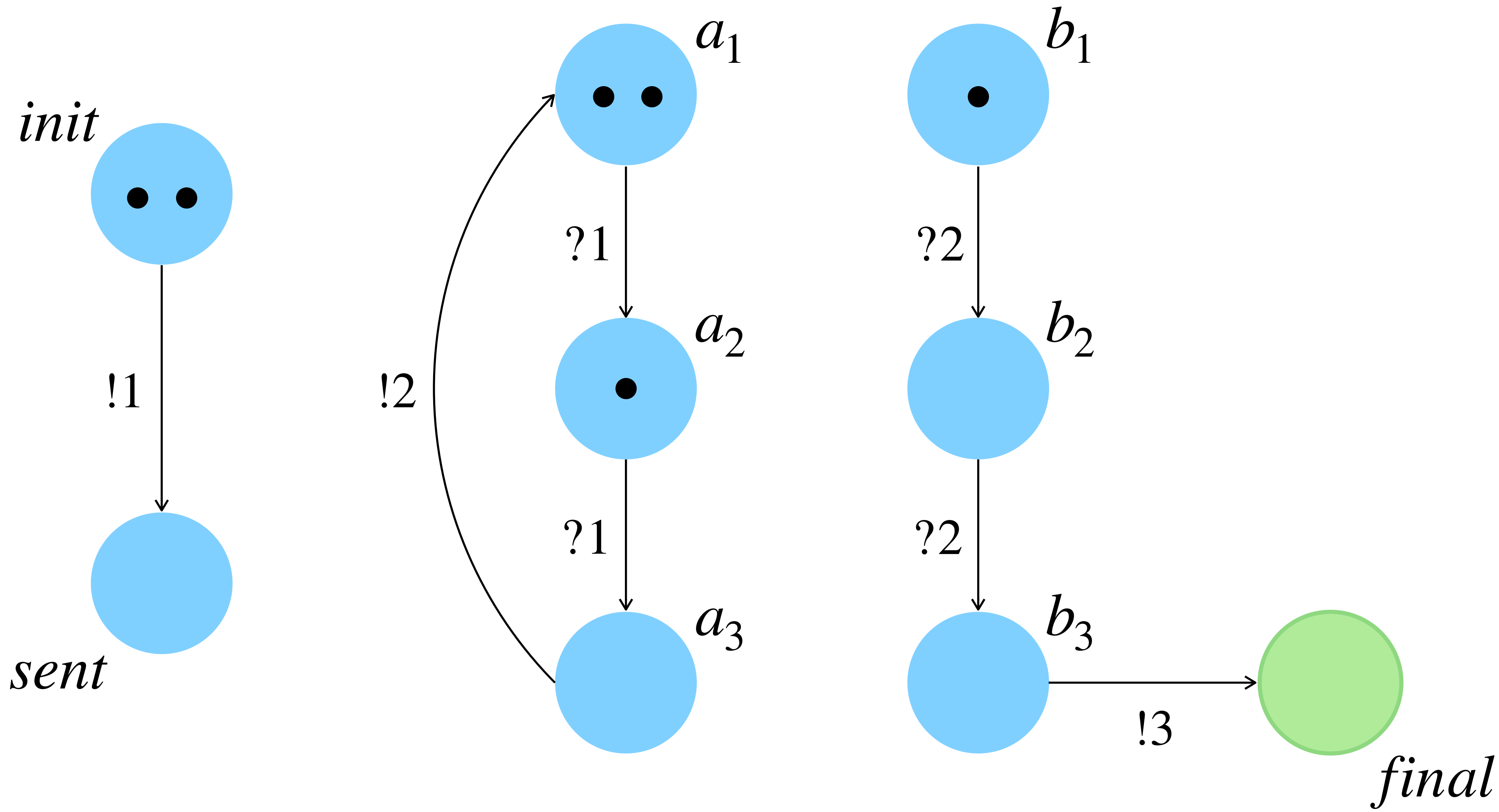

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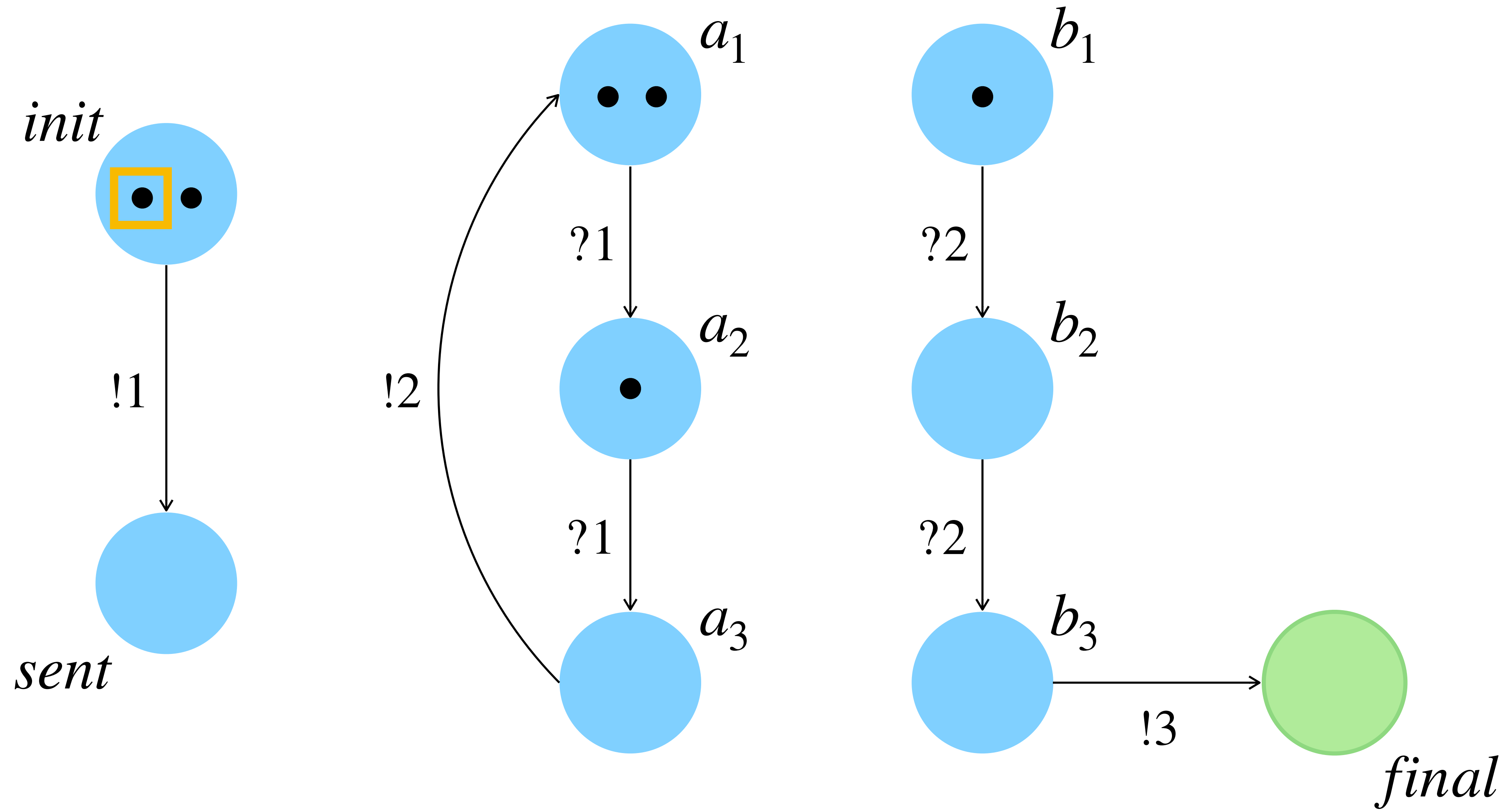

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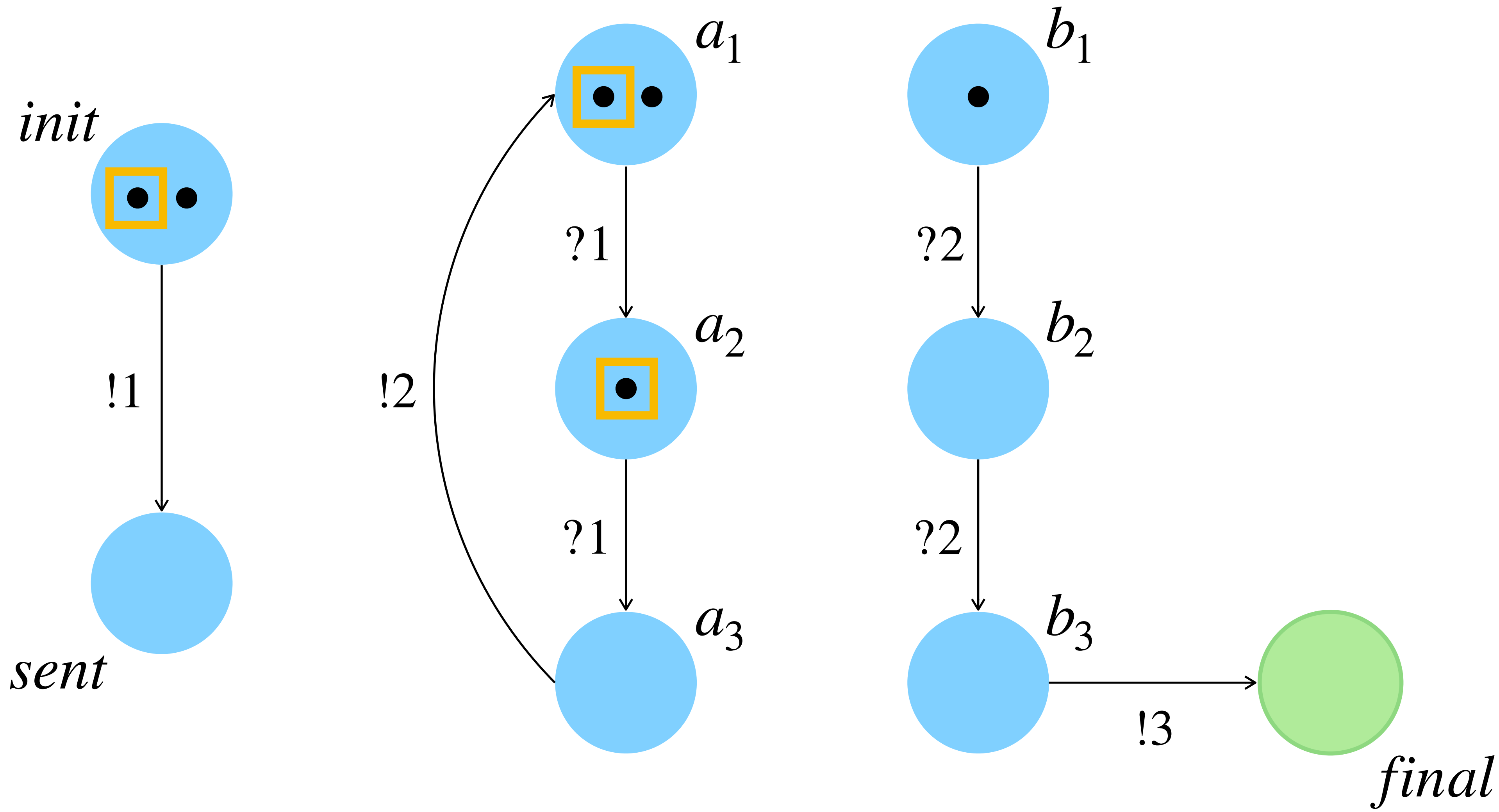

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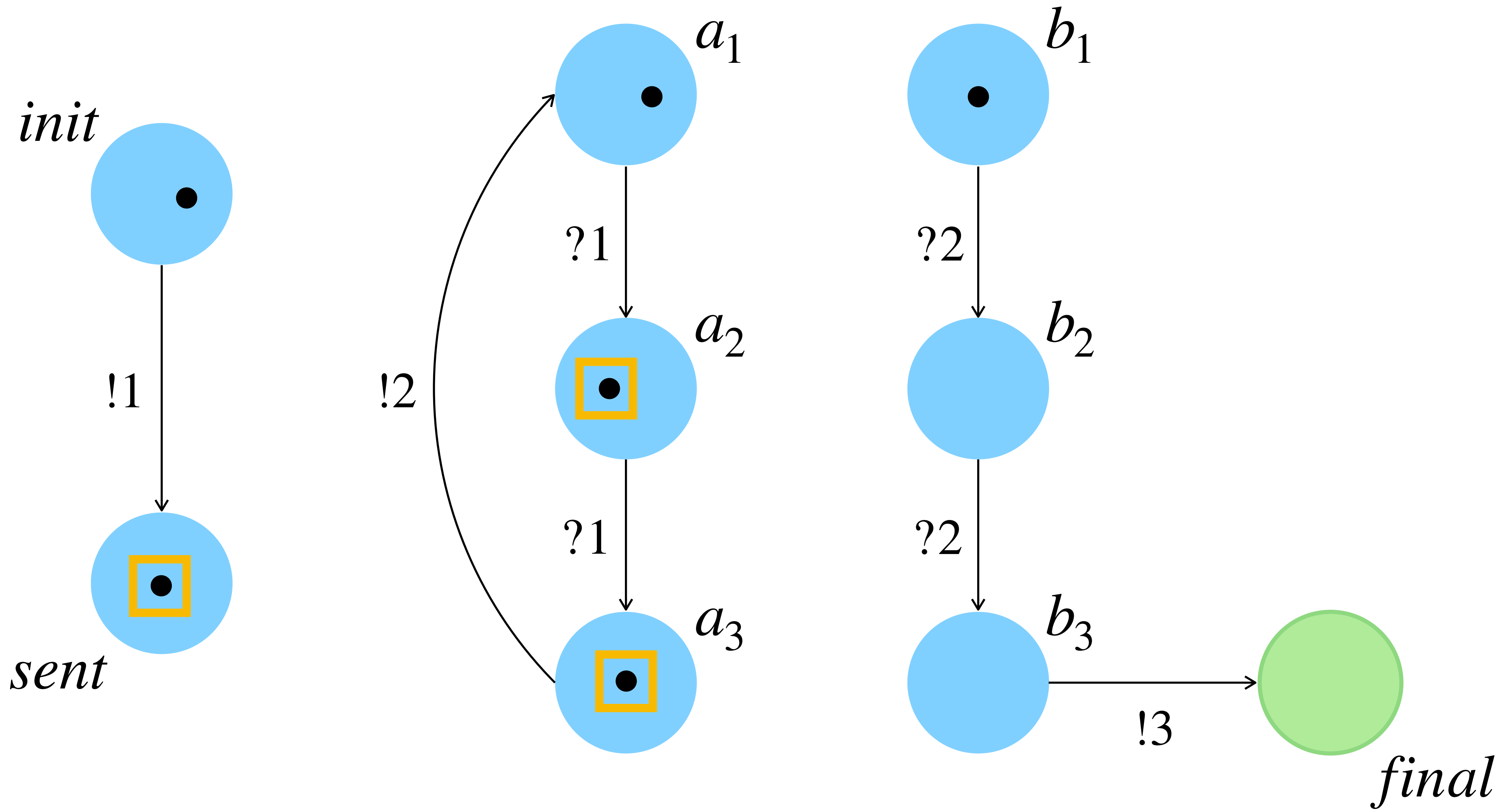

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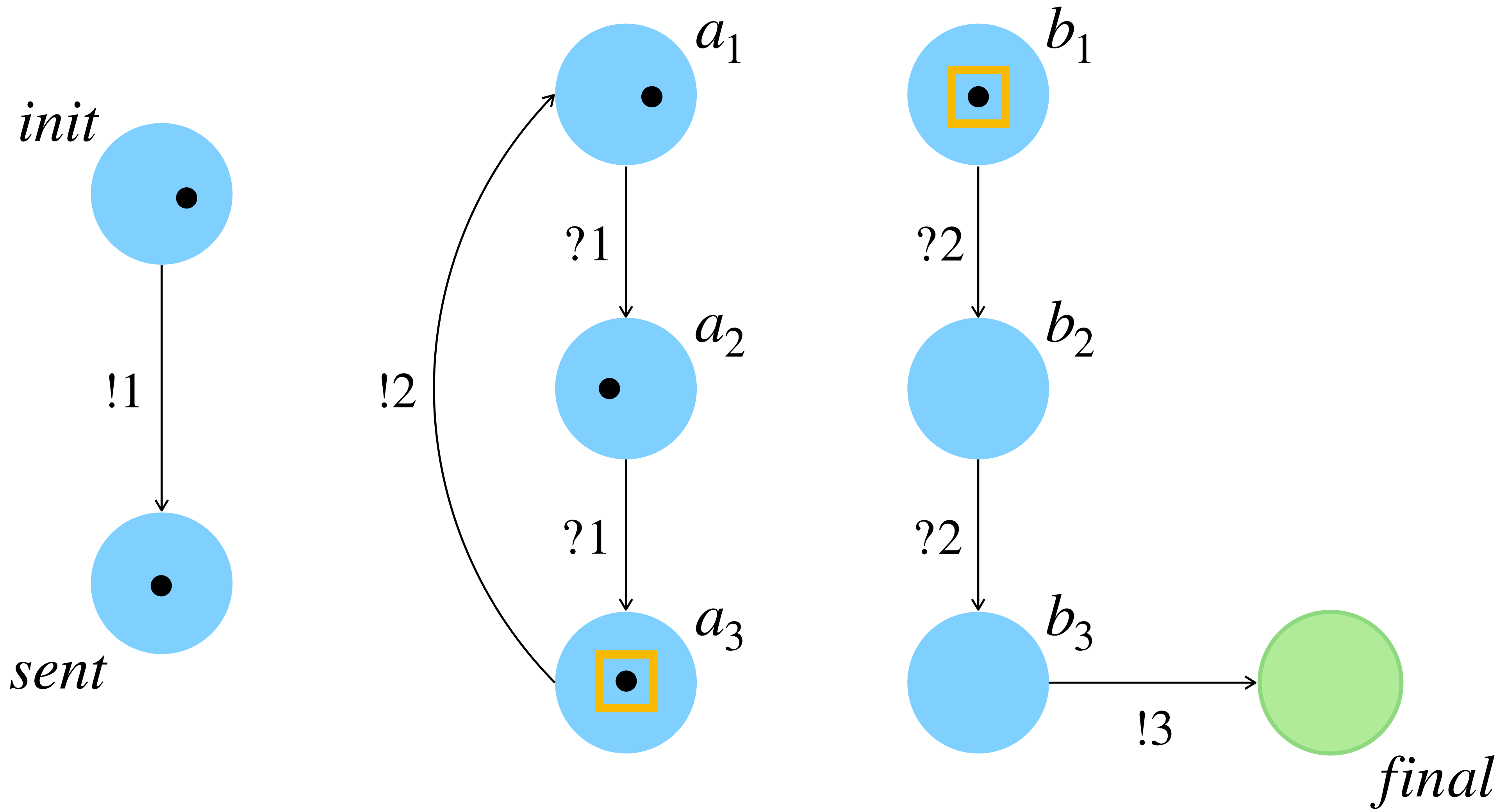

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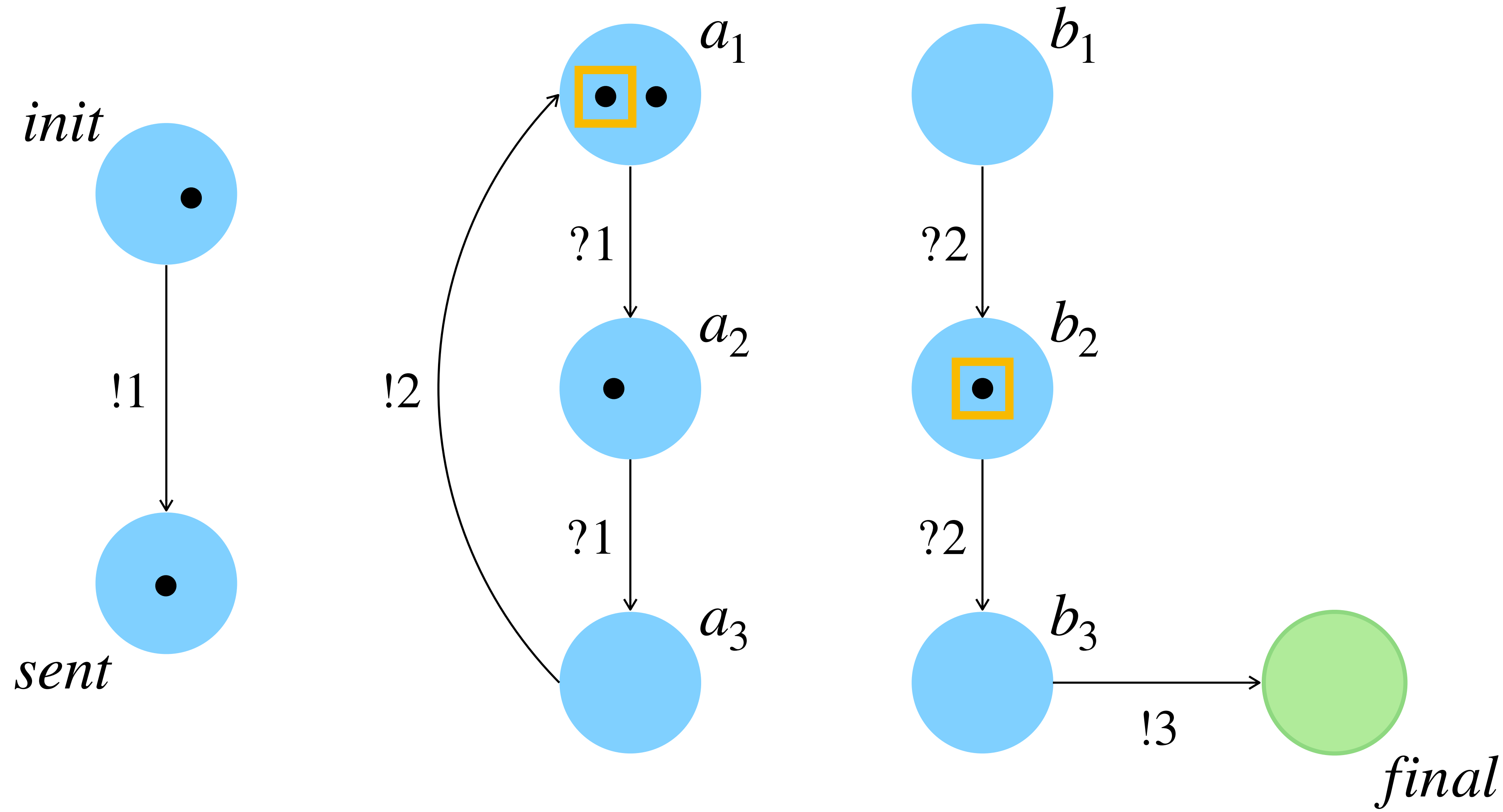

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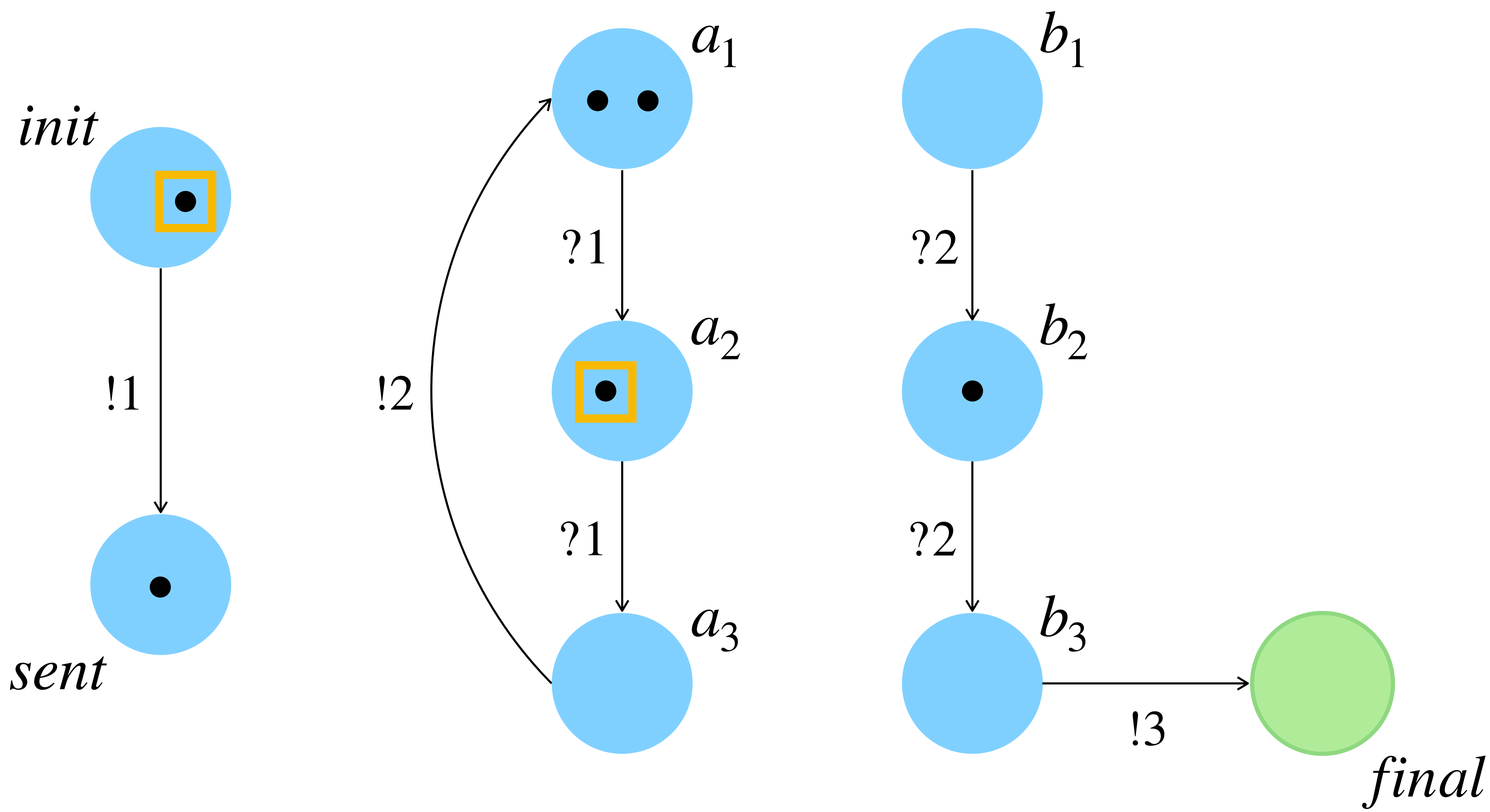

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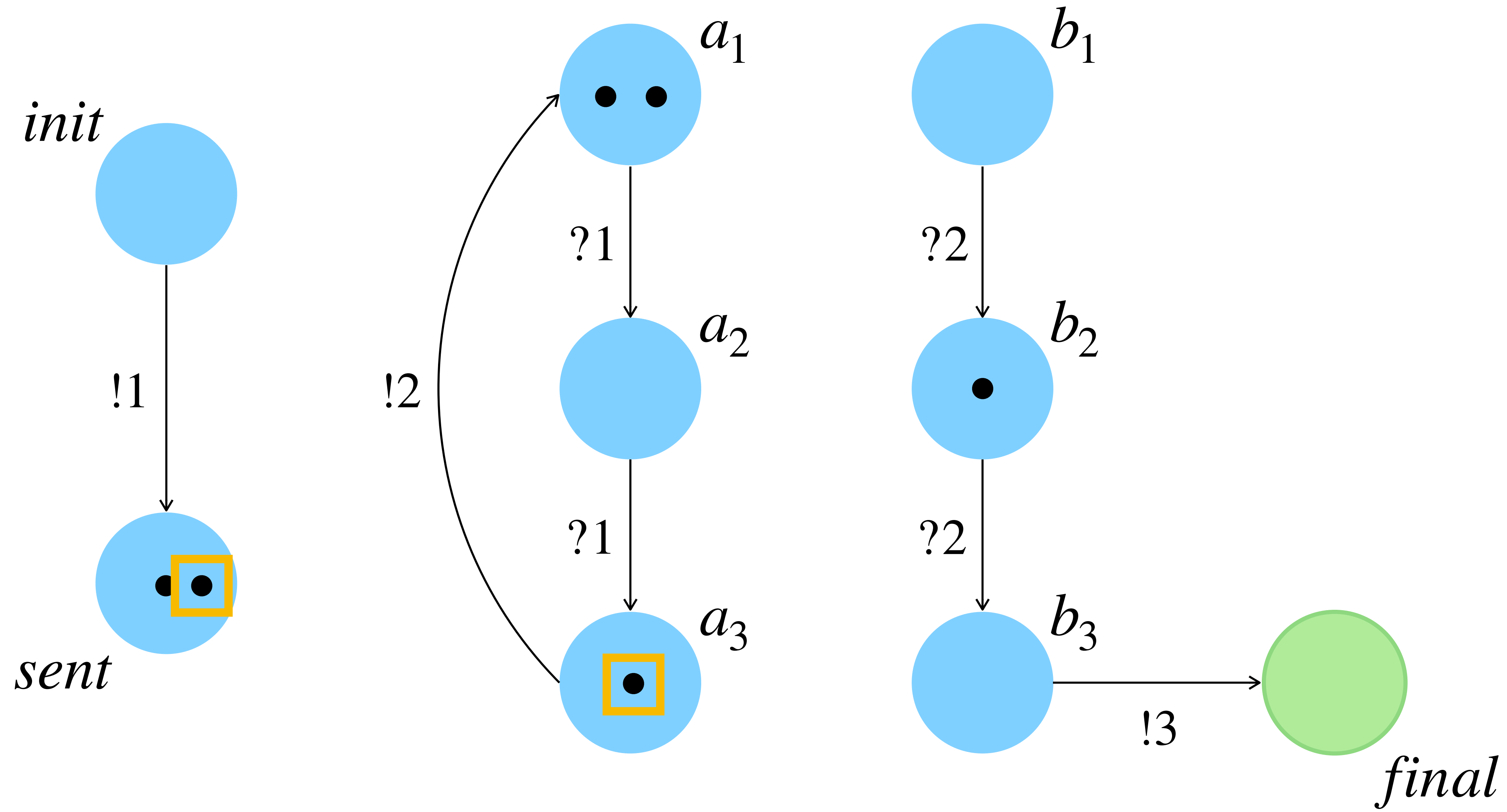

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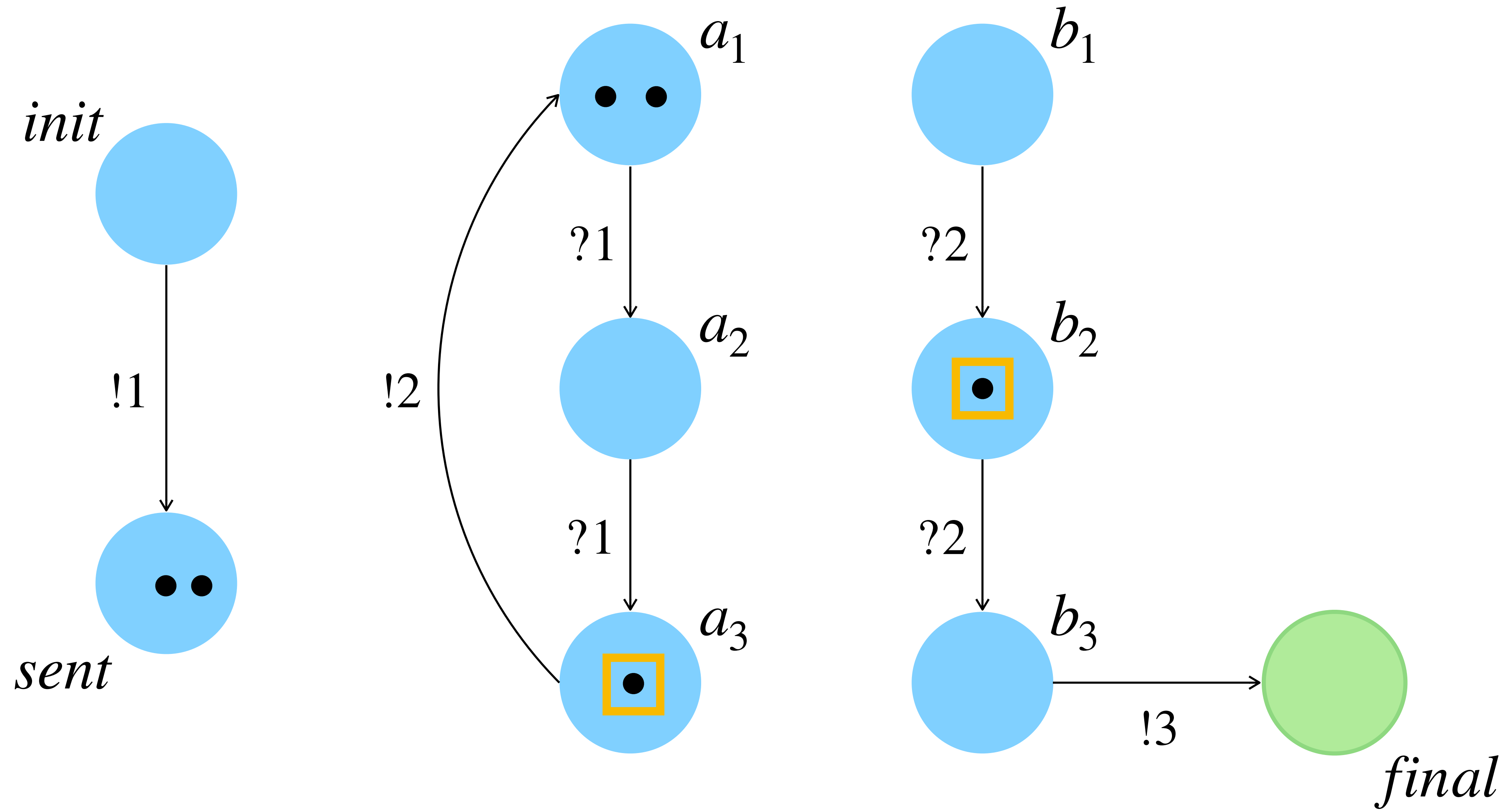

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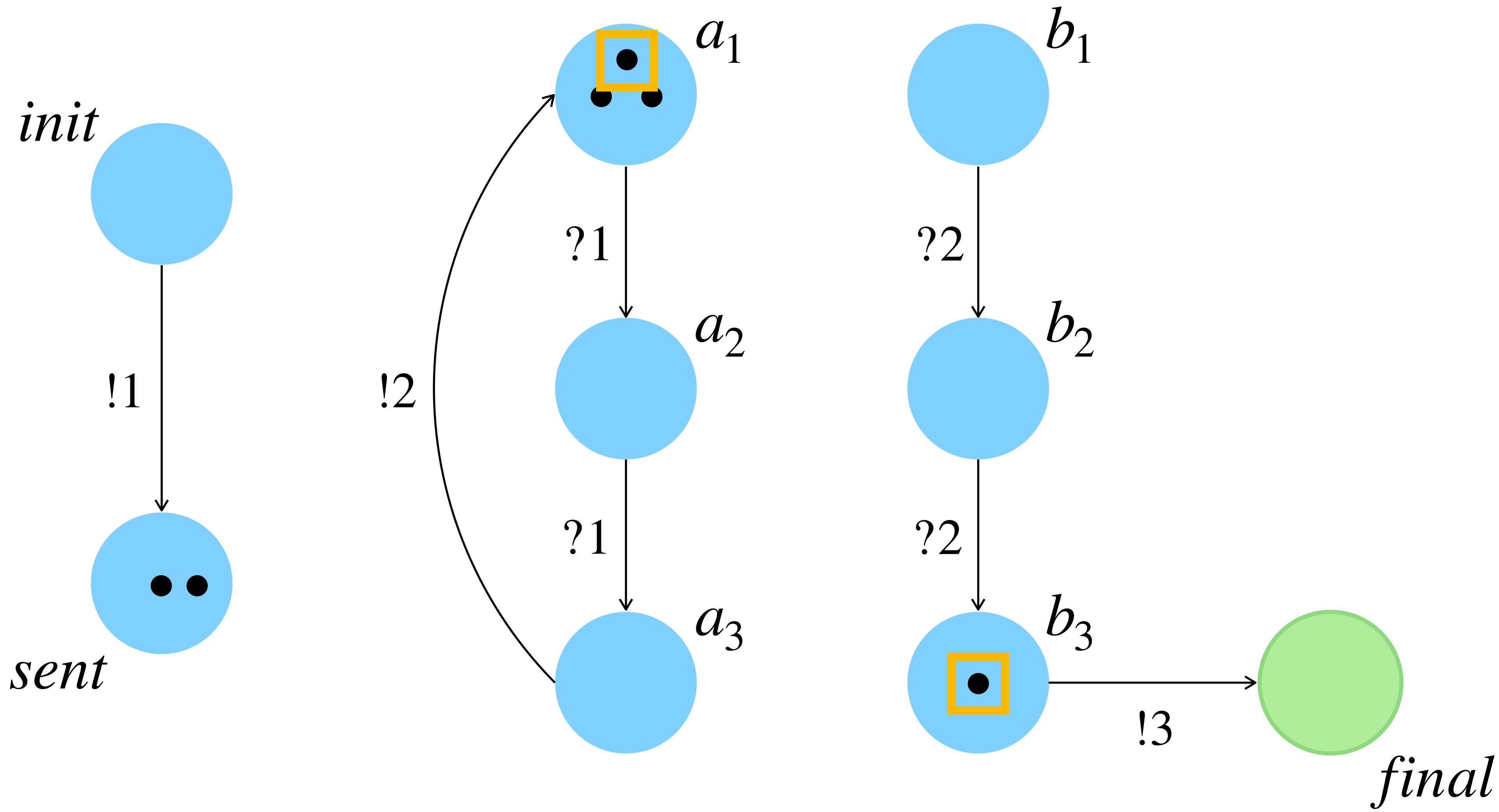

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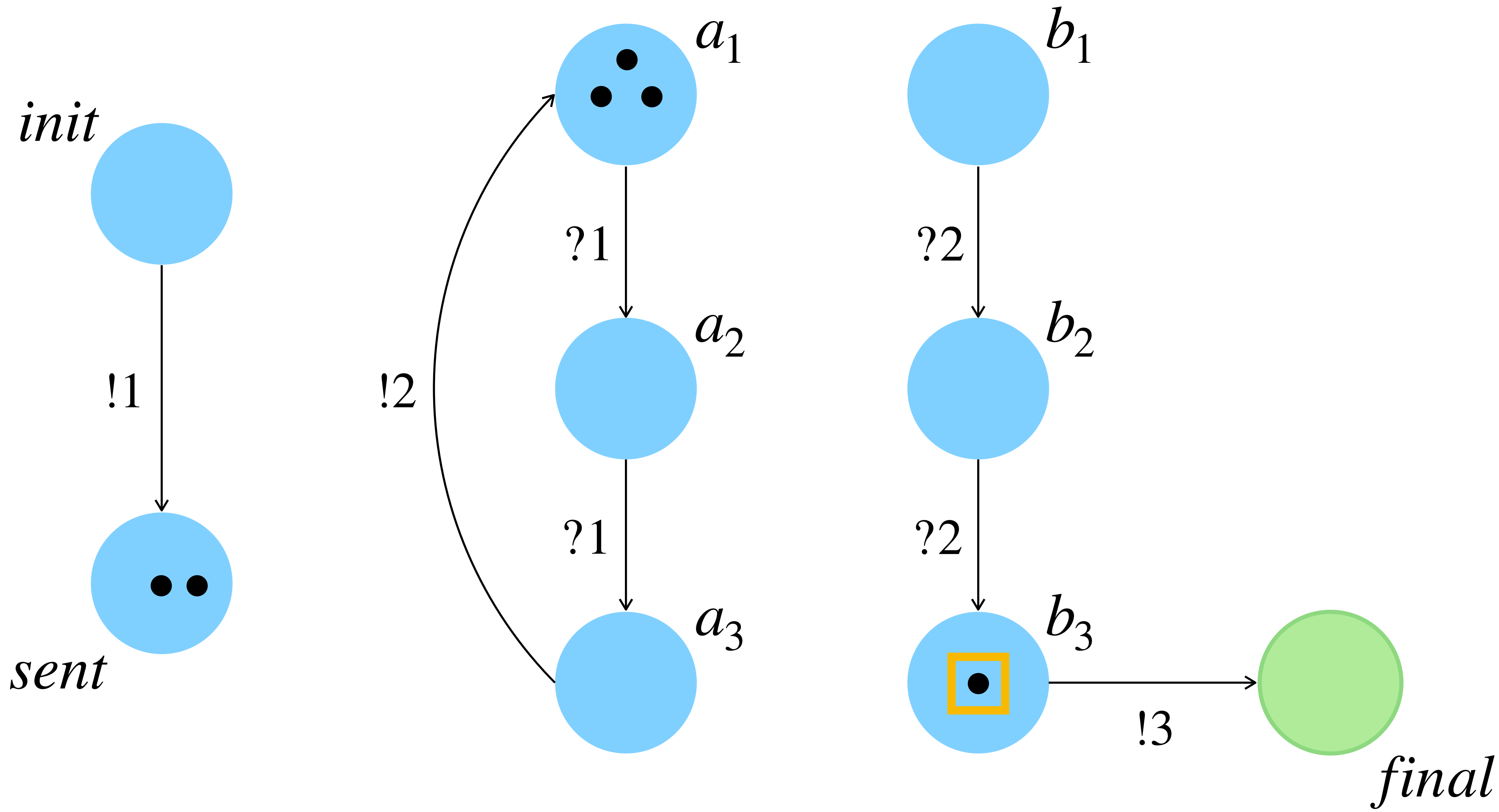

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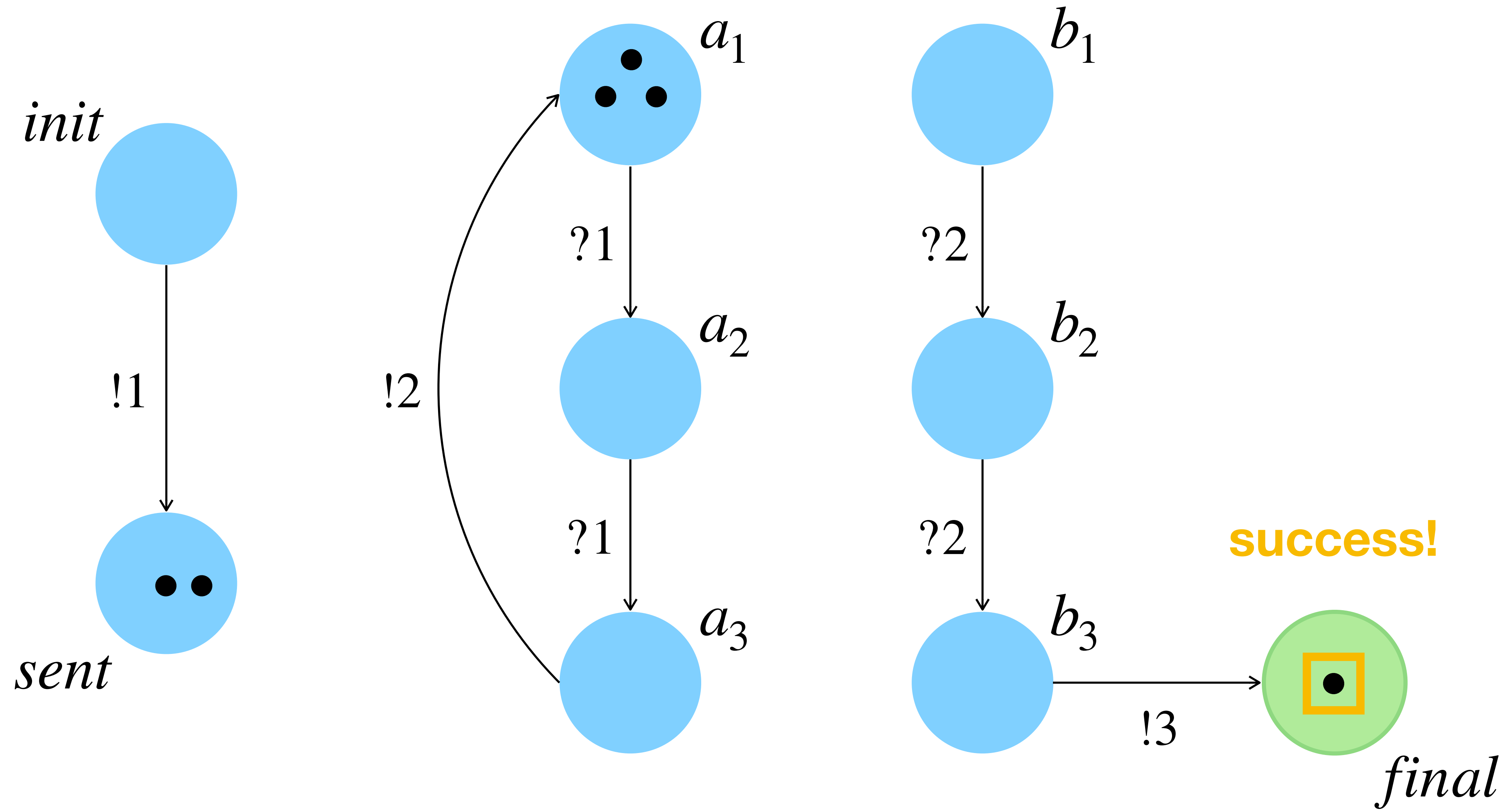
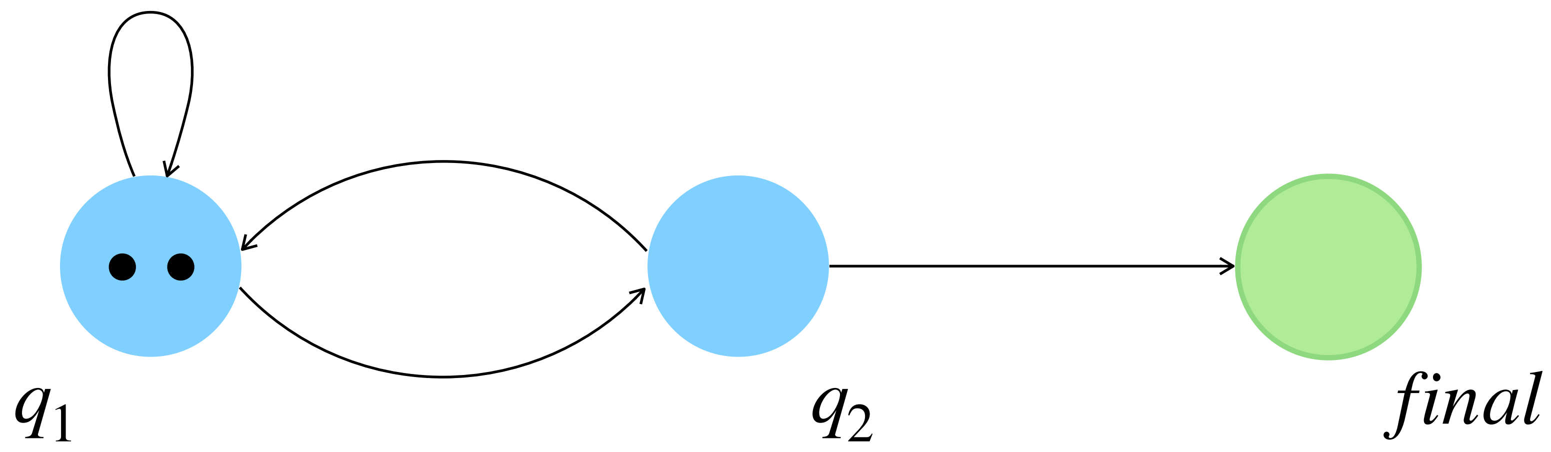


ASMS



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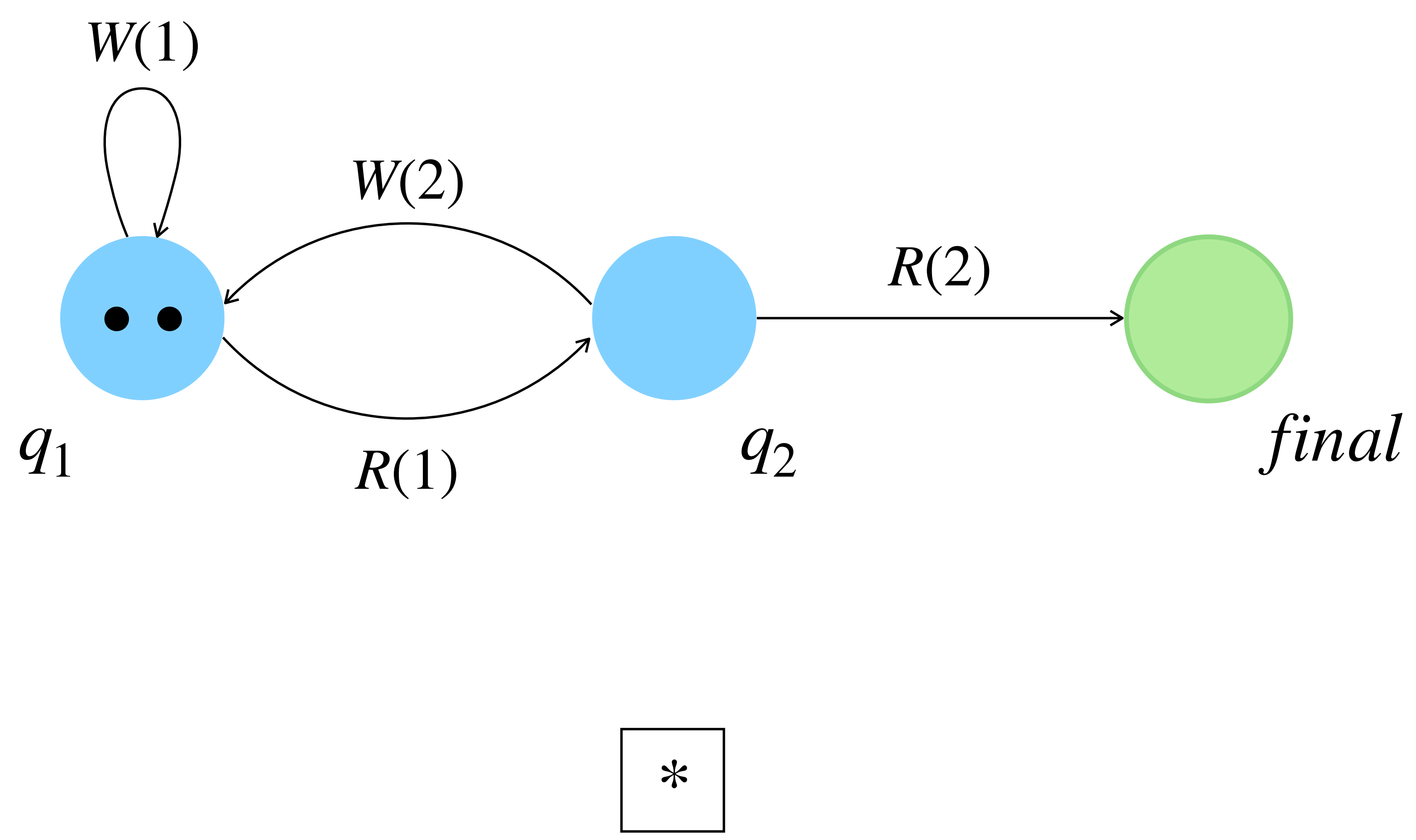

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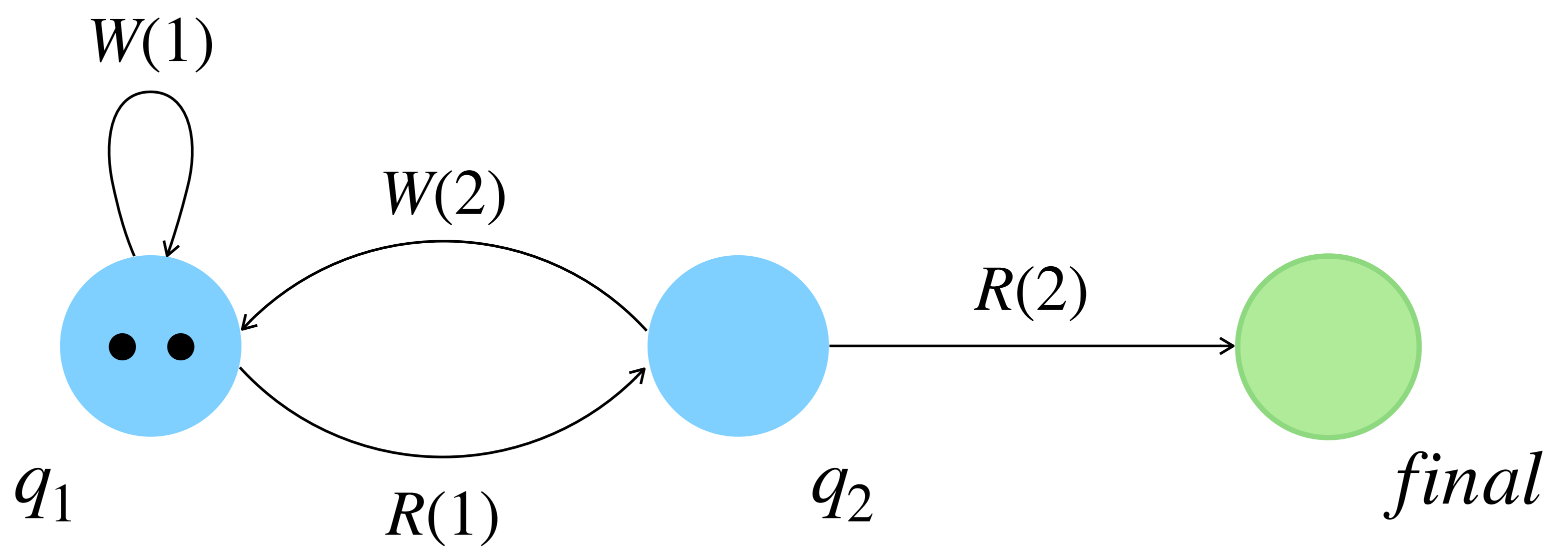

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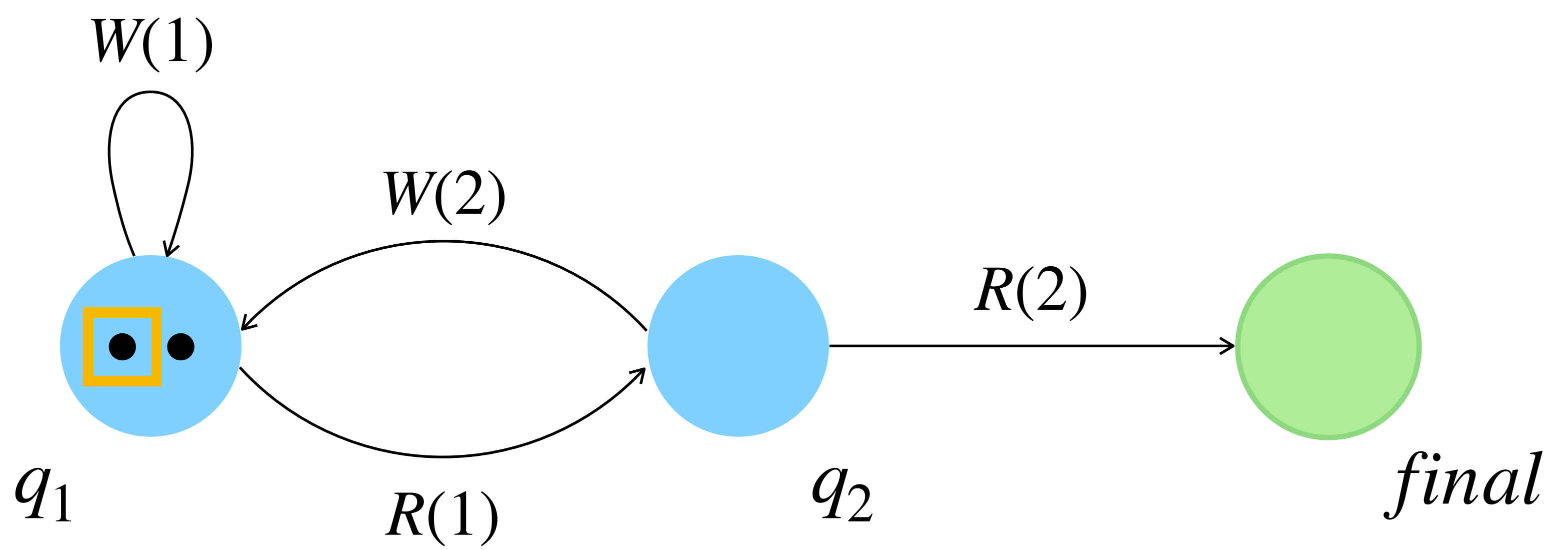

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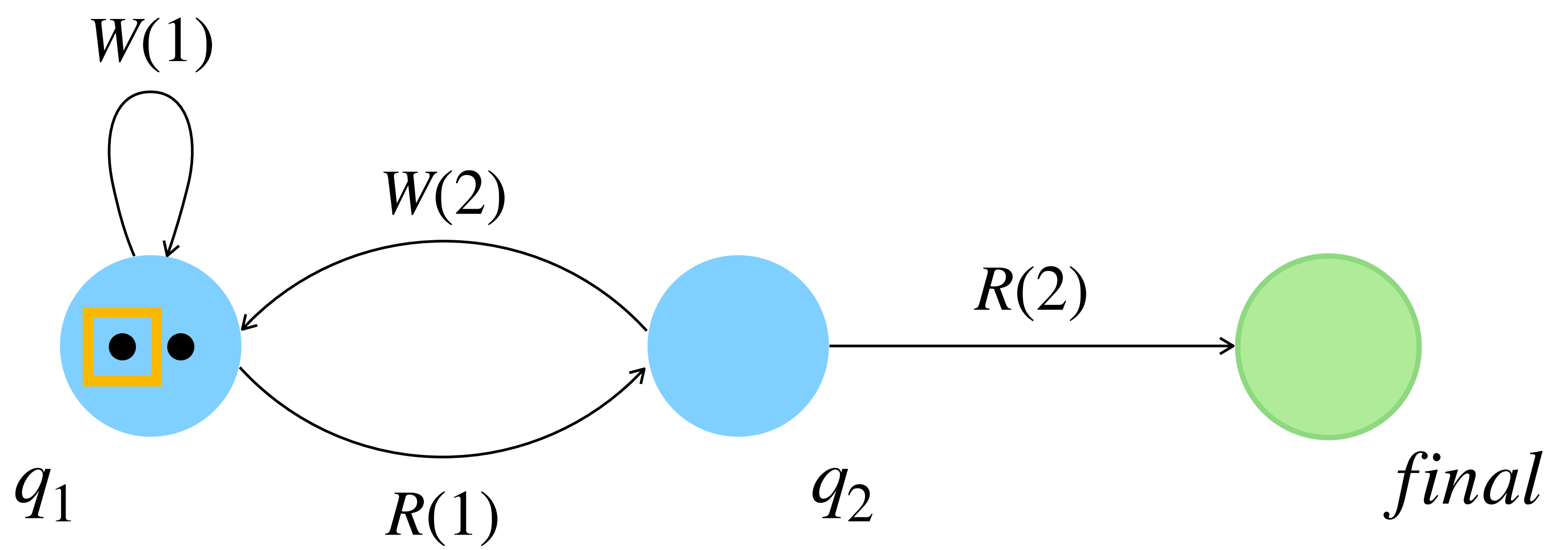

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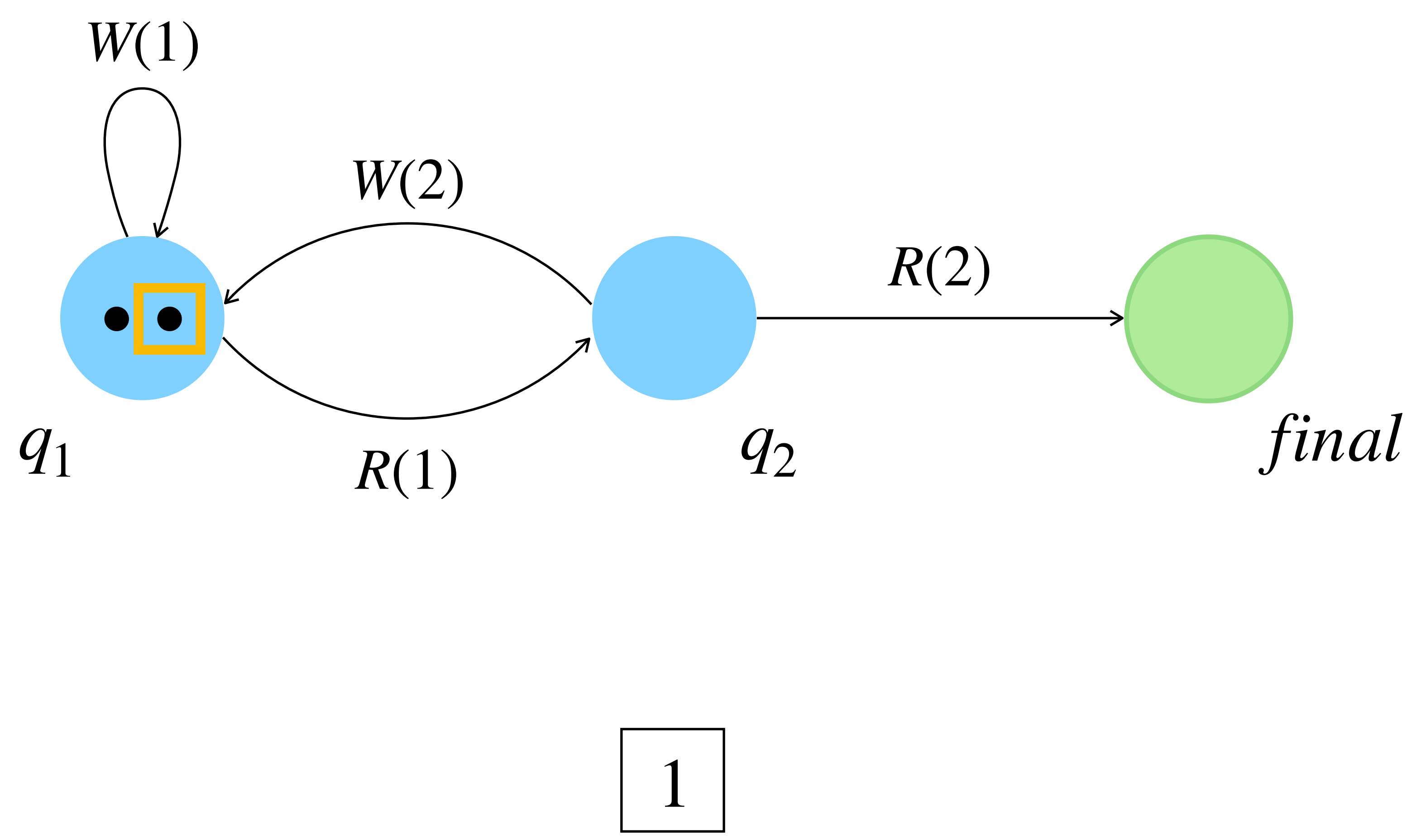

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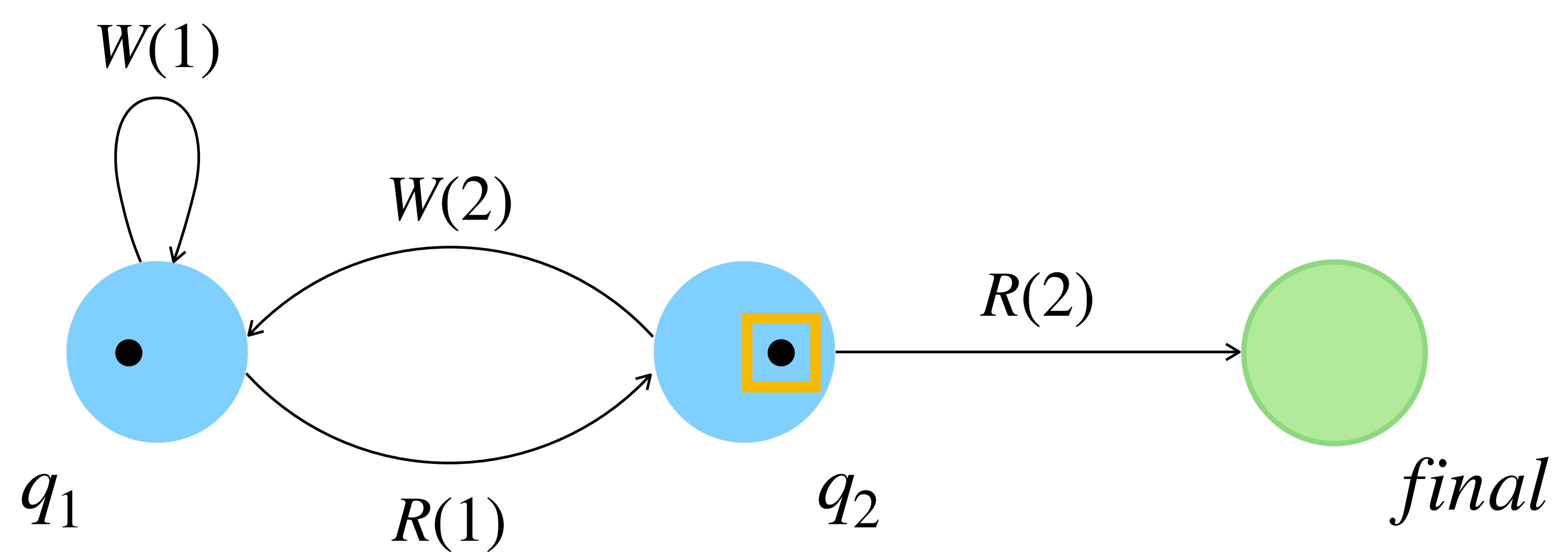

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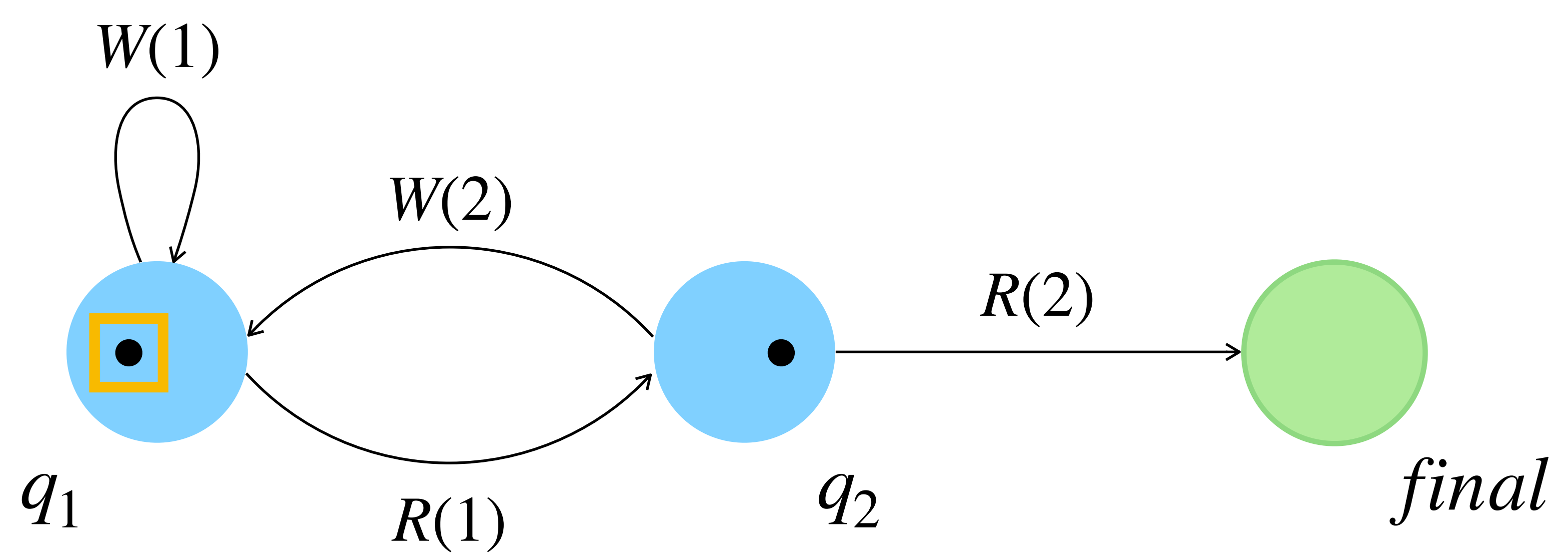

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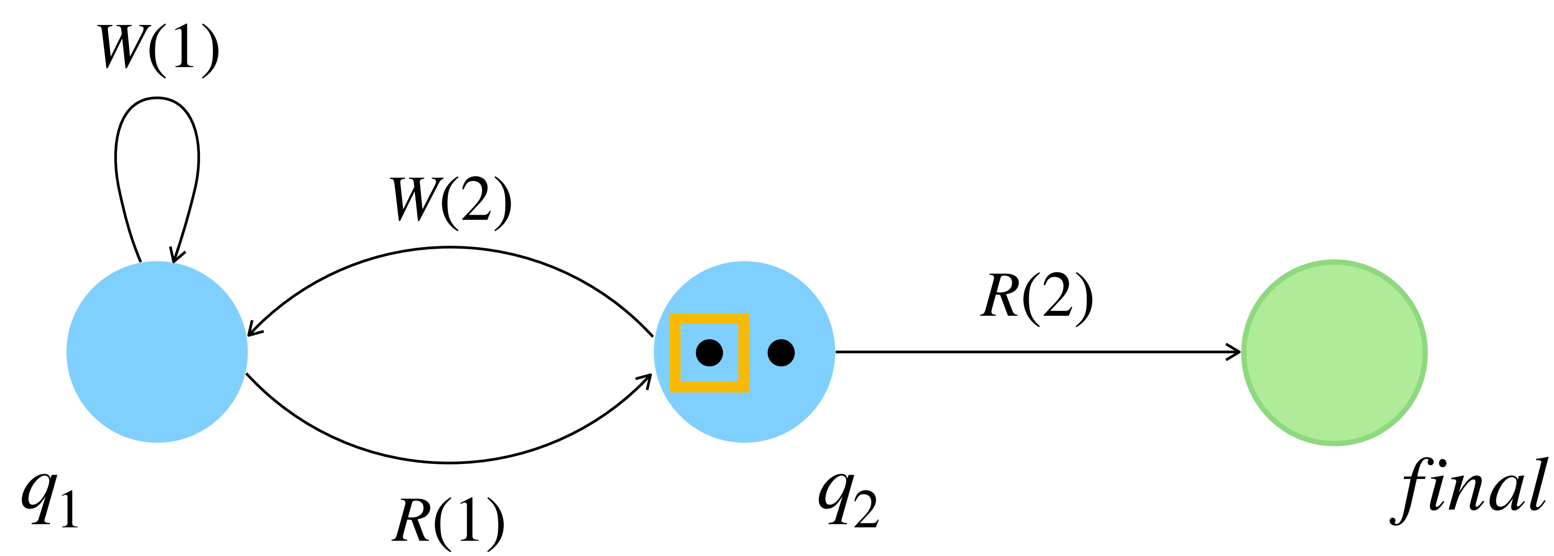

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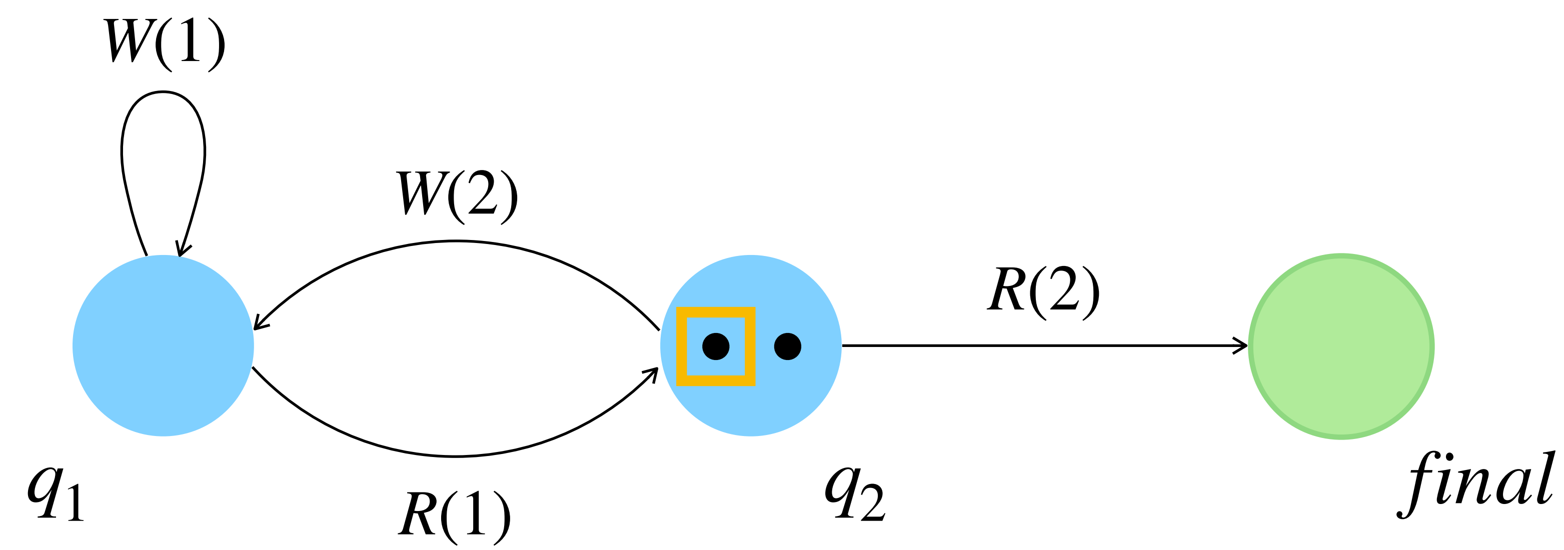

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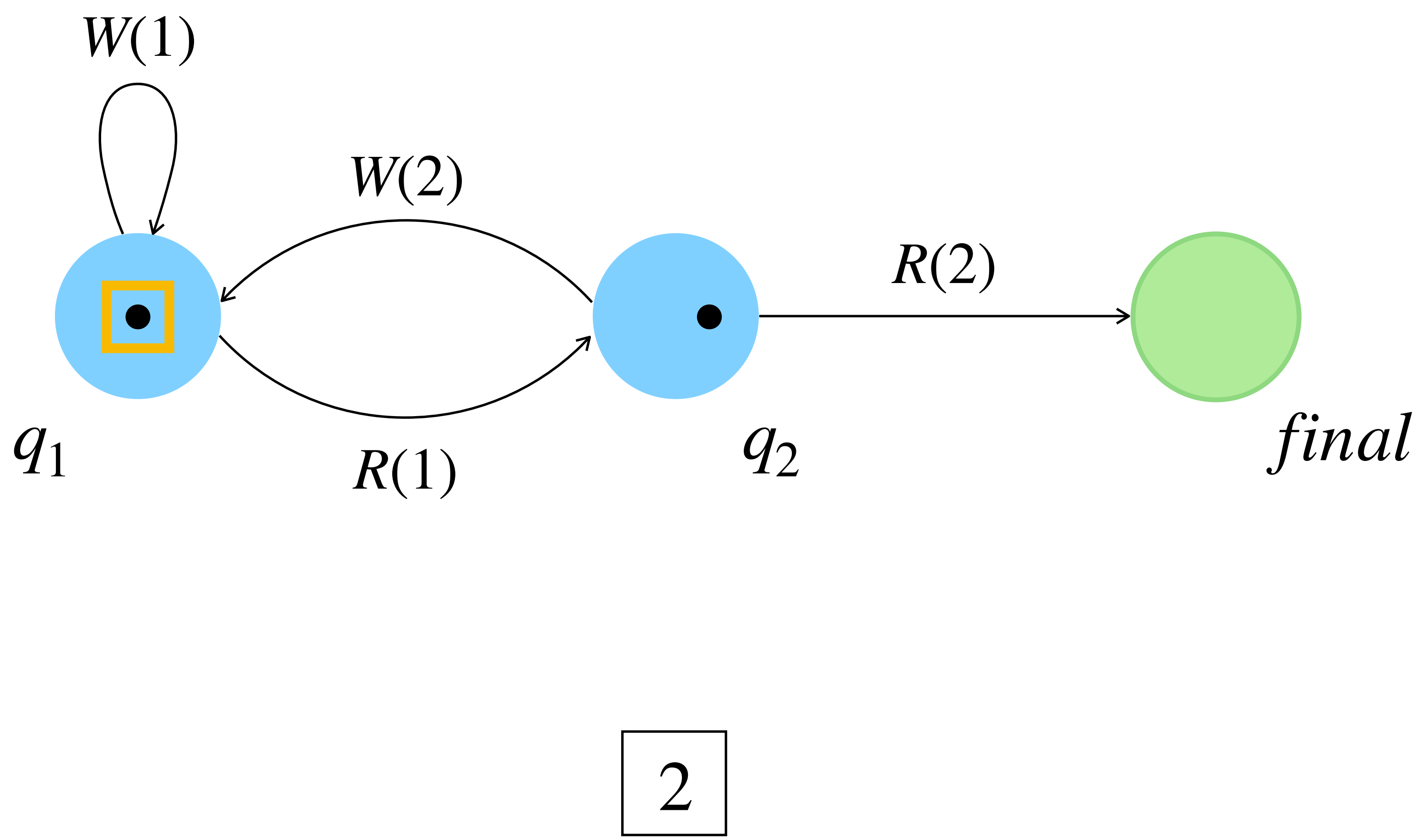

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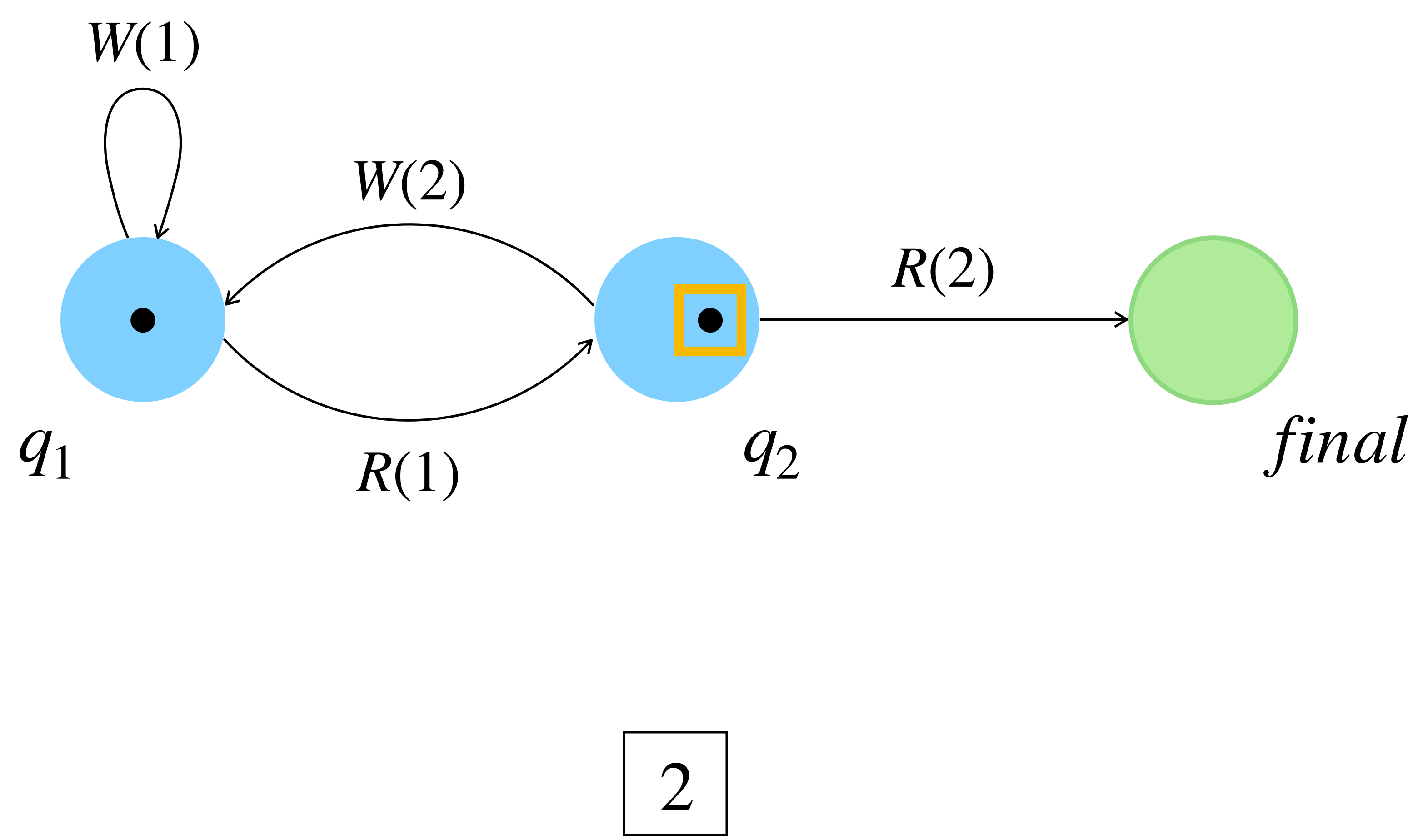

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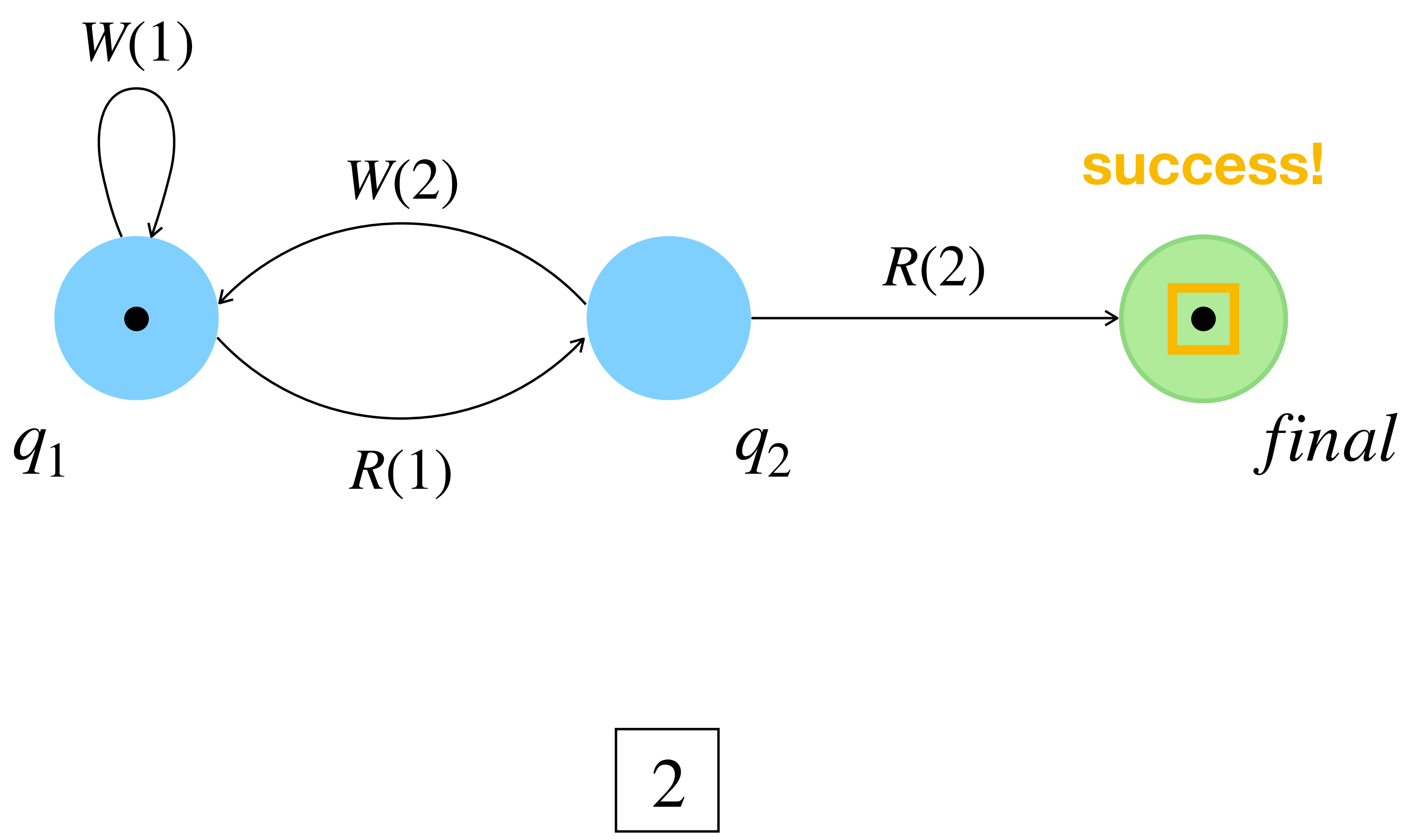

ASMS simulates RBN

Simulation of polynomial-size with bijection between configurations

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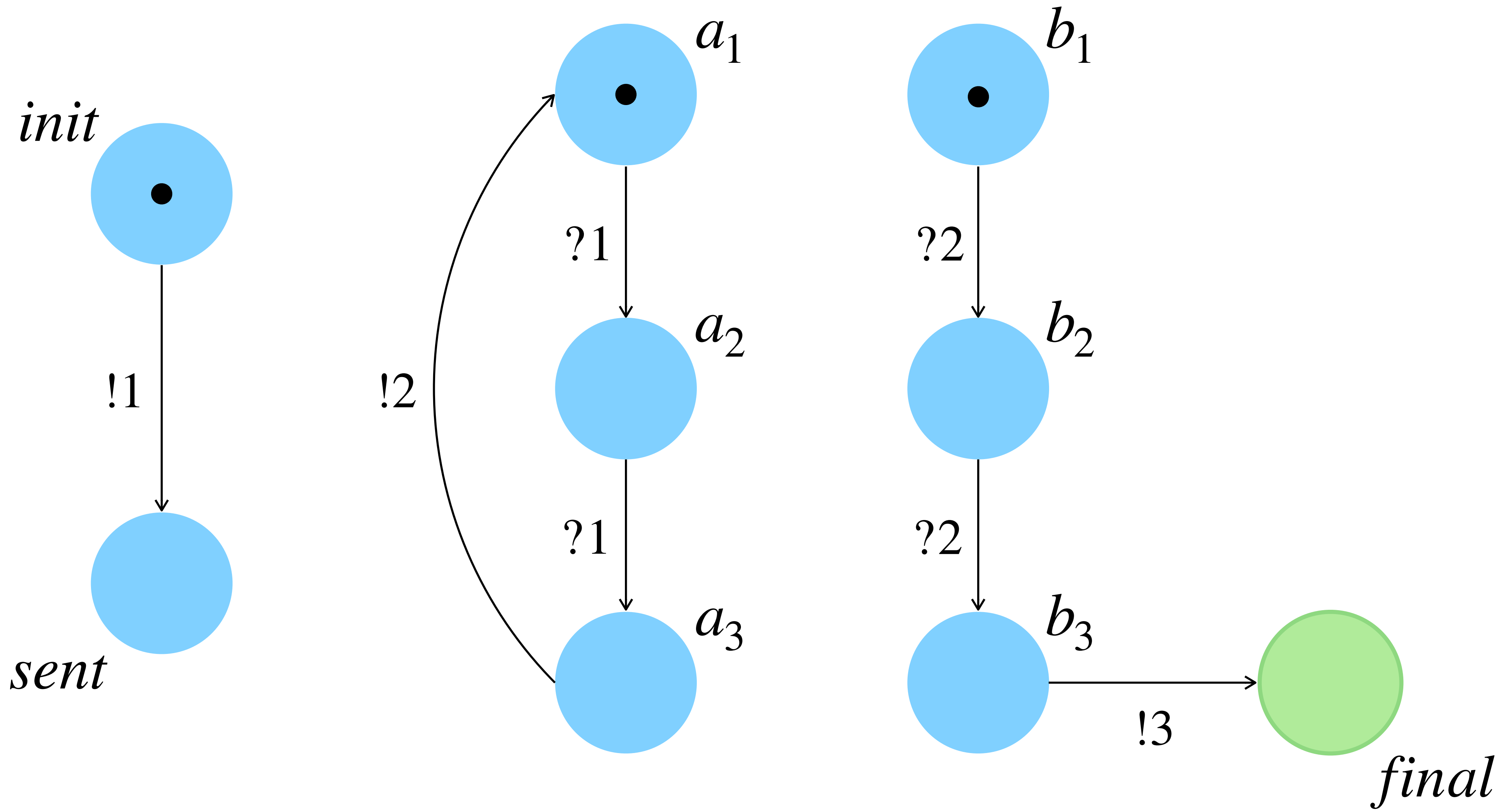

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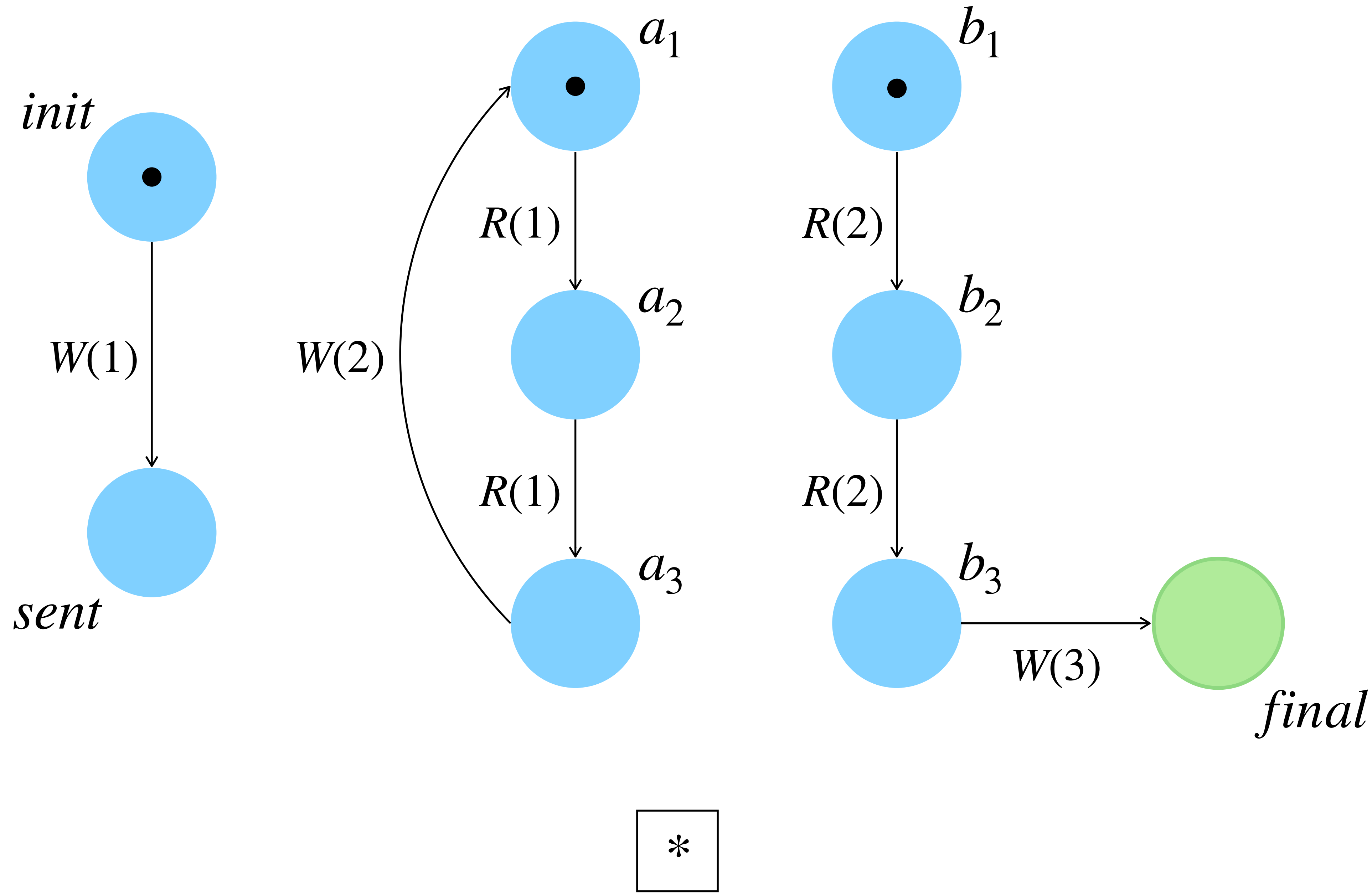

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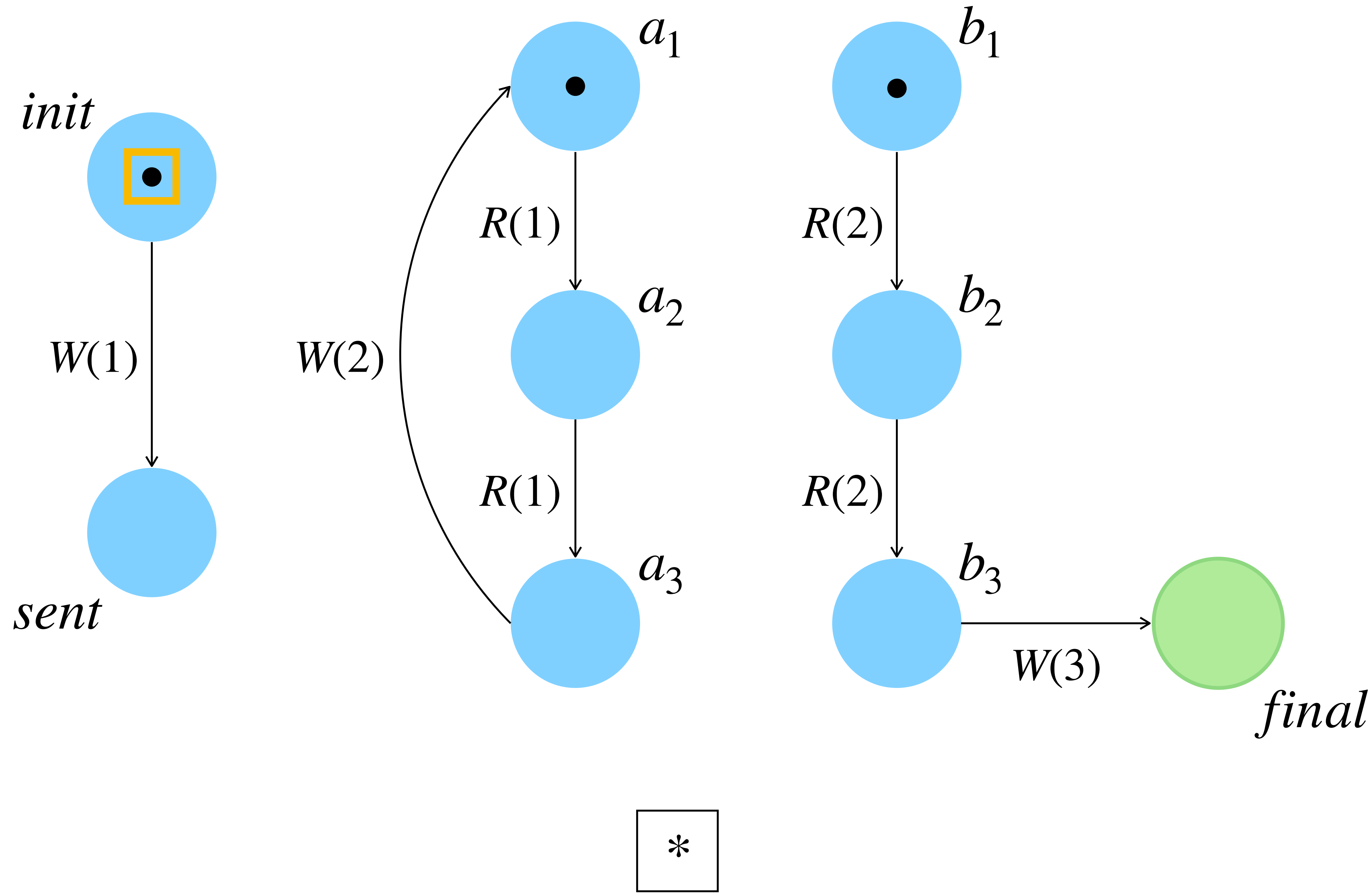

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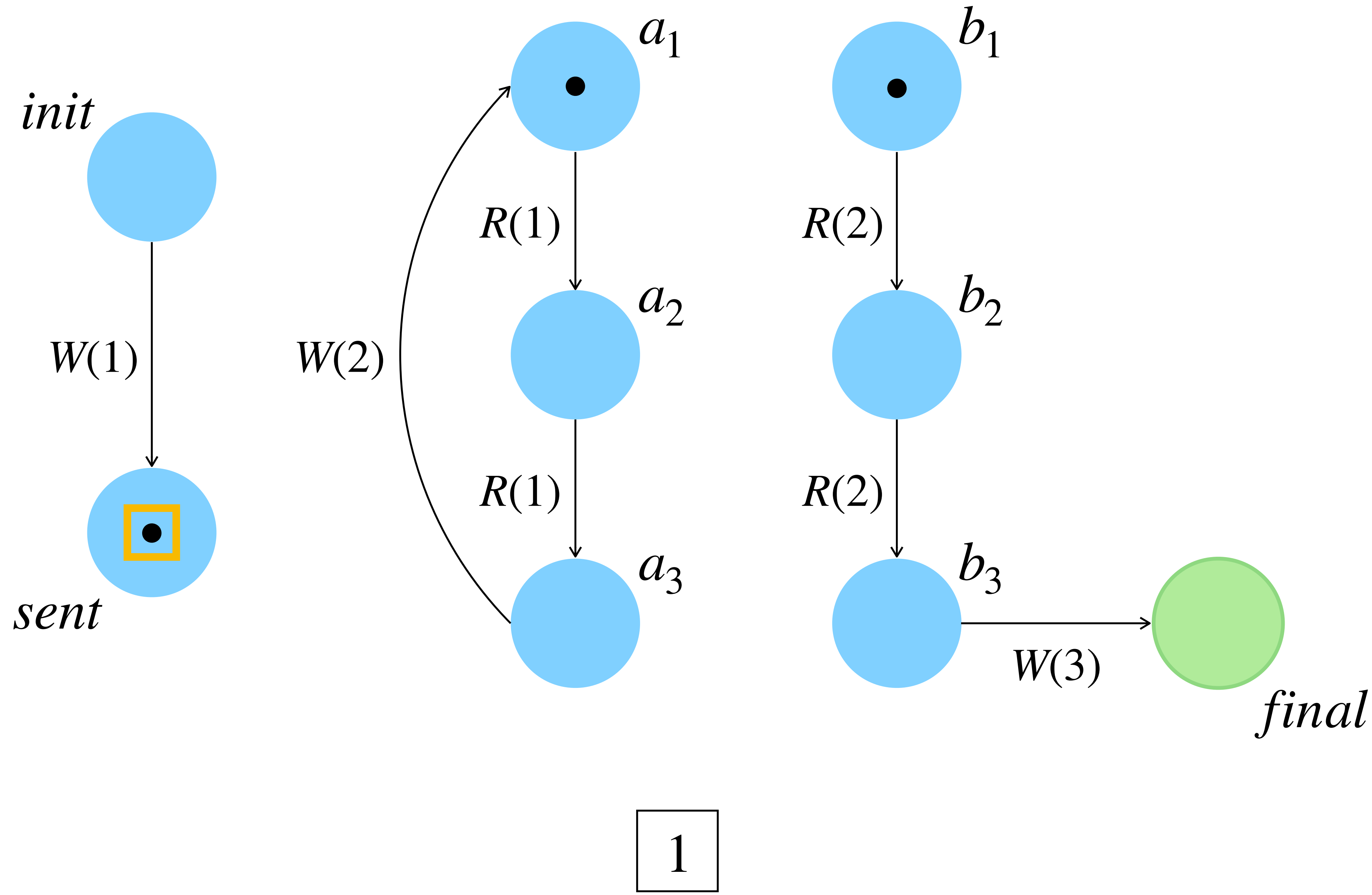

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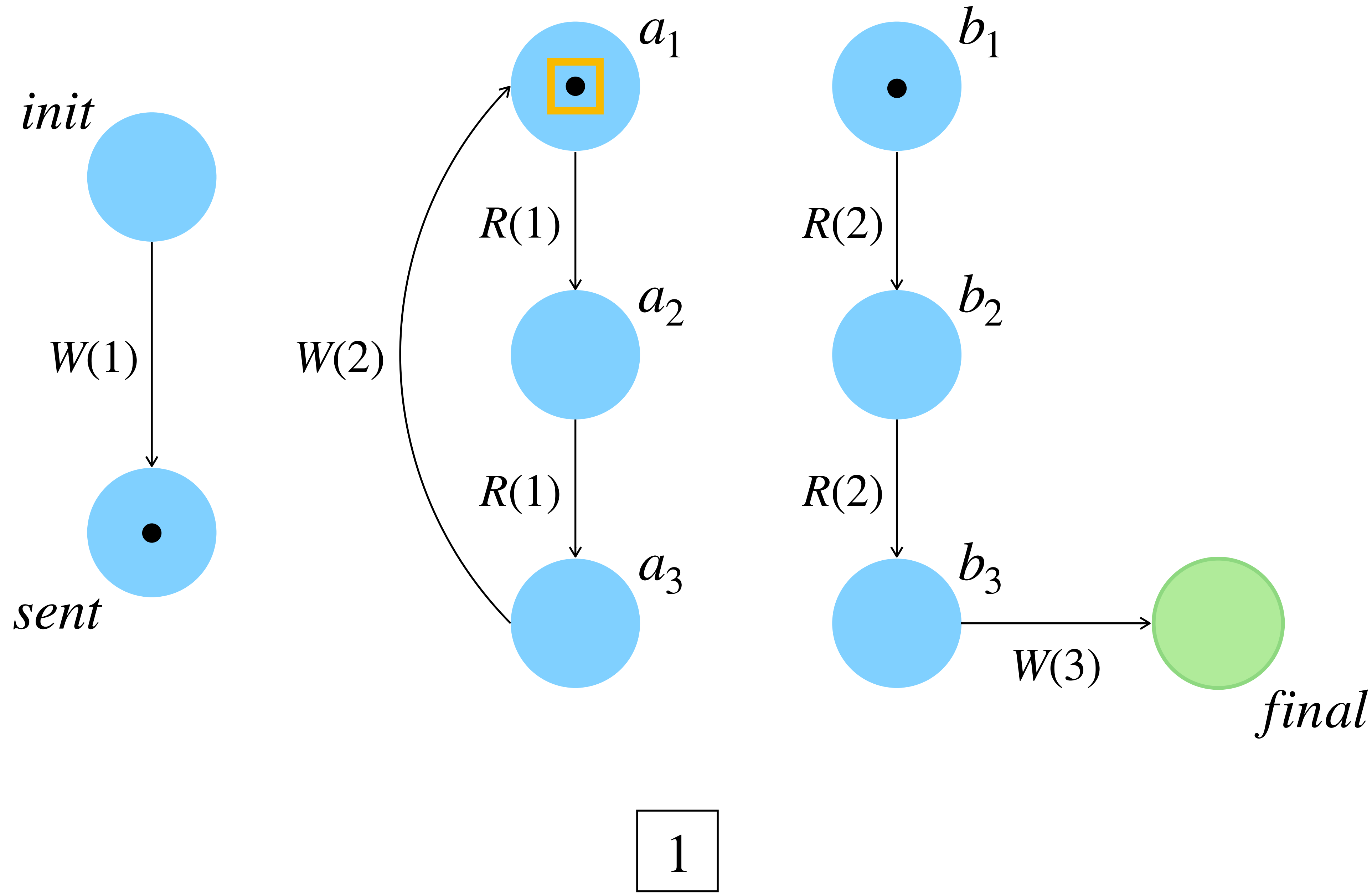

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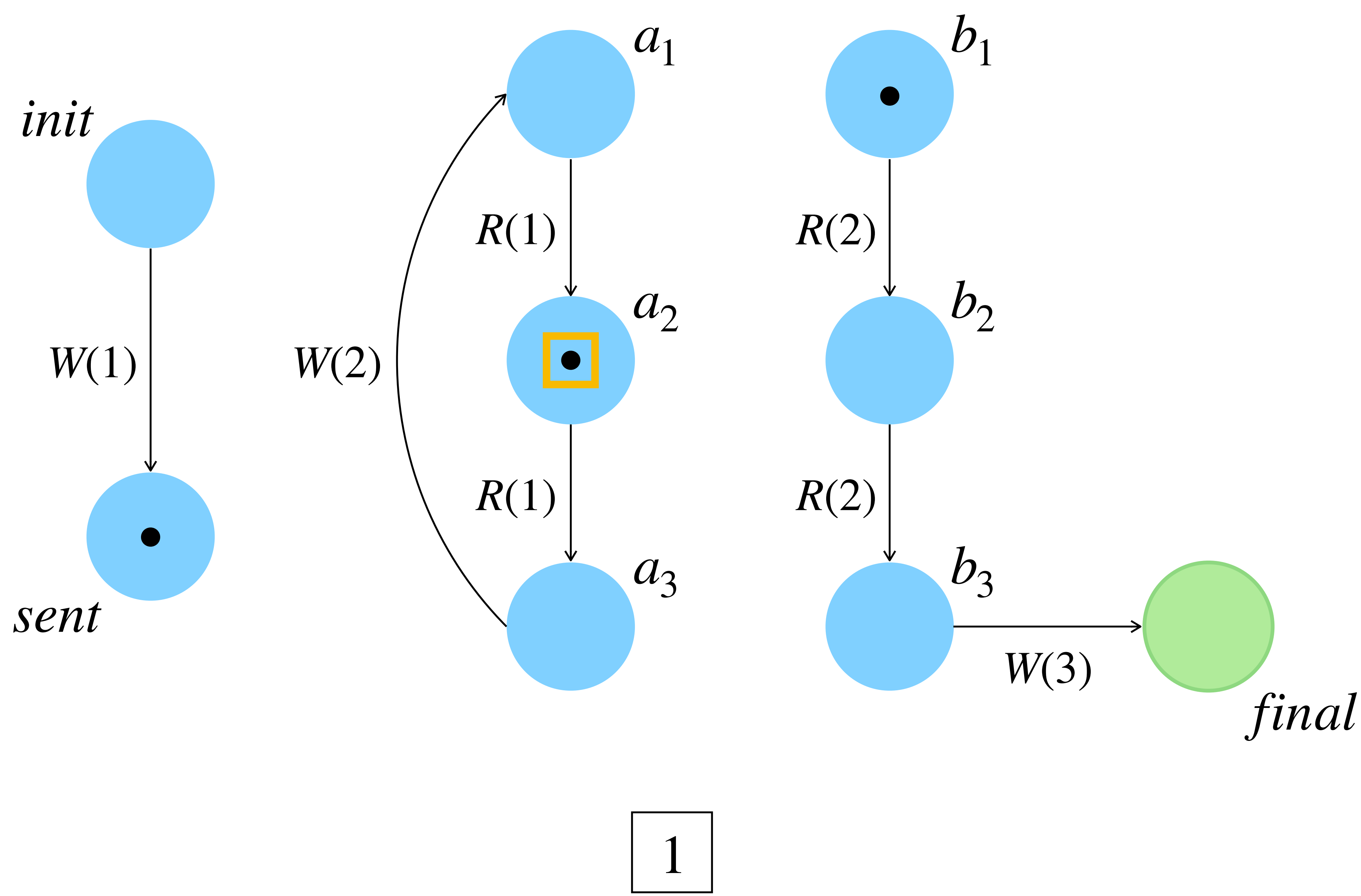

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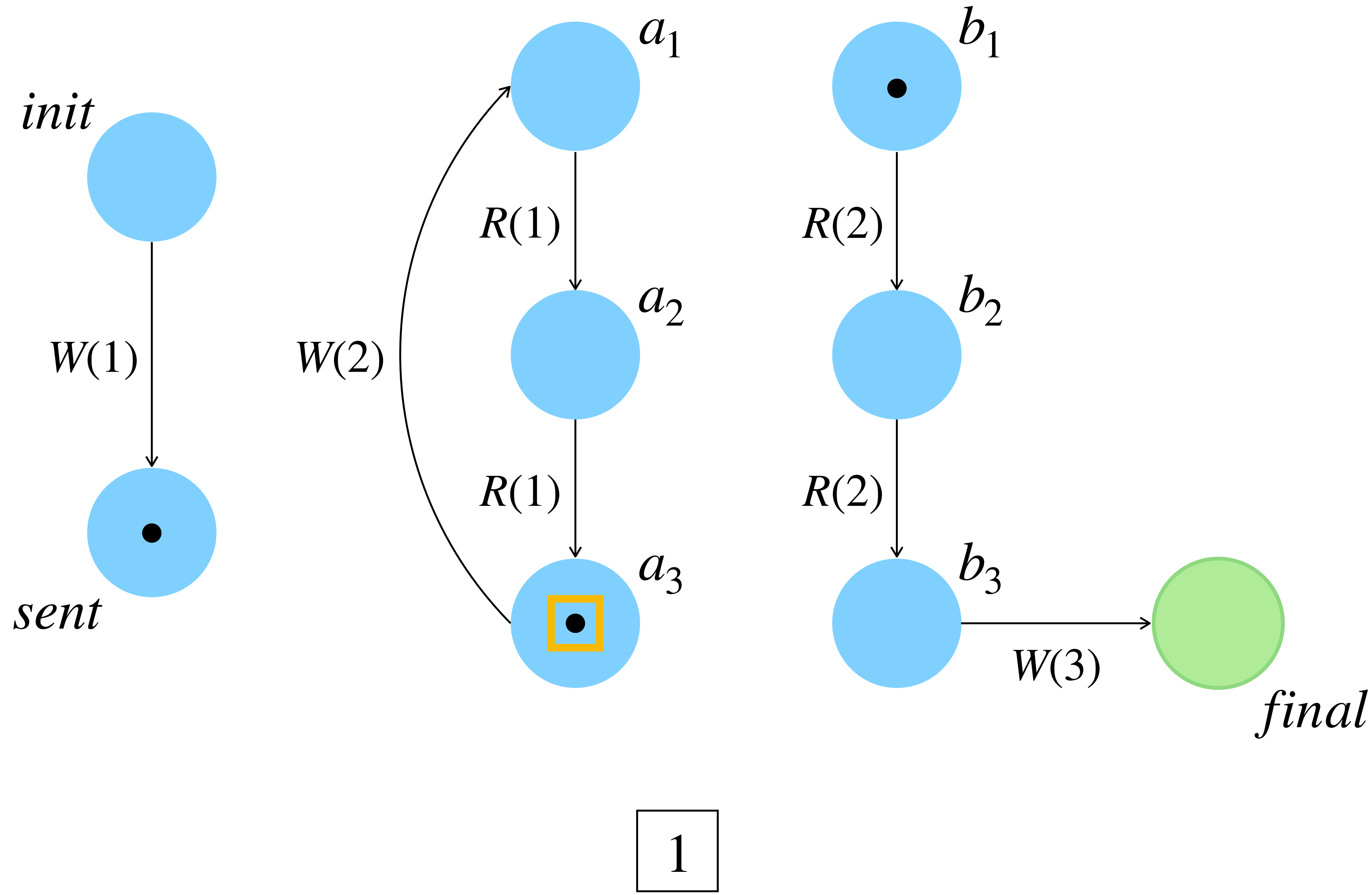

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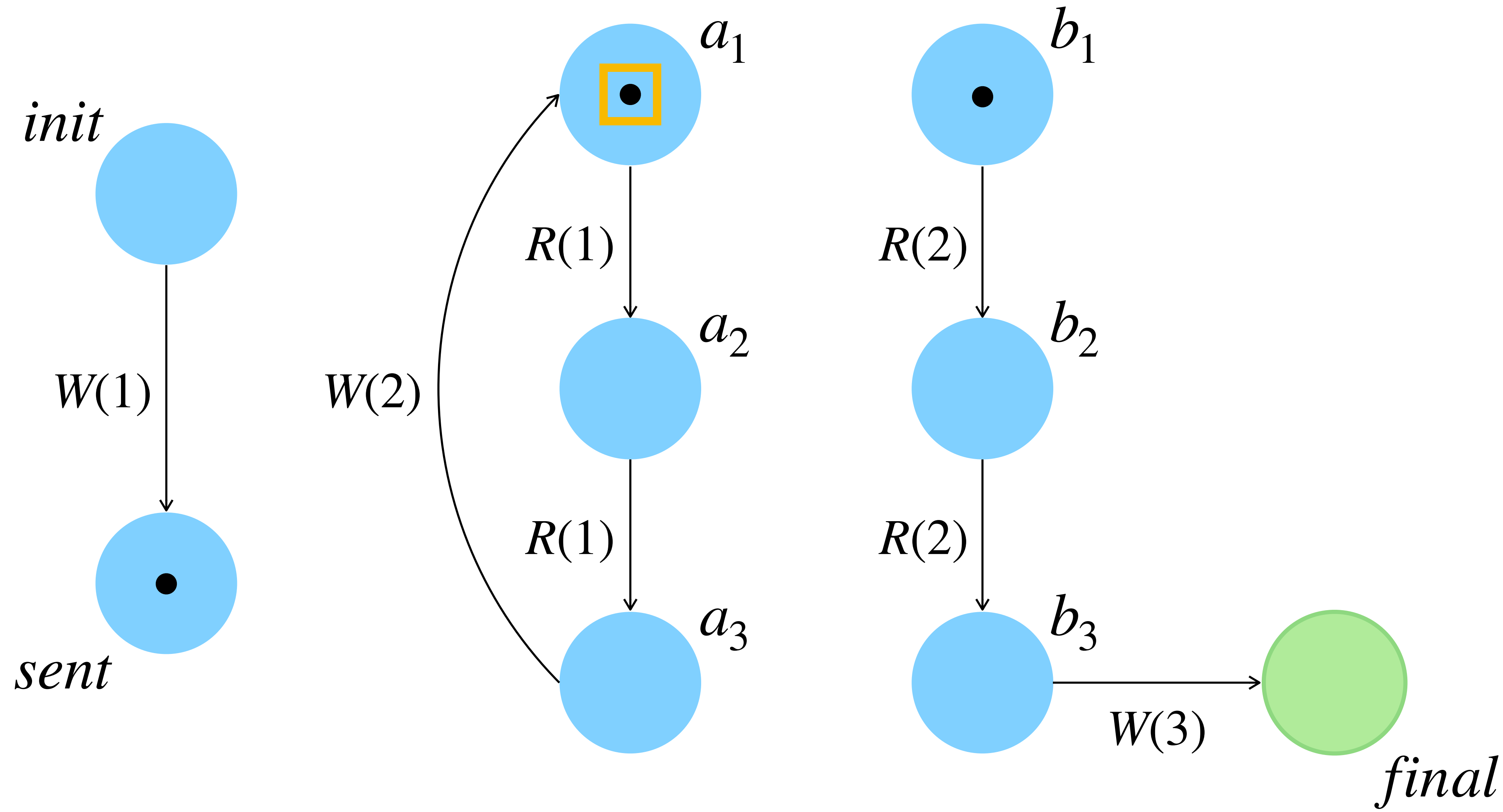

2

ASMS simulates RBN

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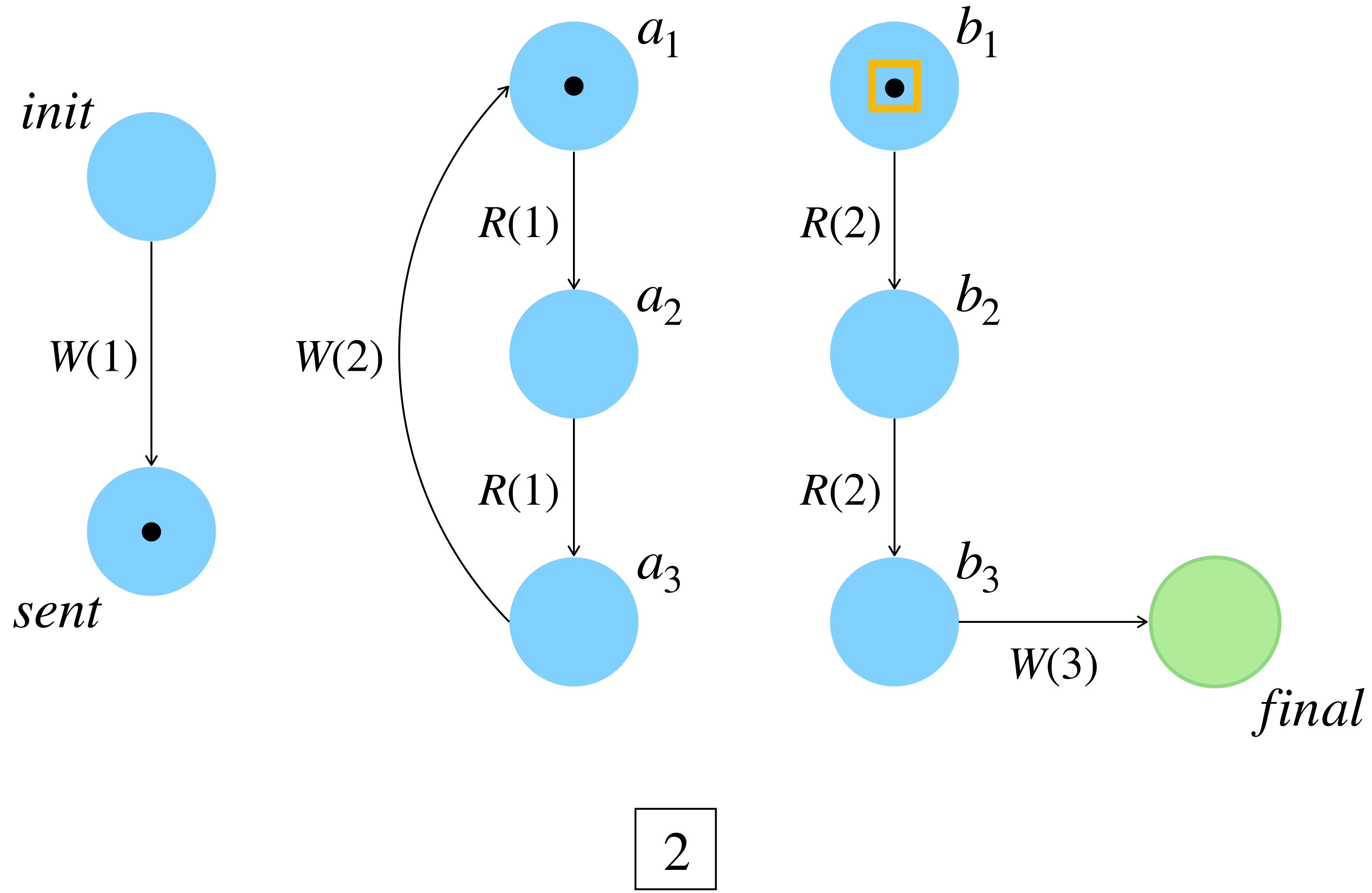

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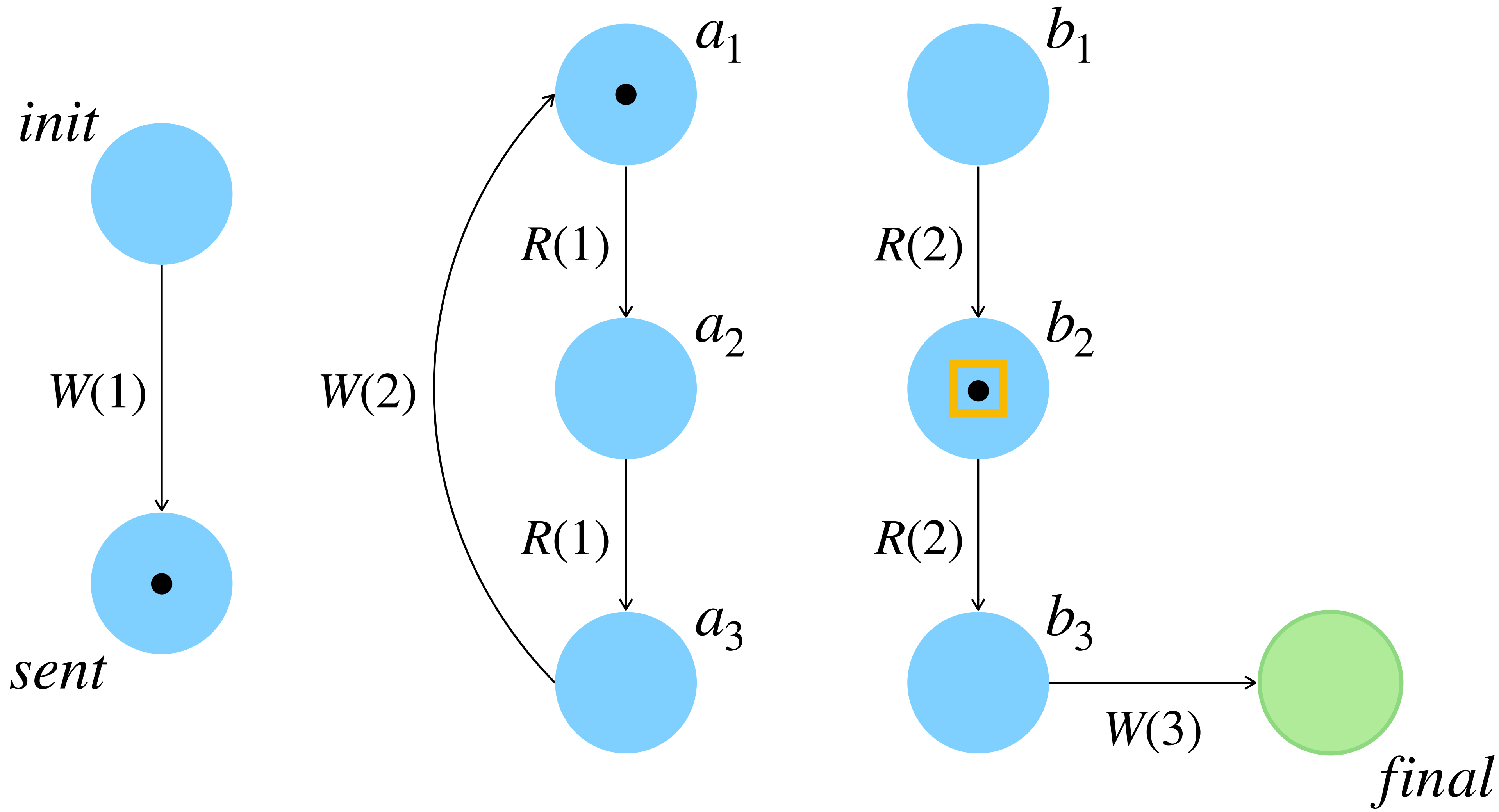

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ASMS simulates RBN

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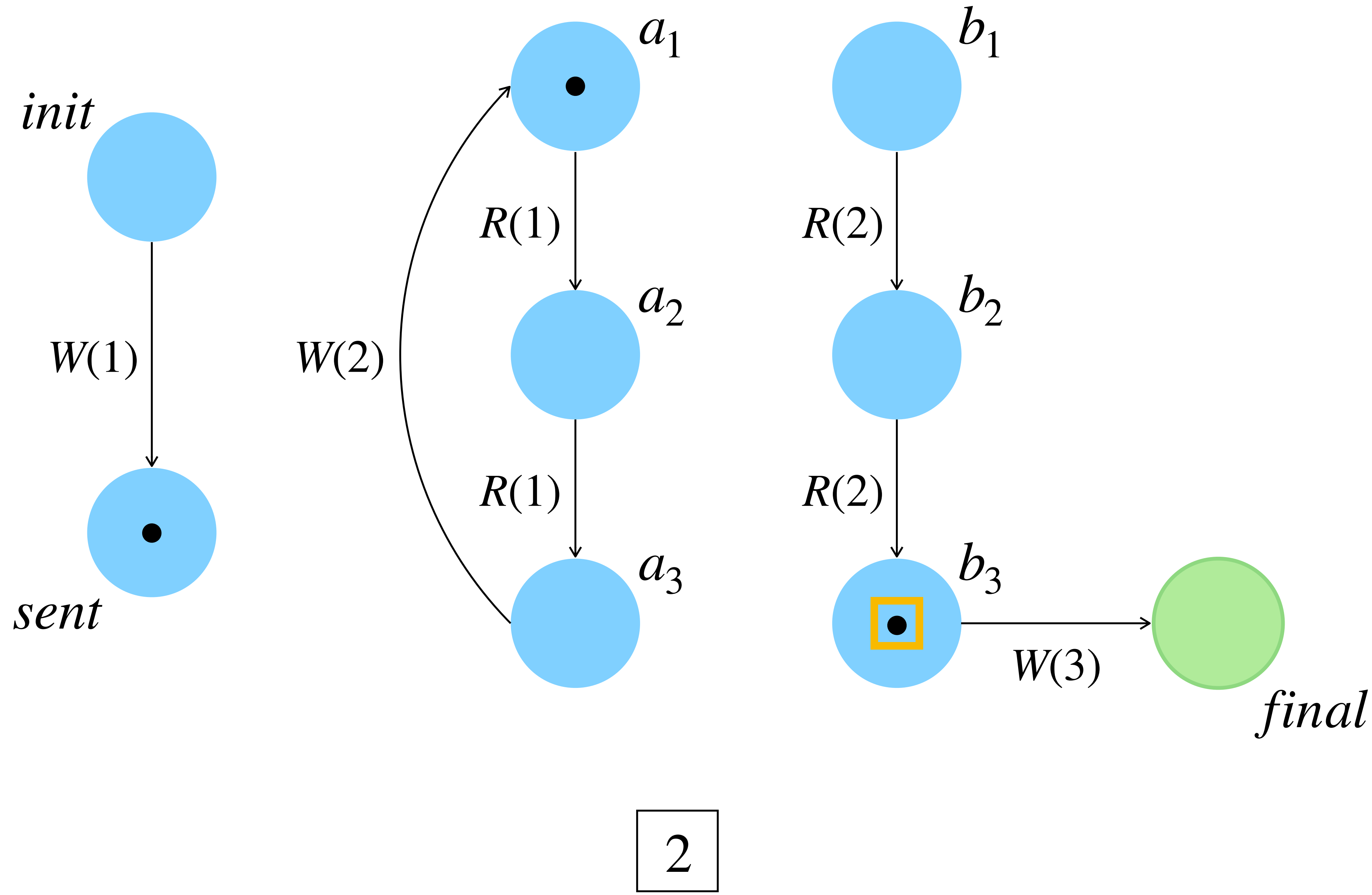

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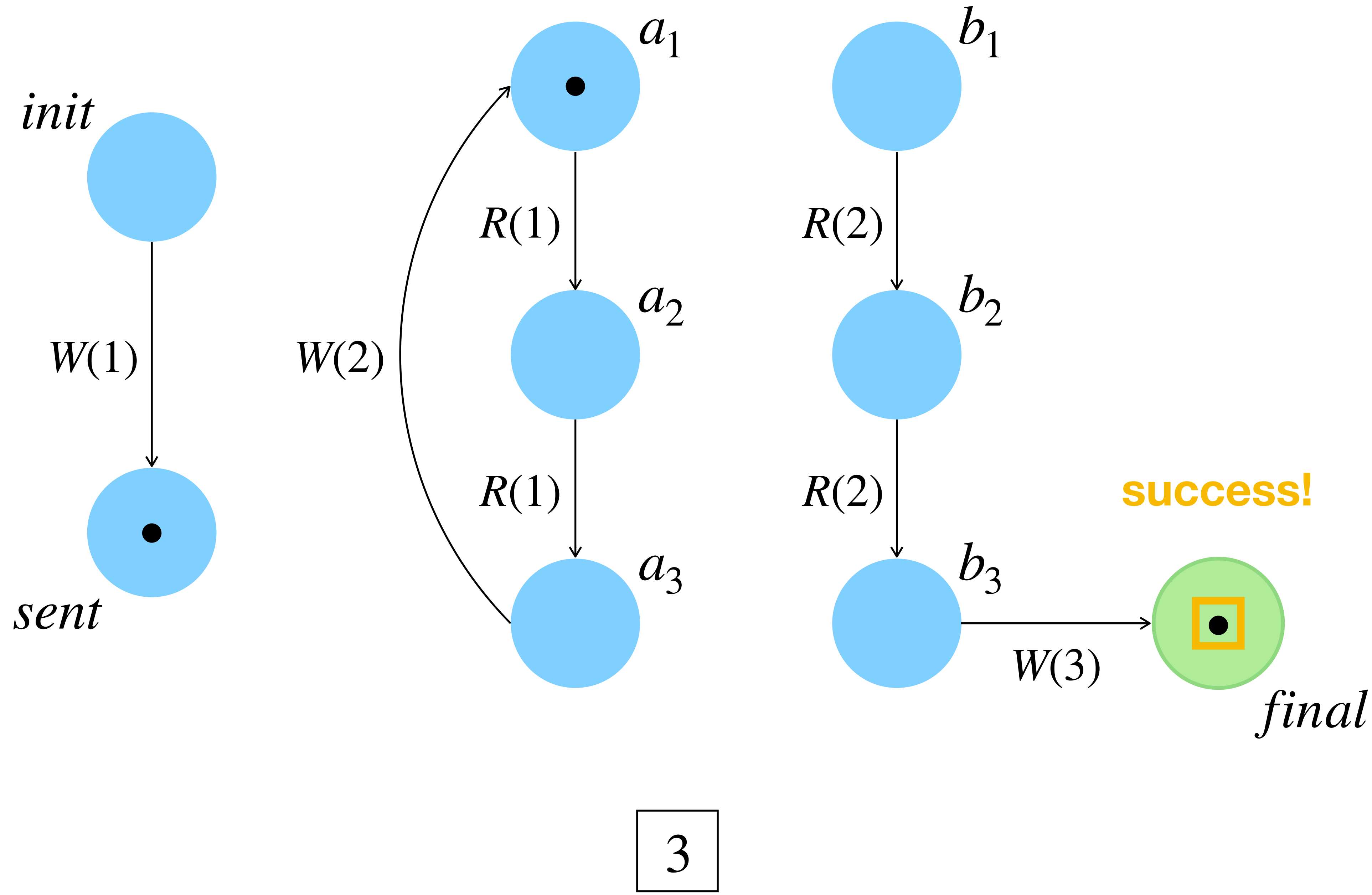

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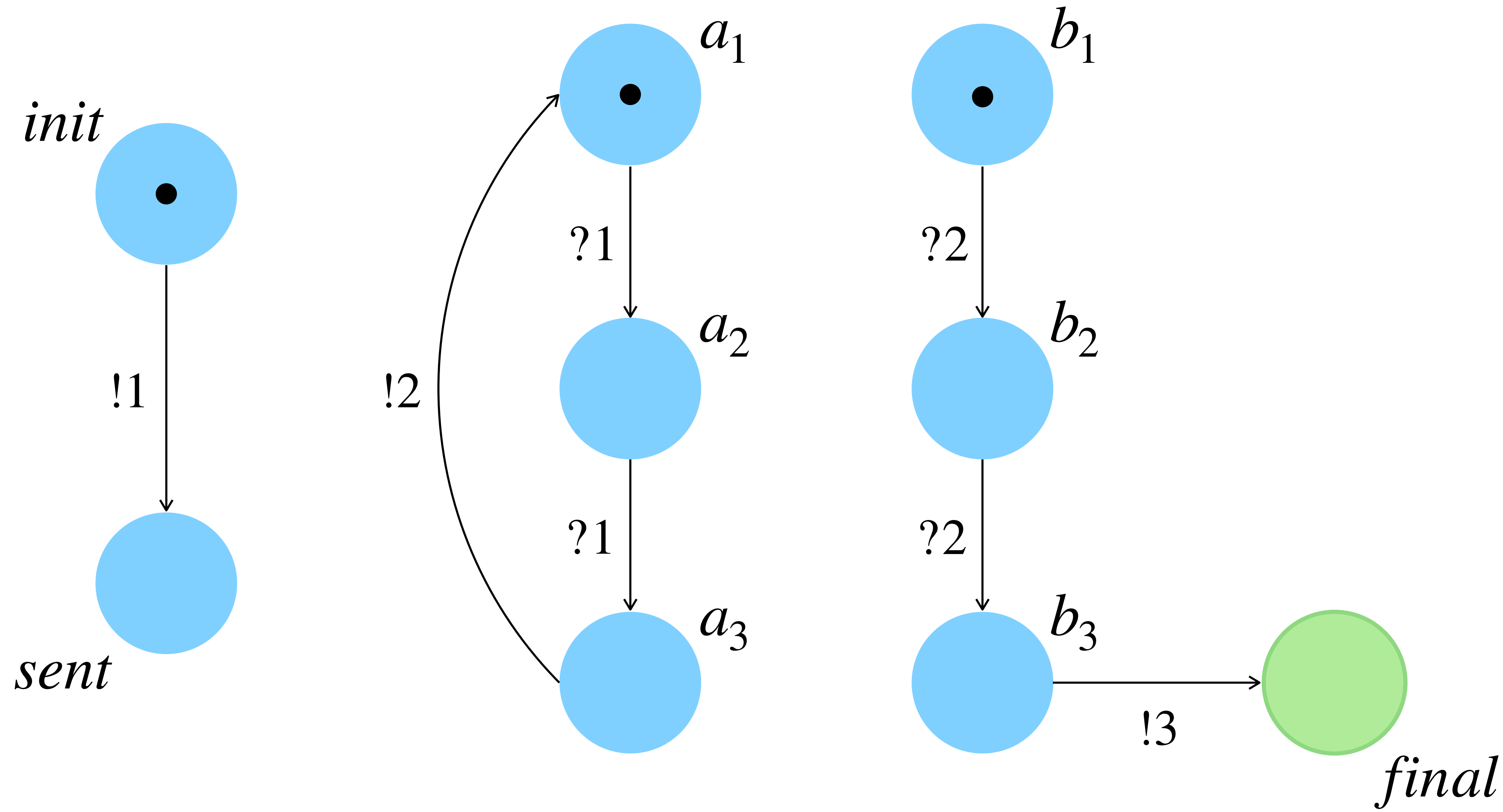

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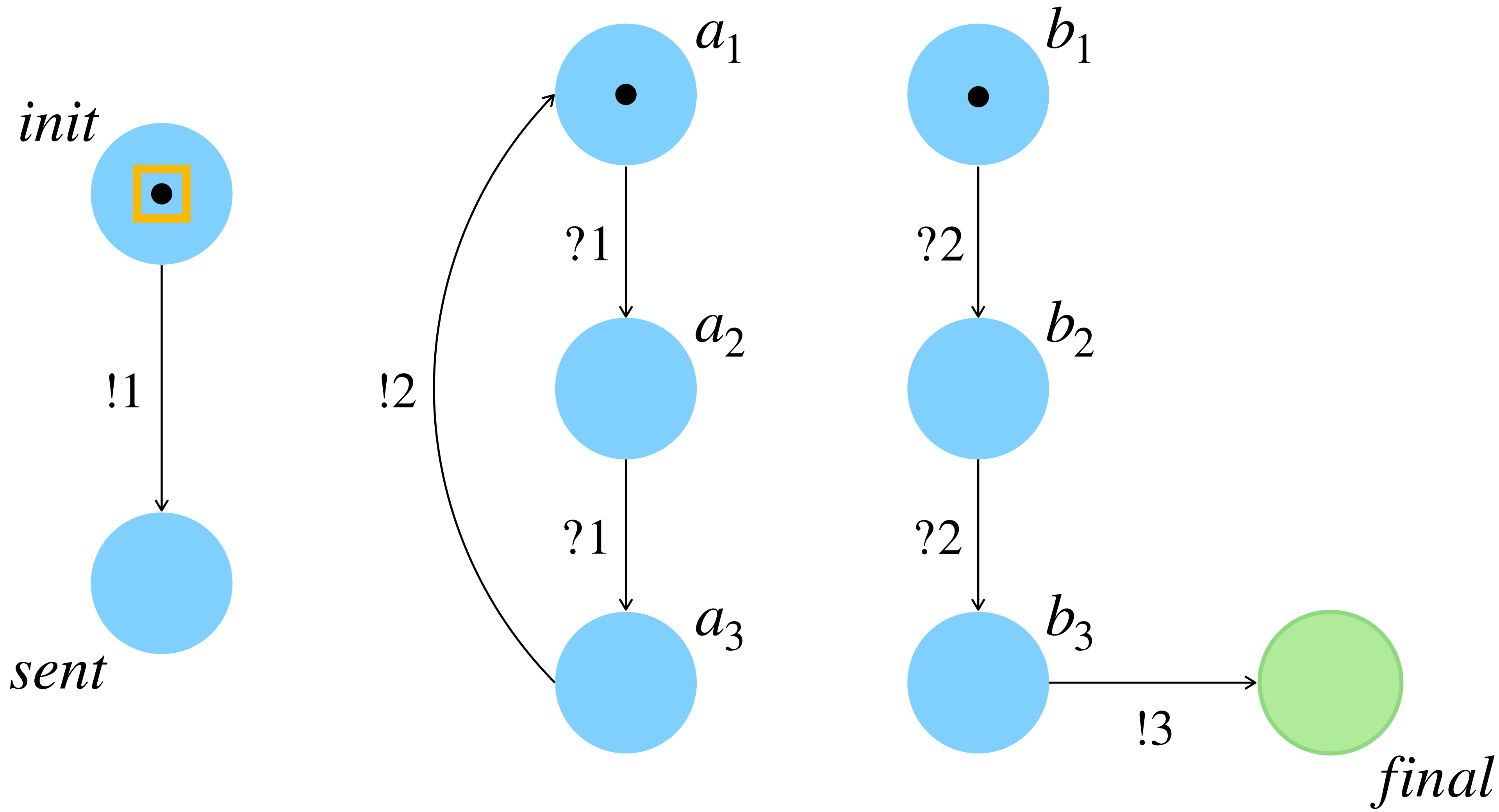

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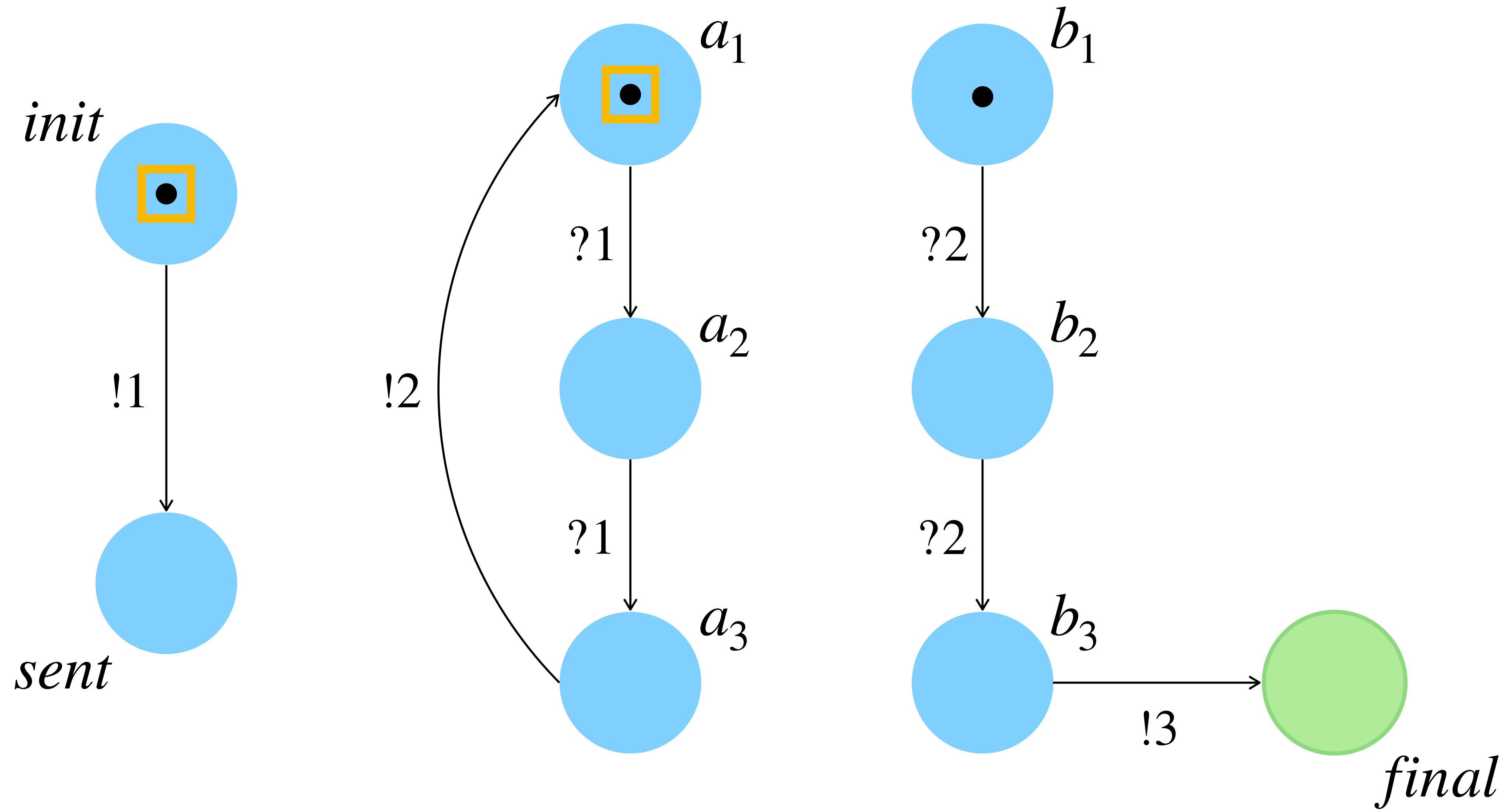

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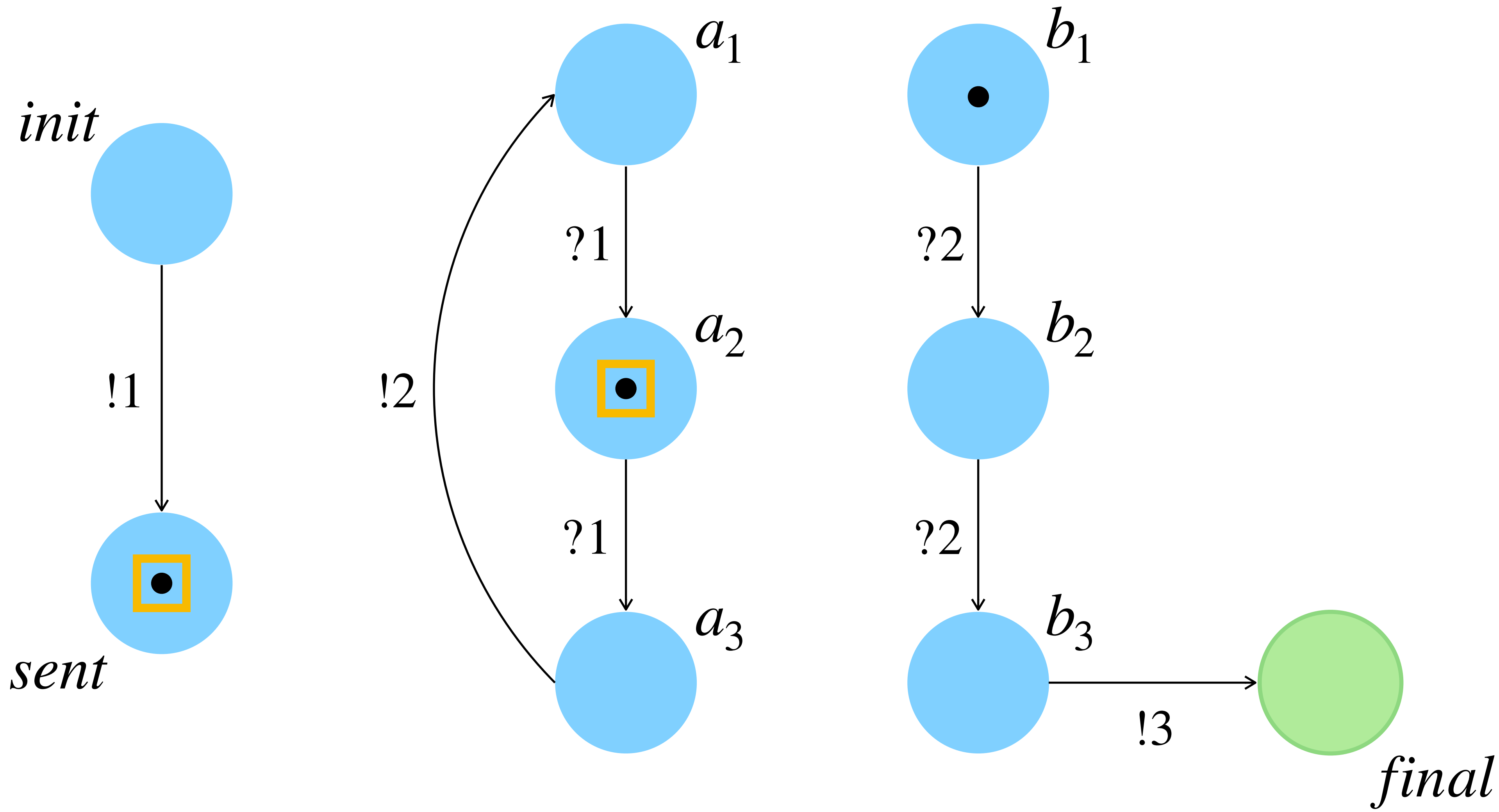

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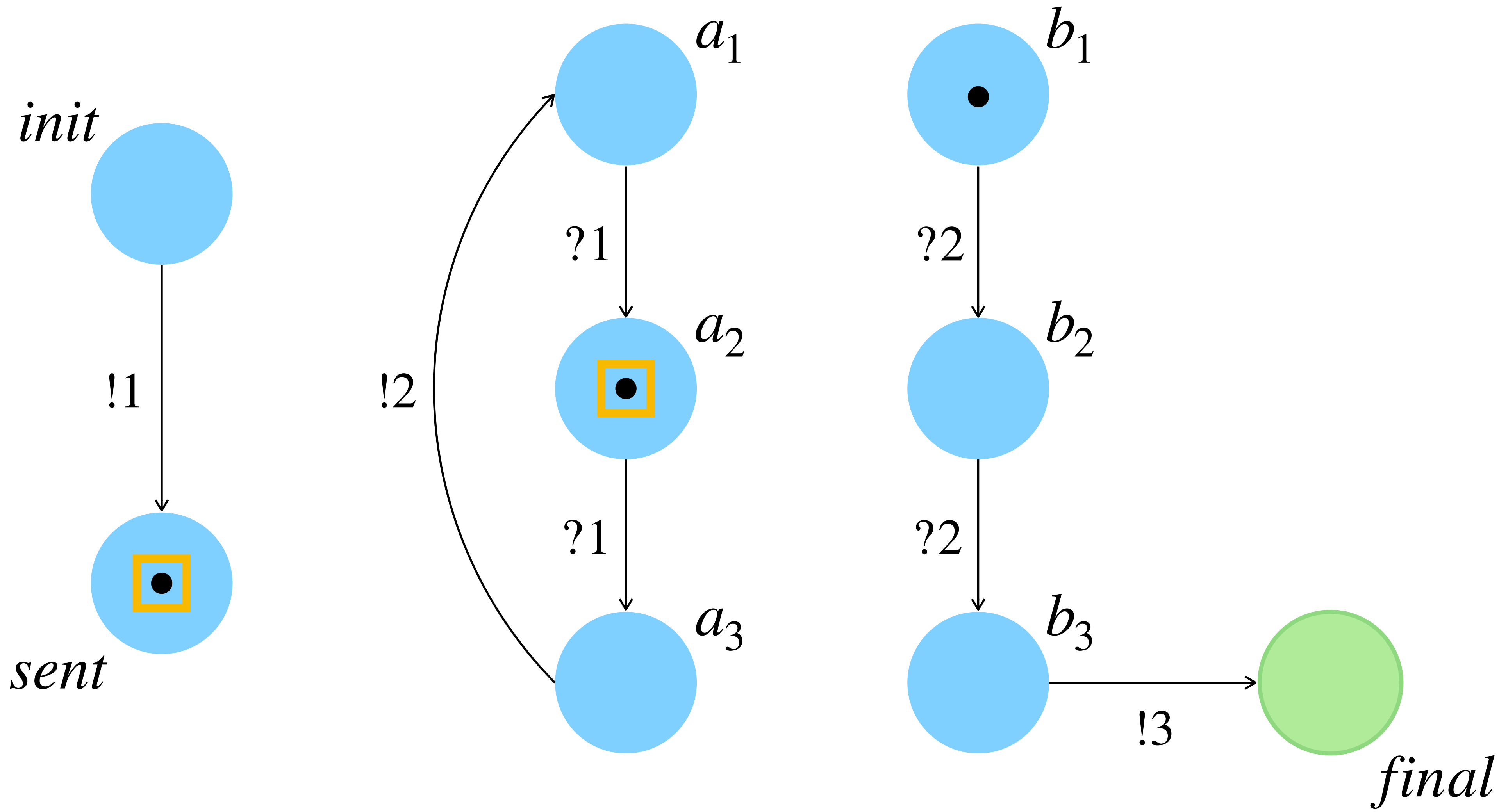

stuck…

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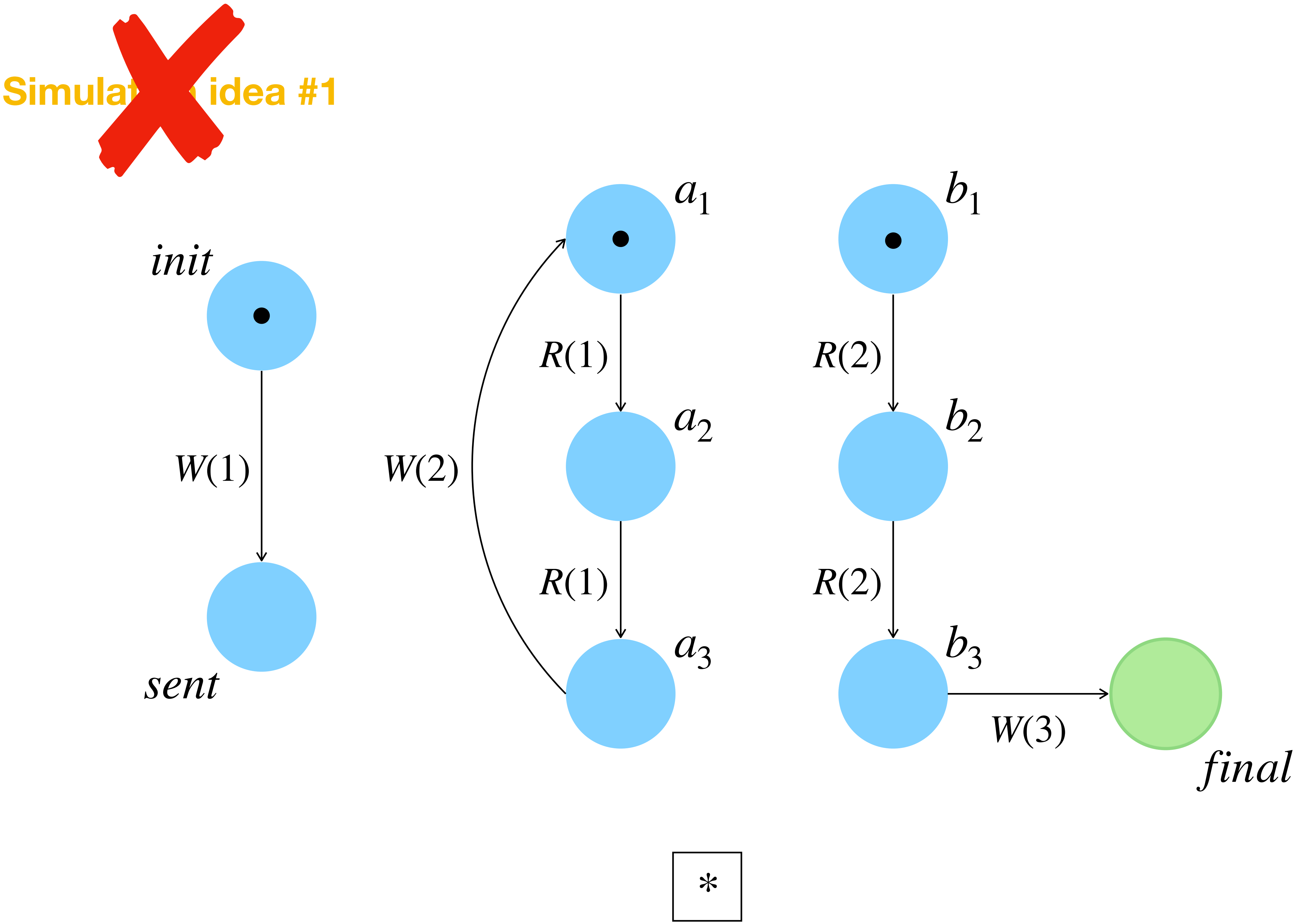

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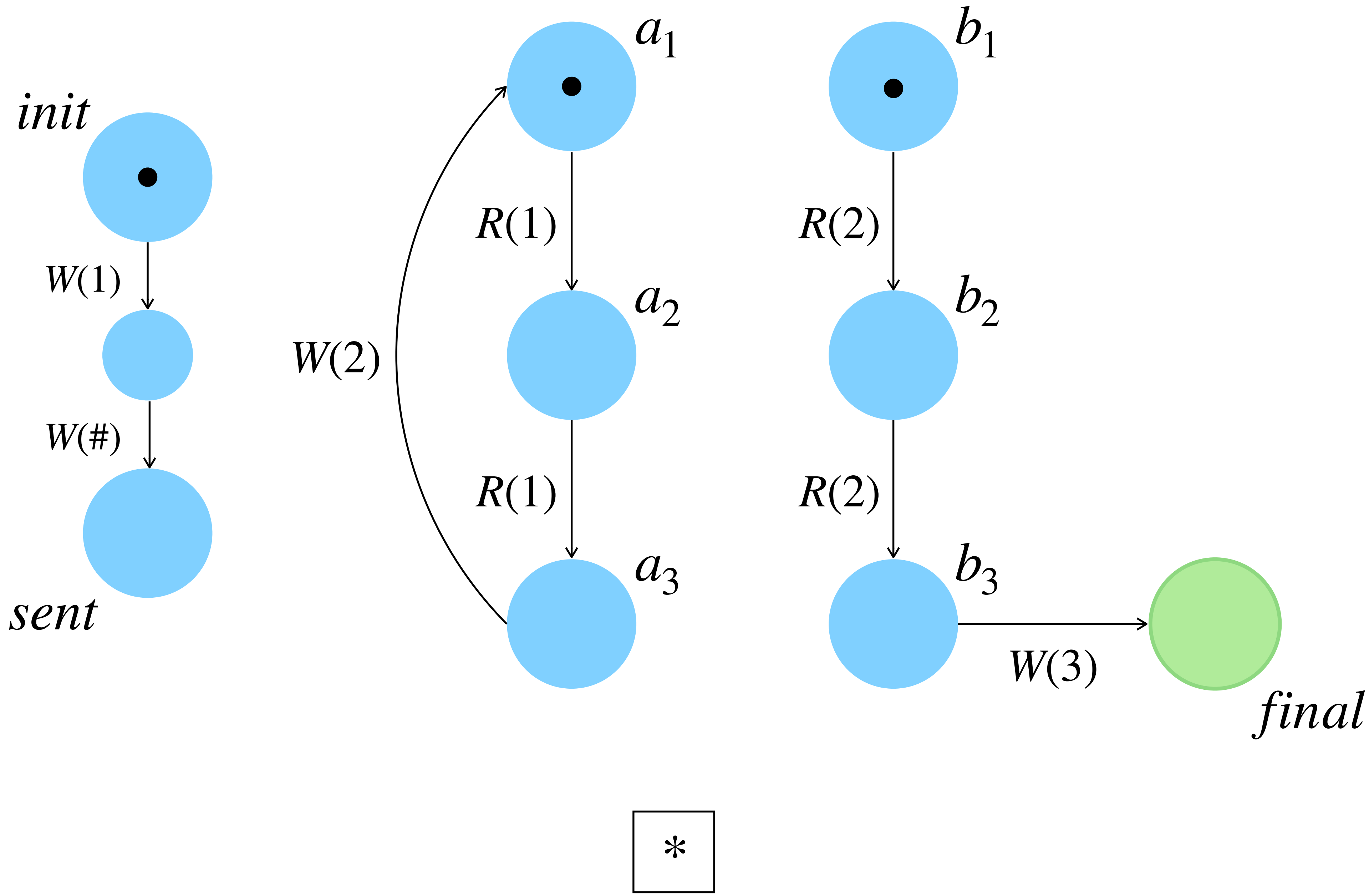
Simulation idea #2



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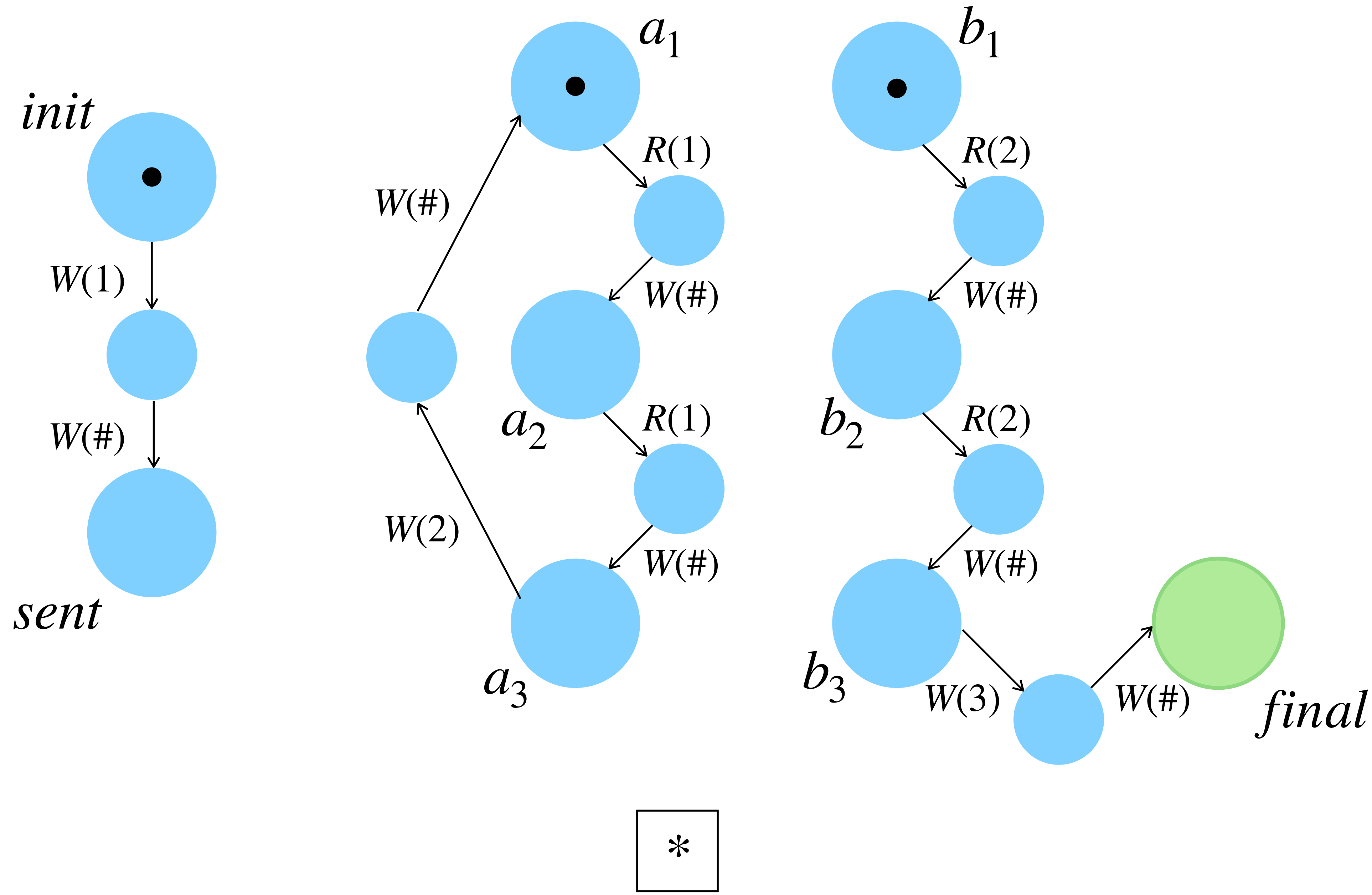

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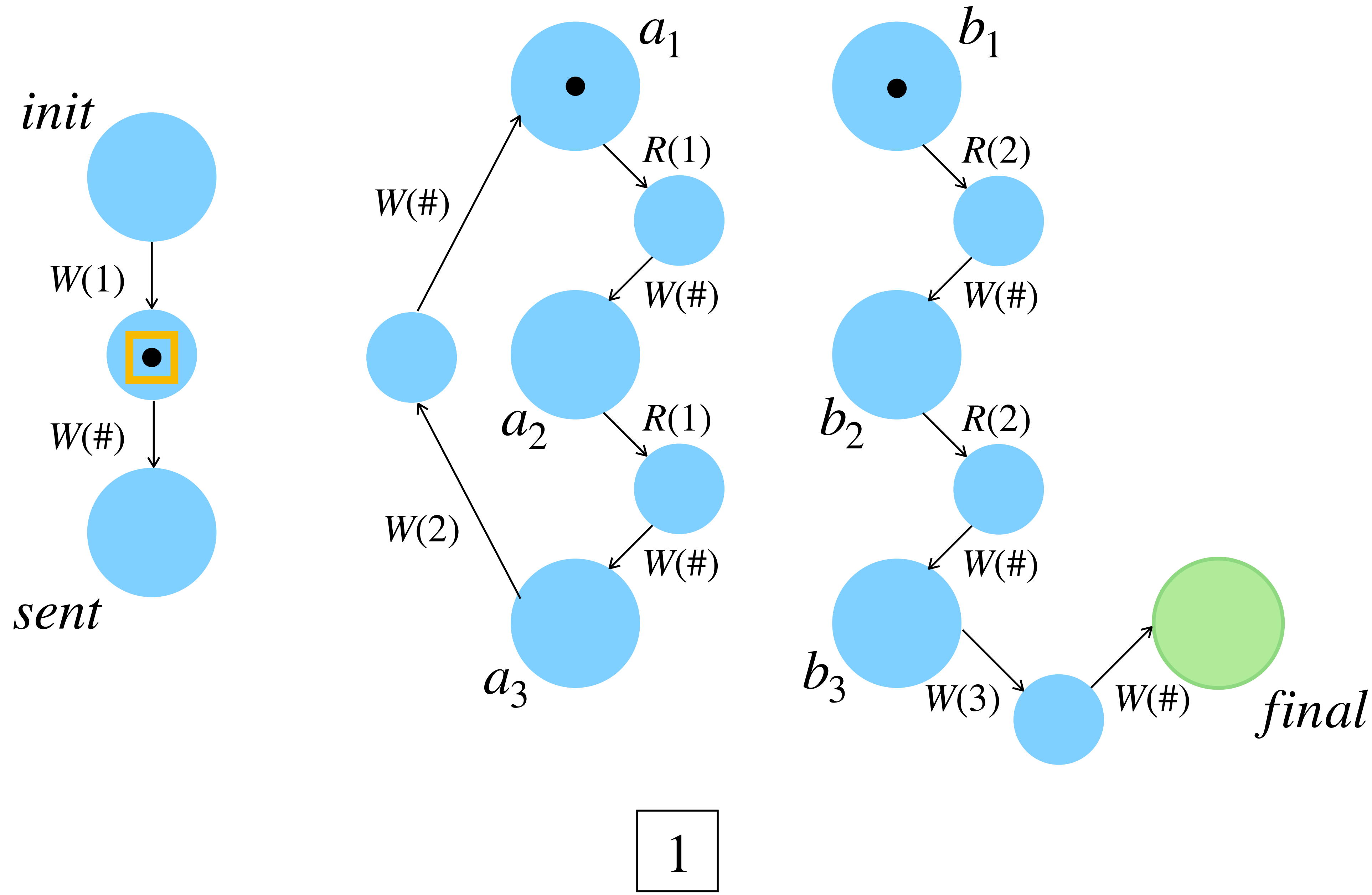

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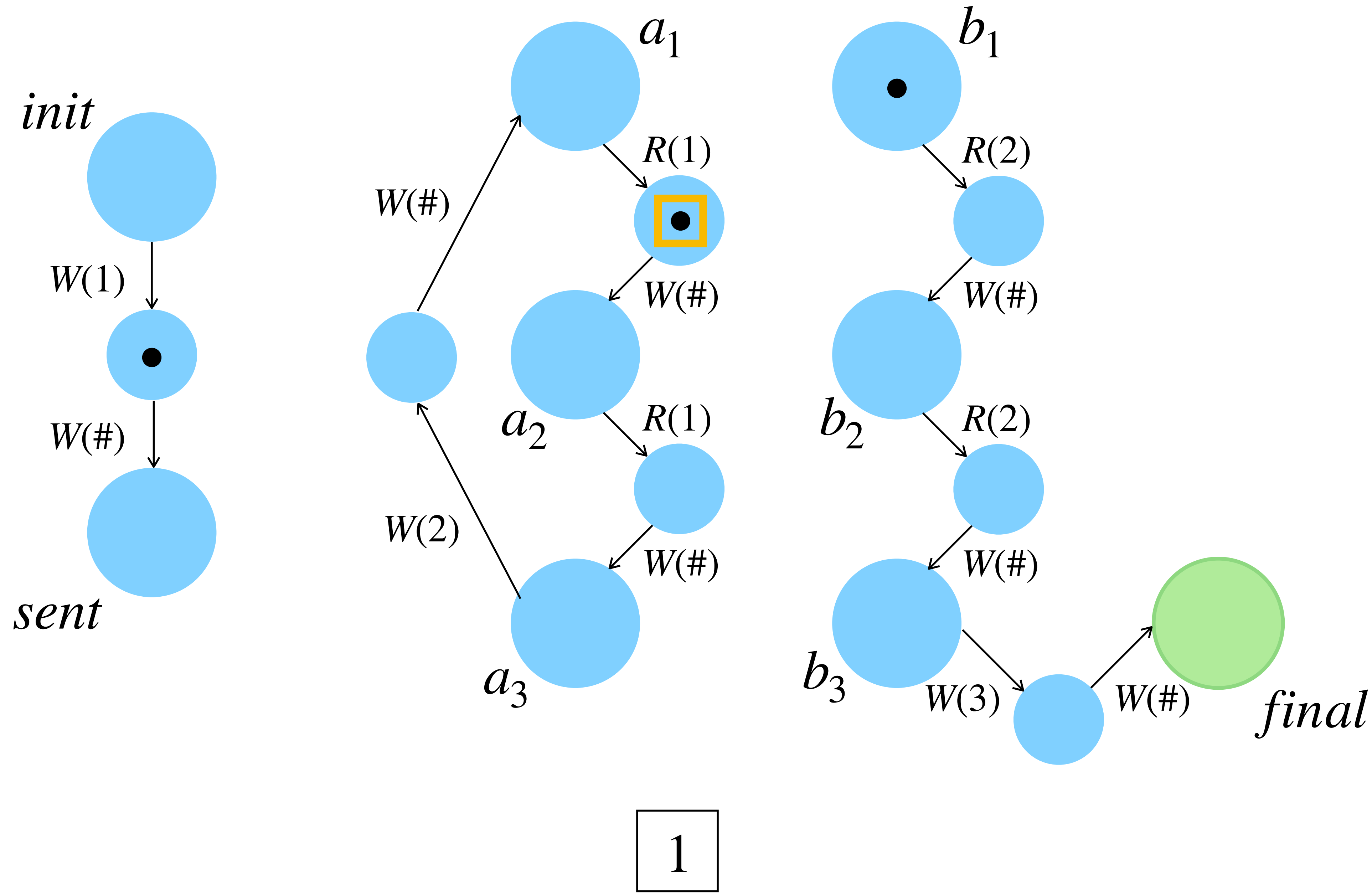

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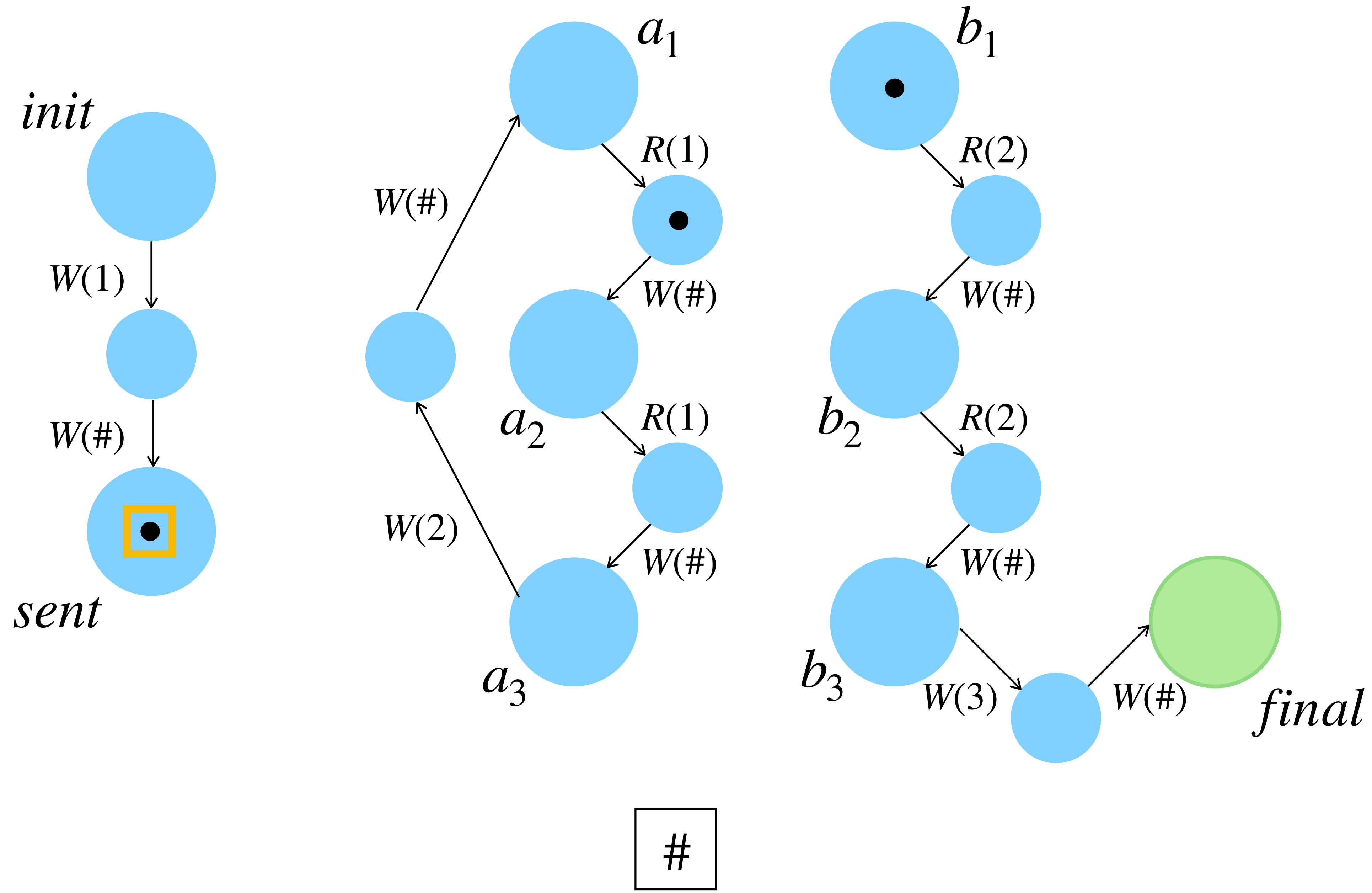

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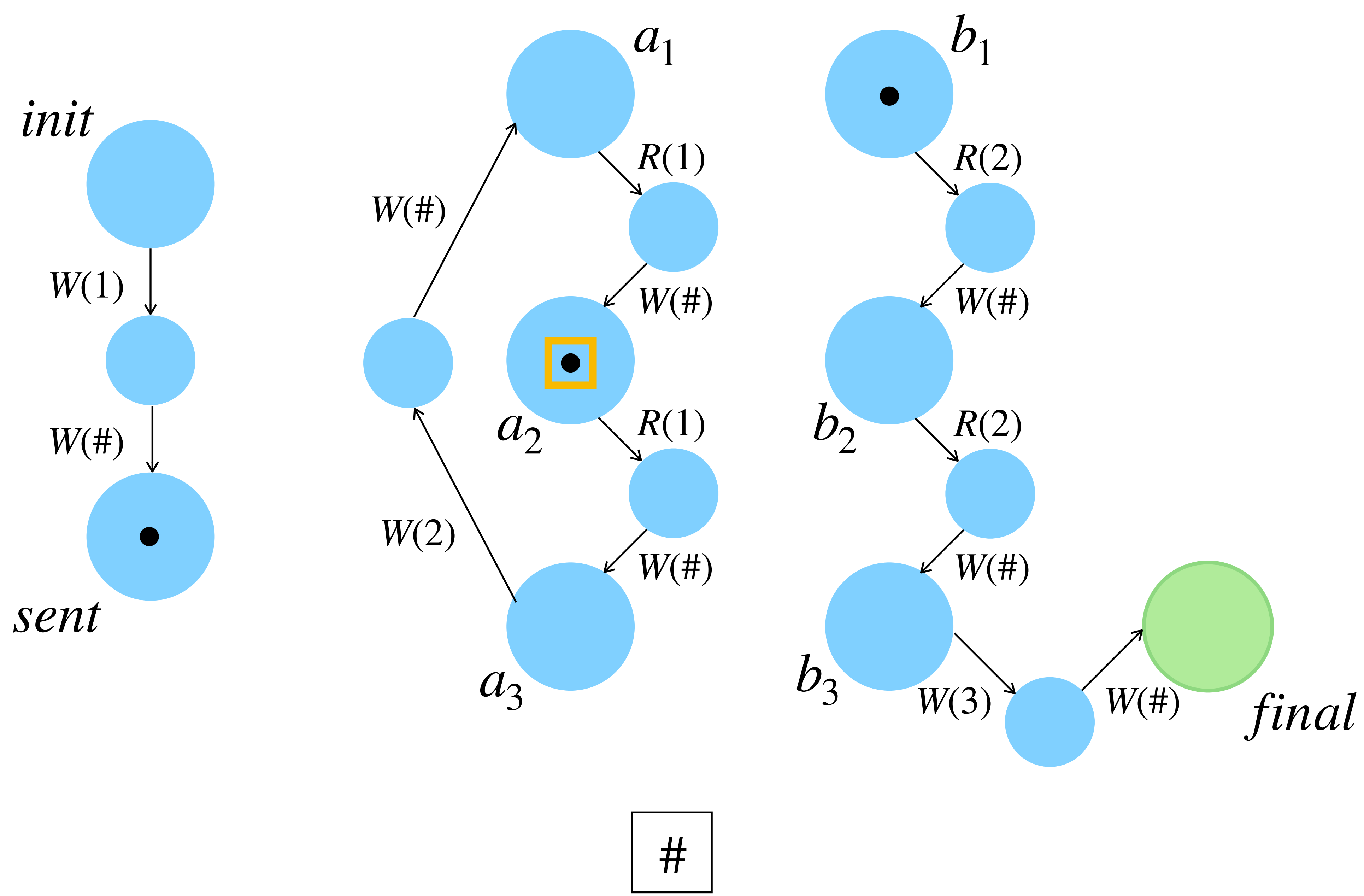

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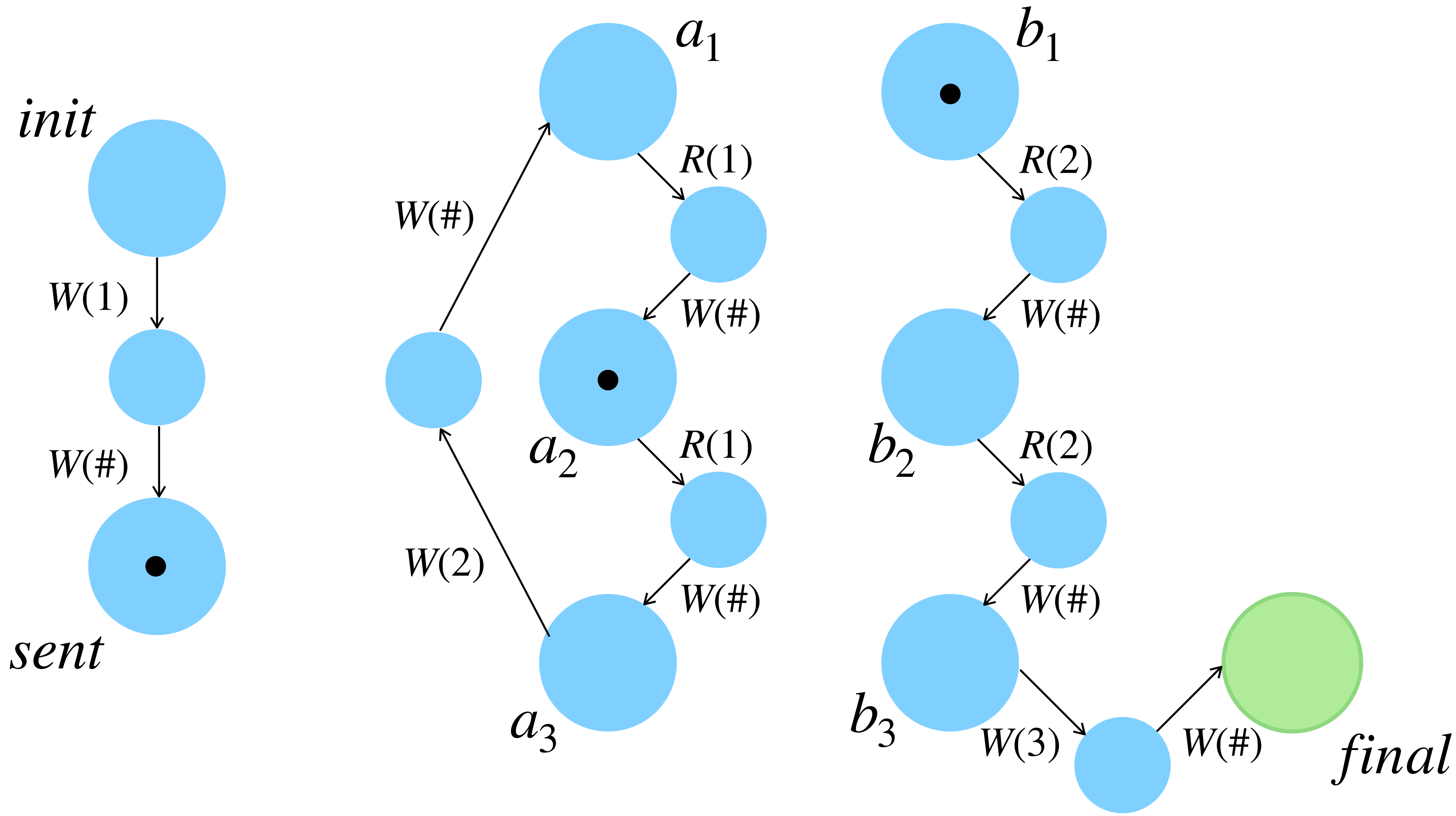

stuck…

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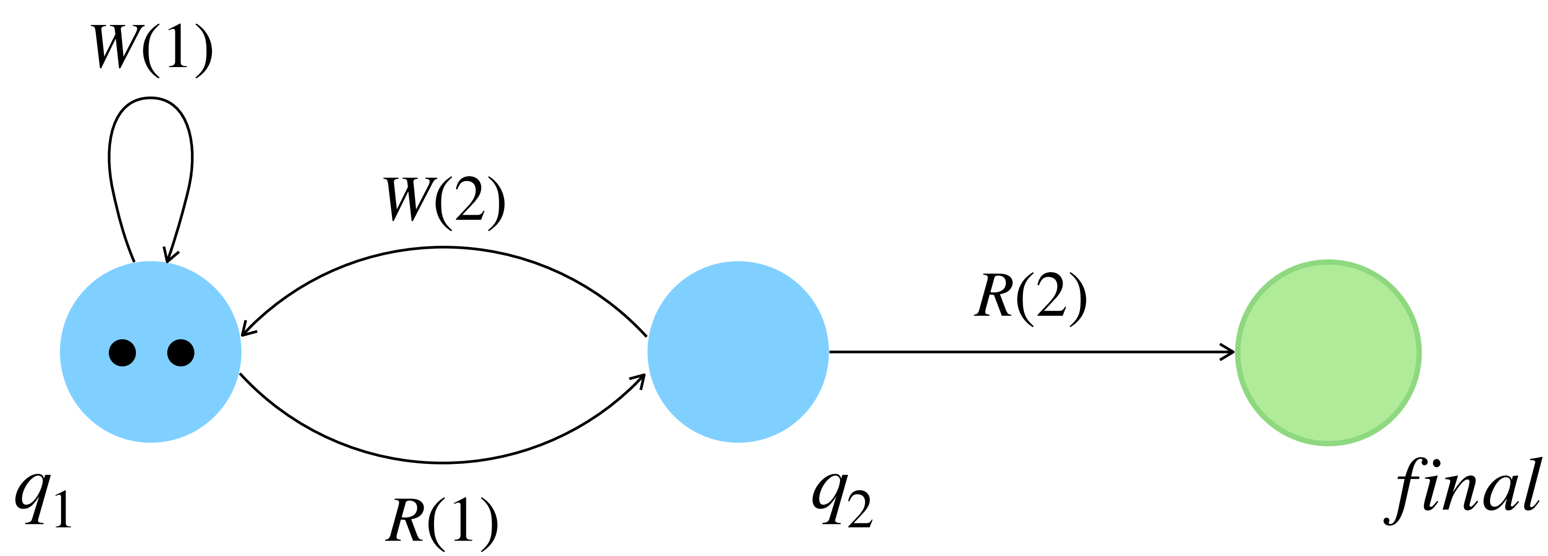
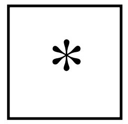
Simulation of polynomial-size with bijection between configurations





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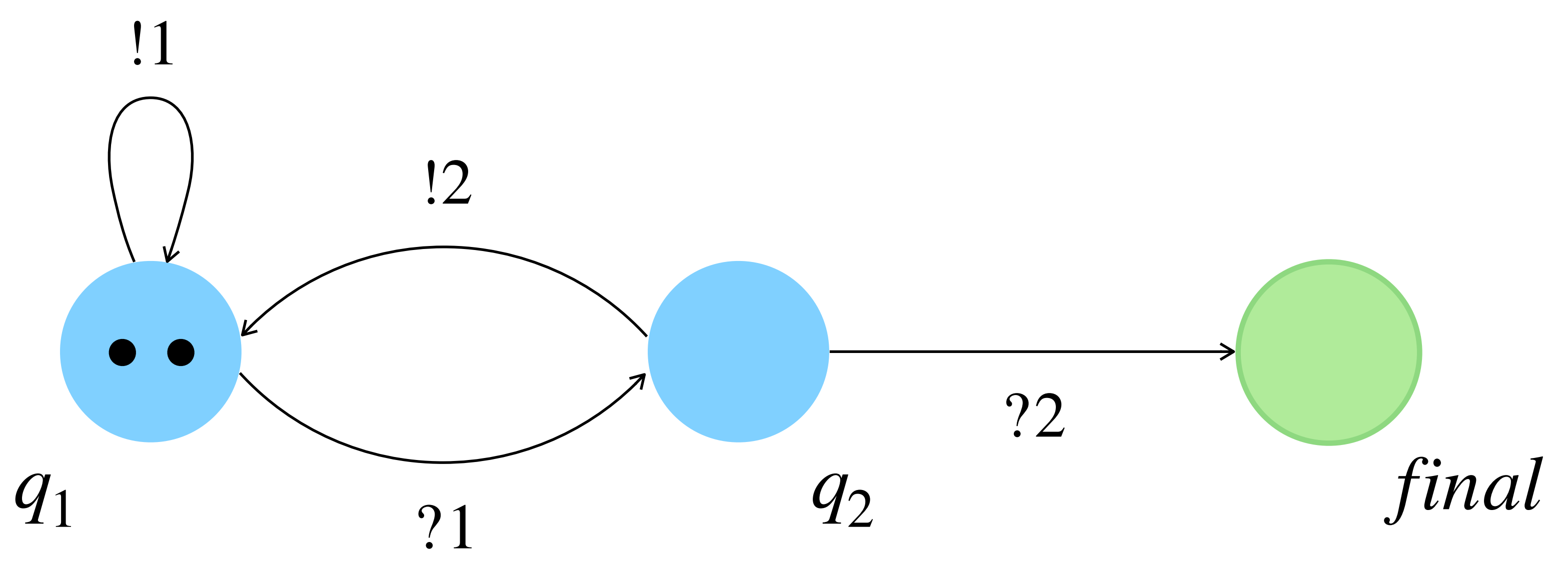

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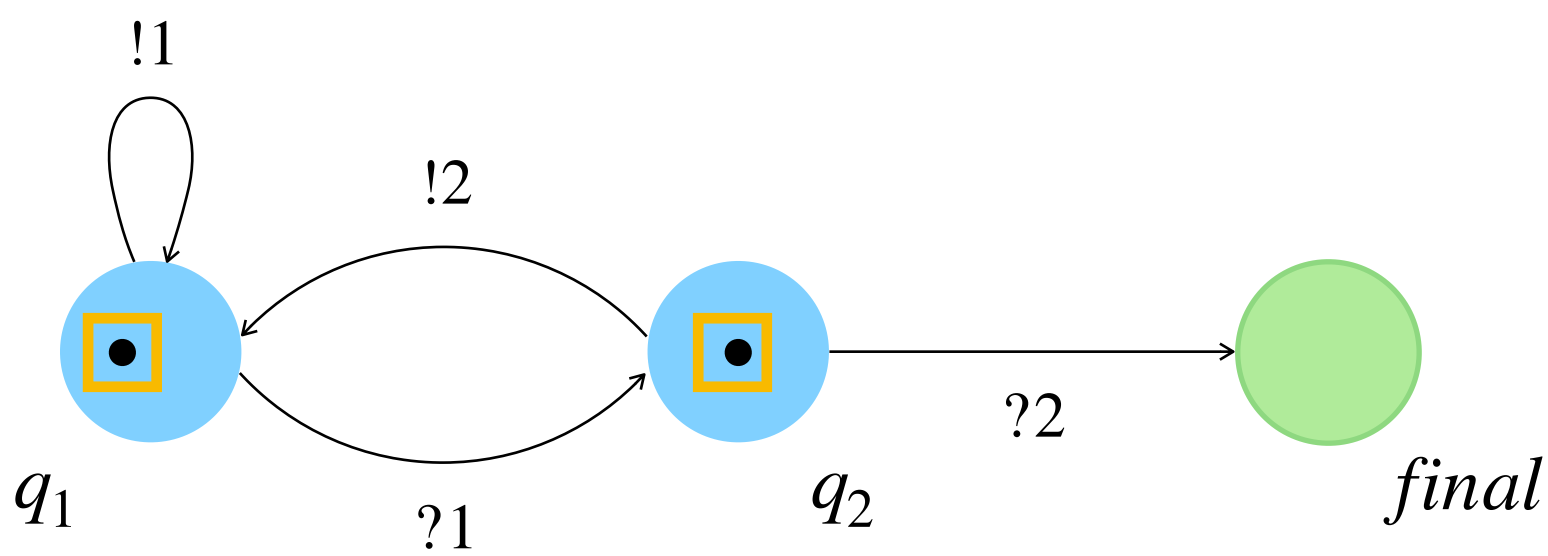

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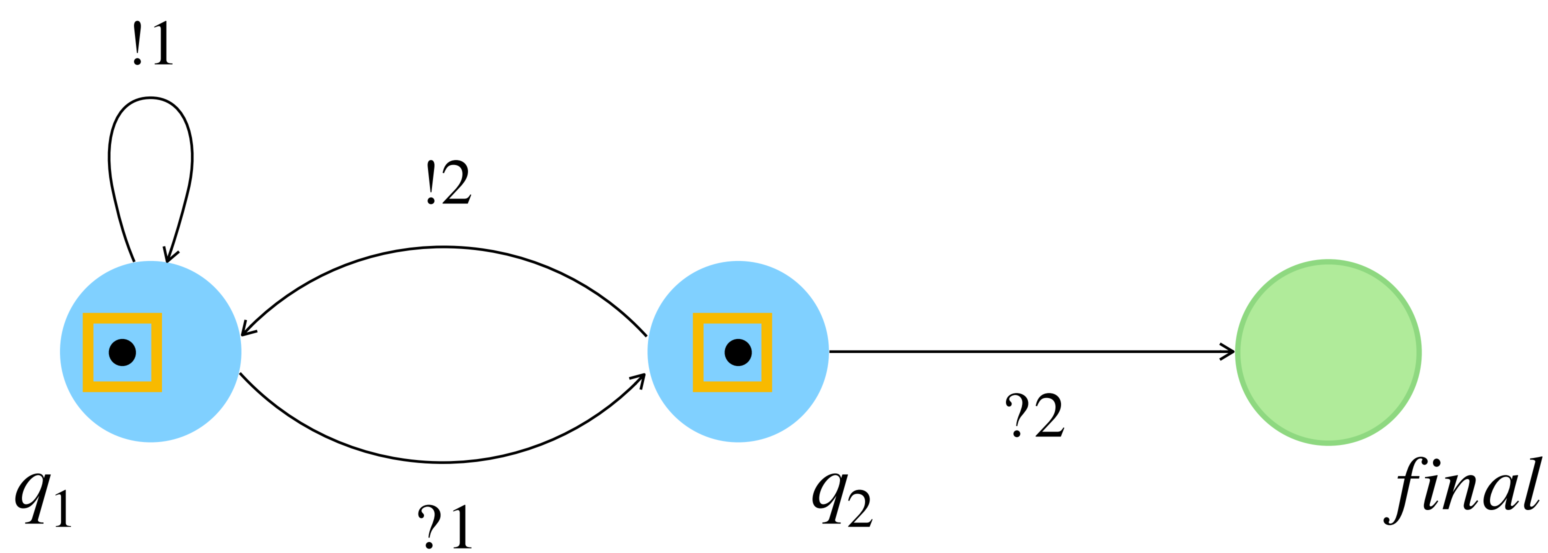

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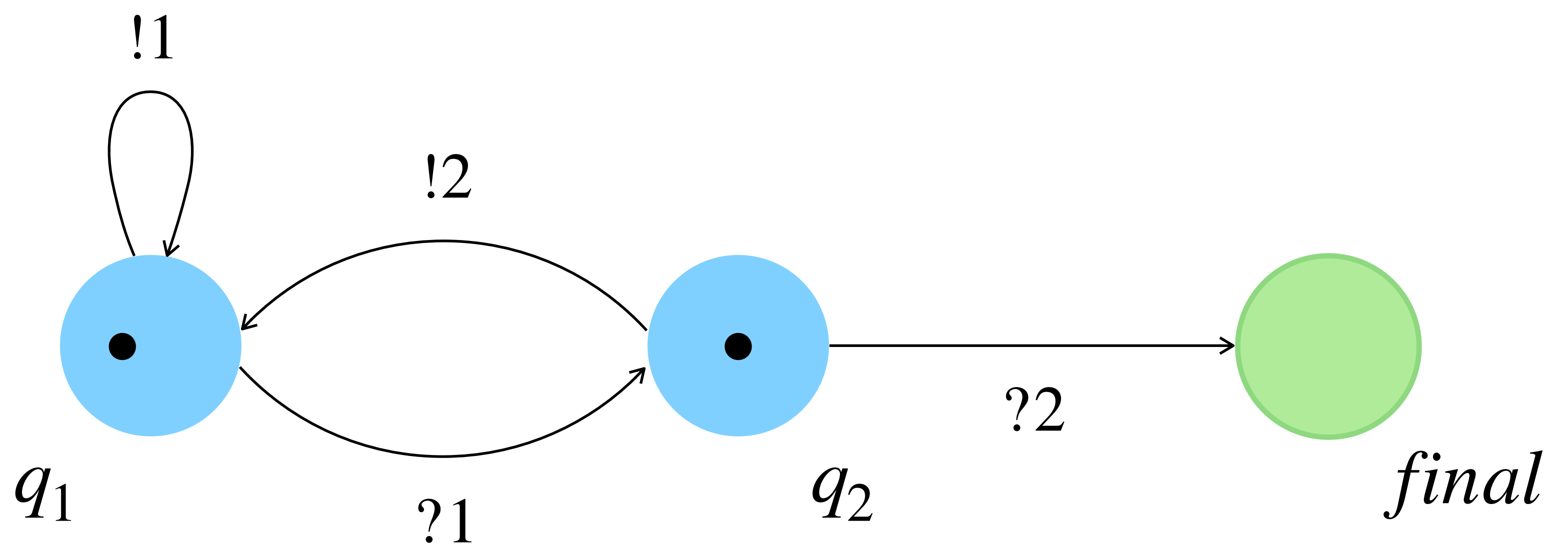

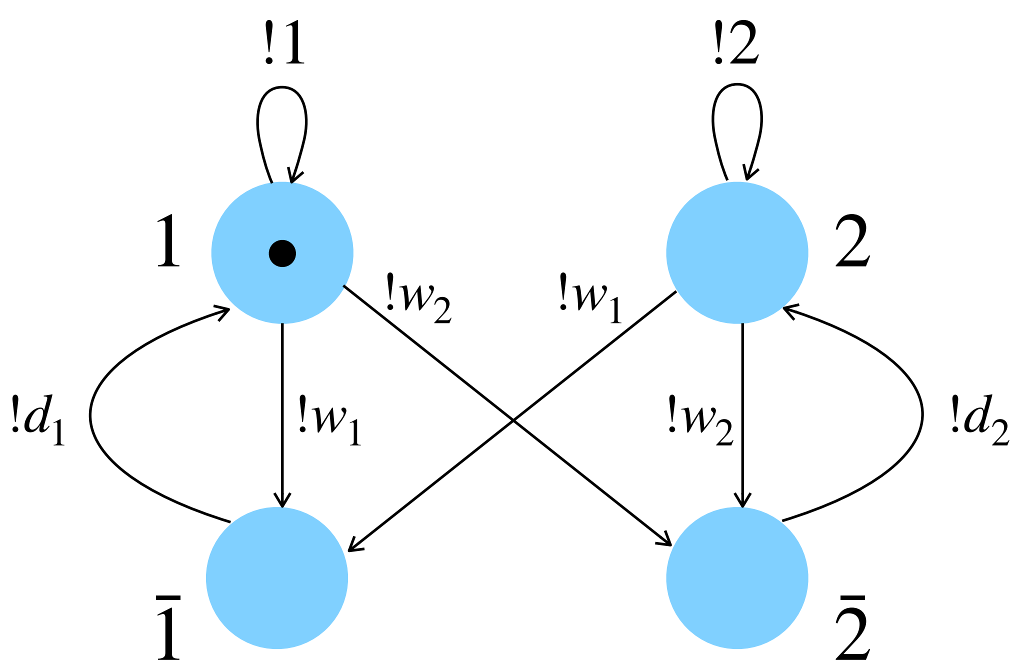

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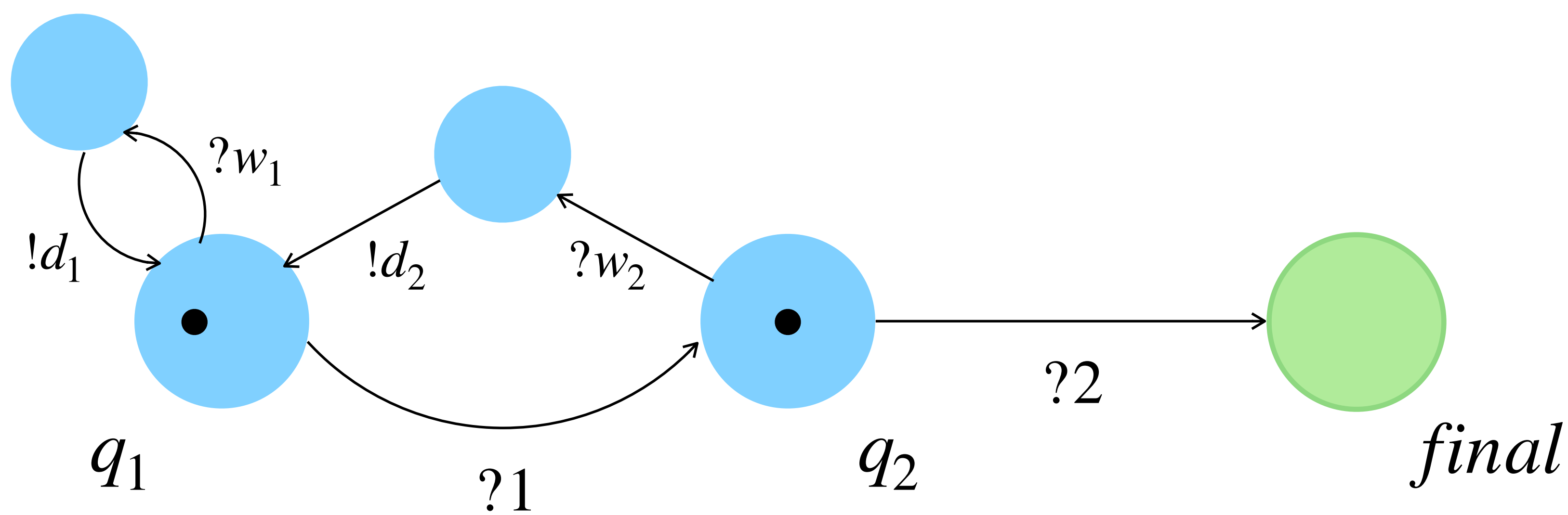

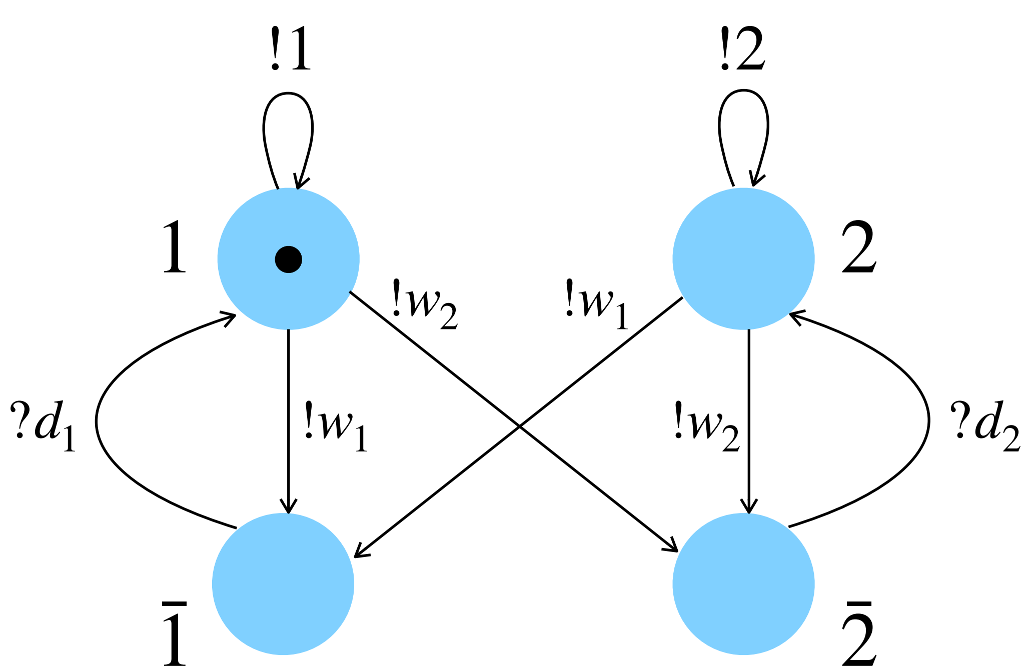

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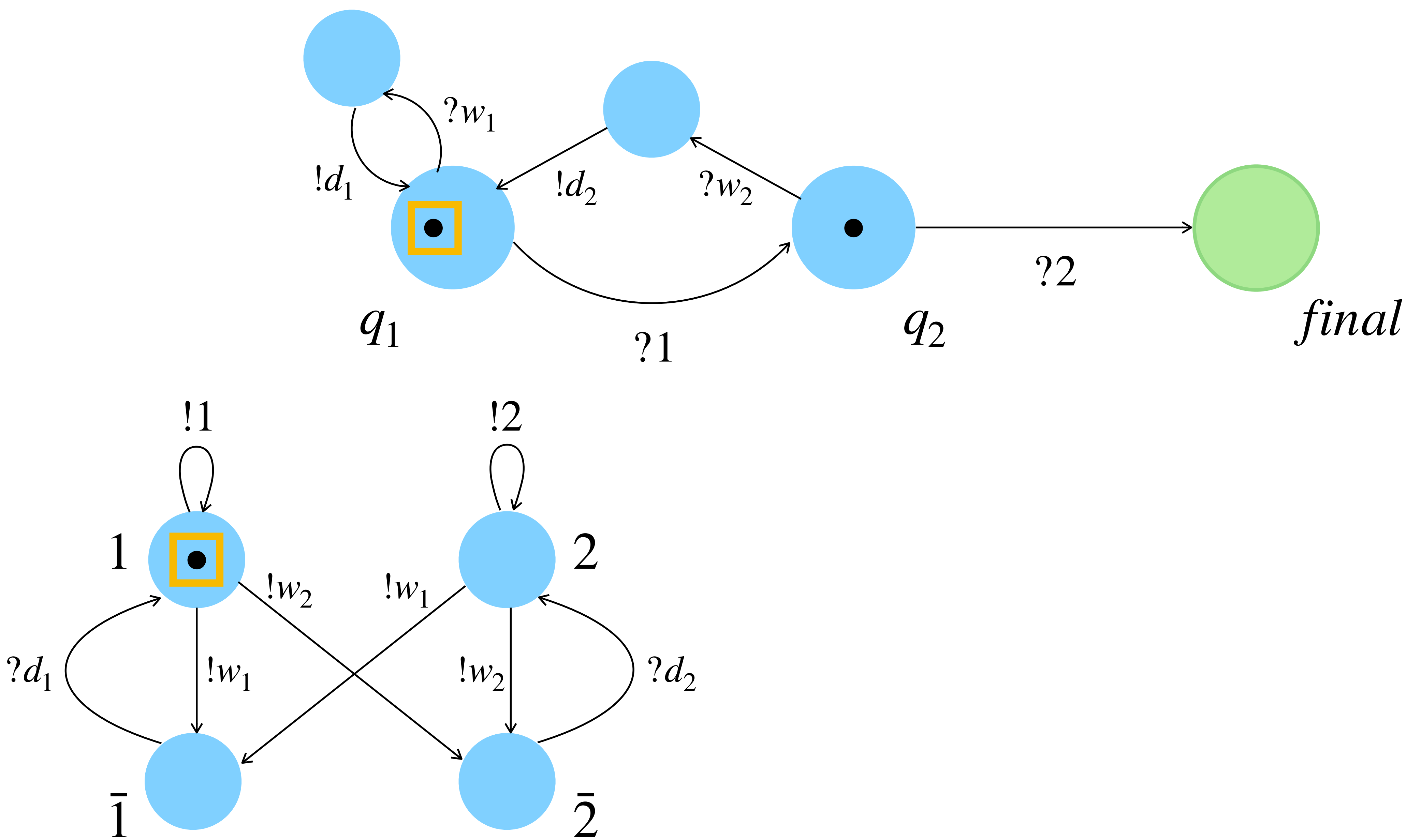

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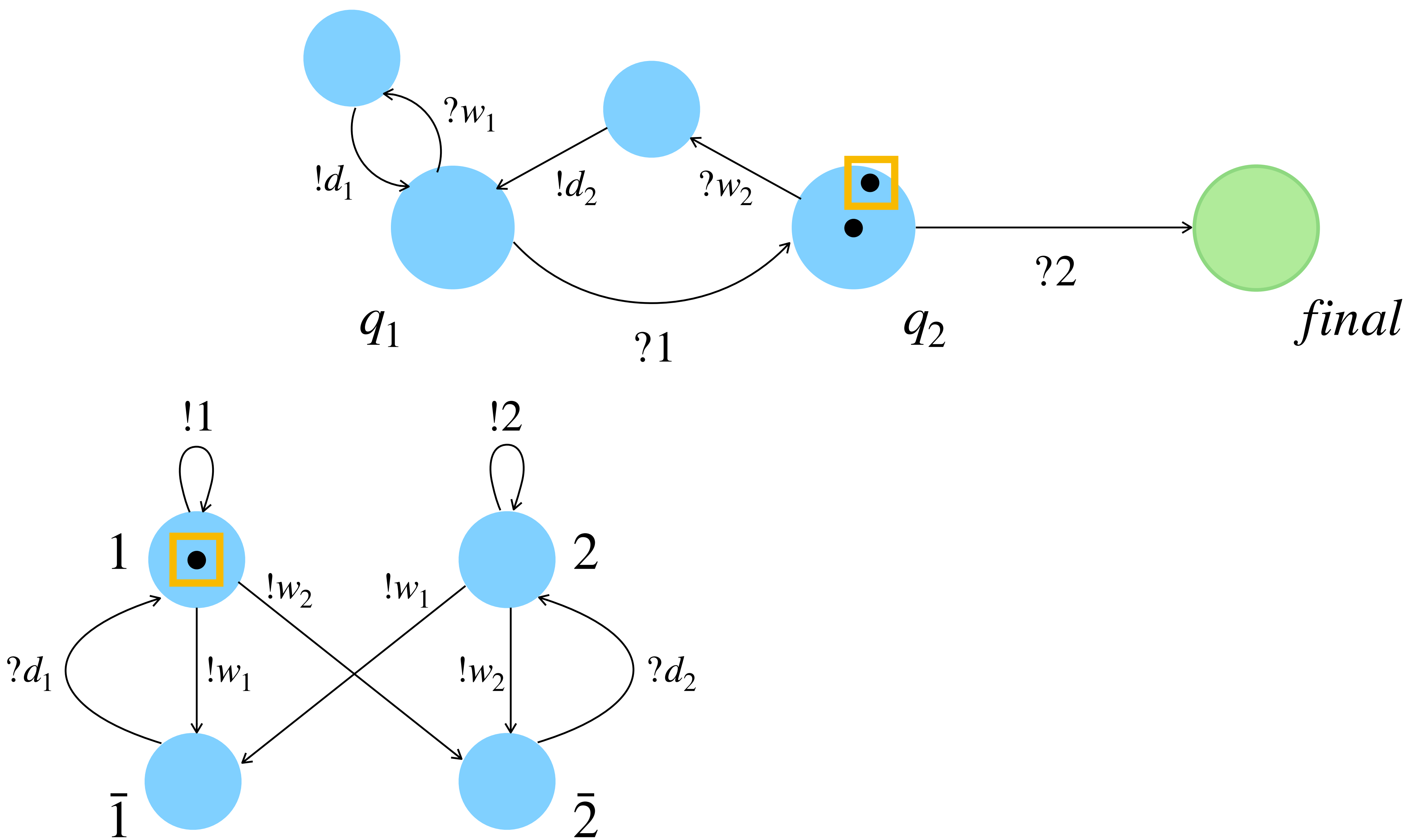

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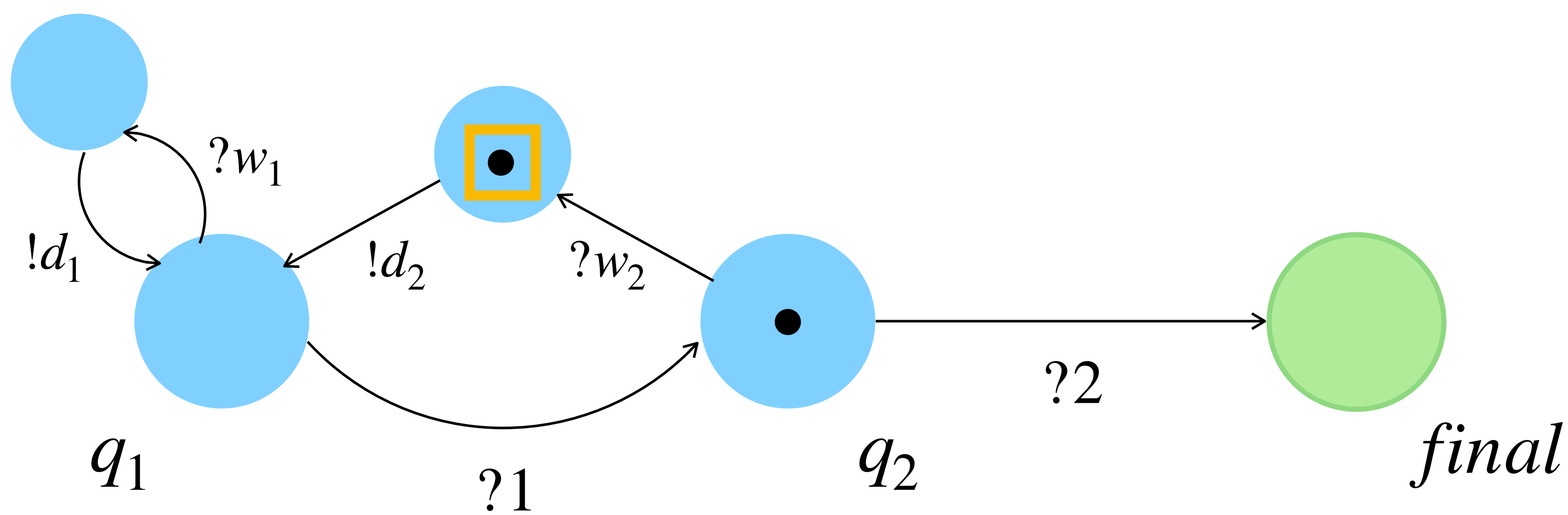

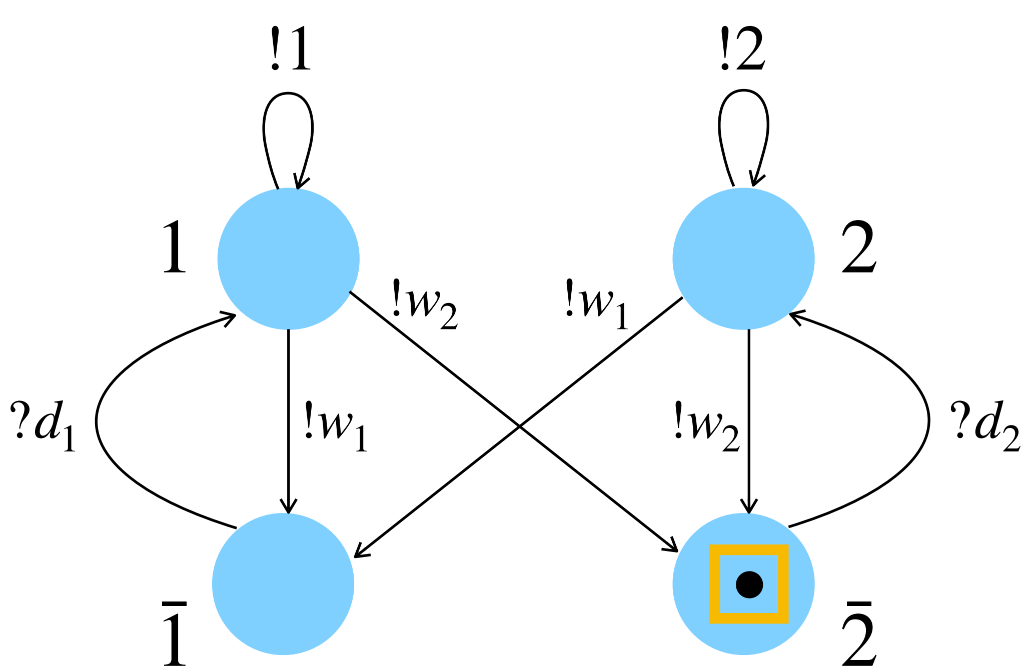

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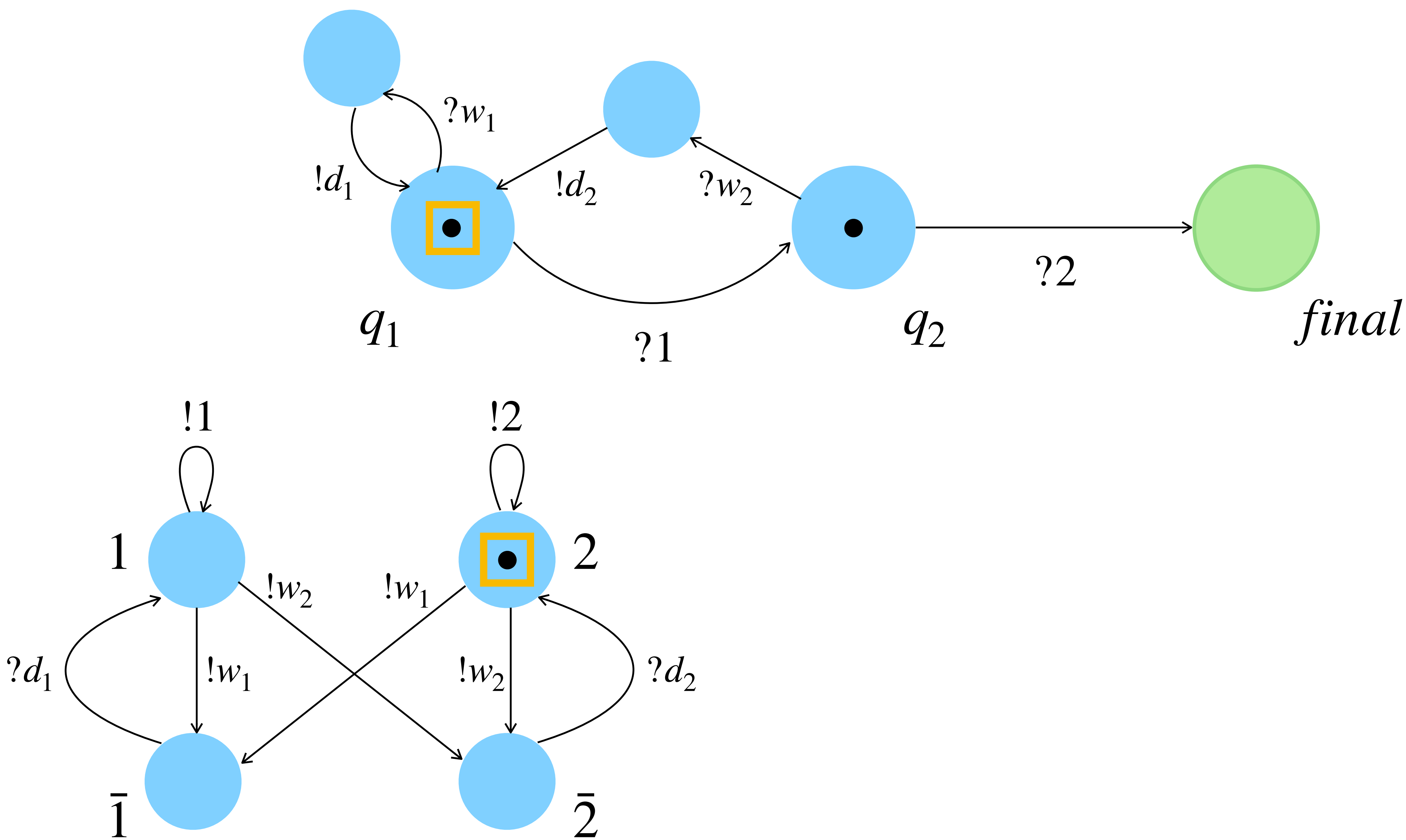
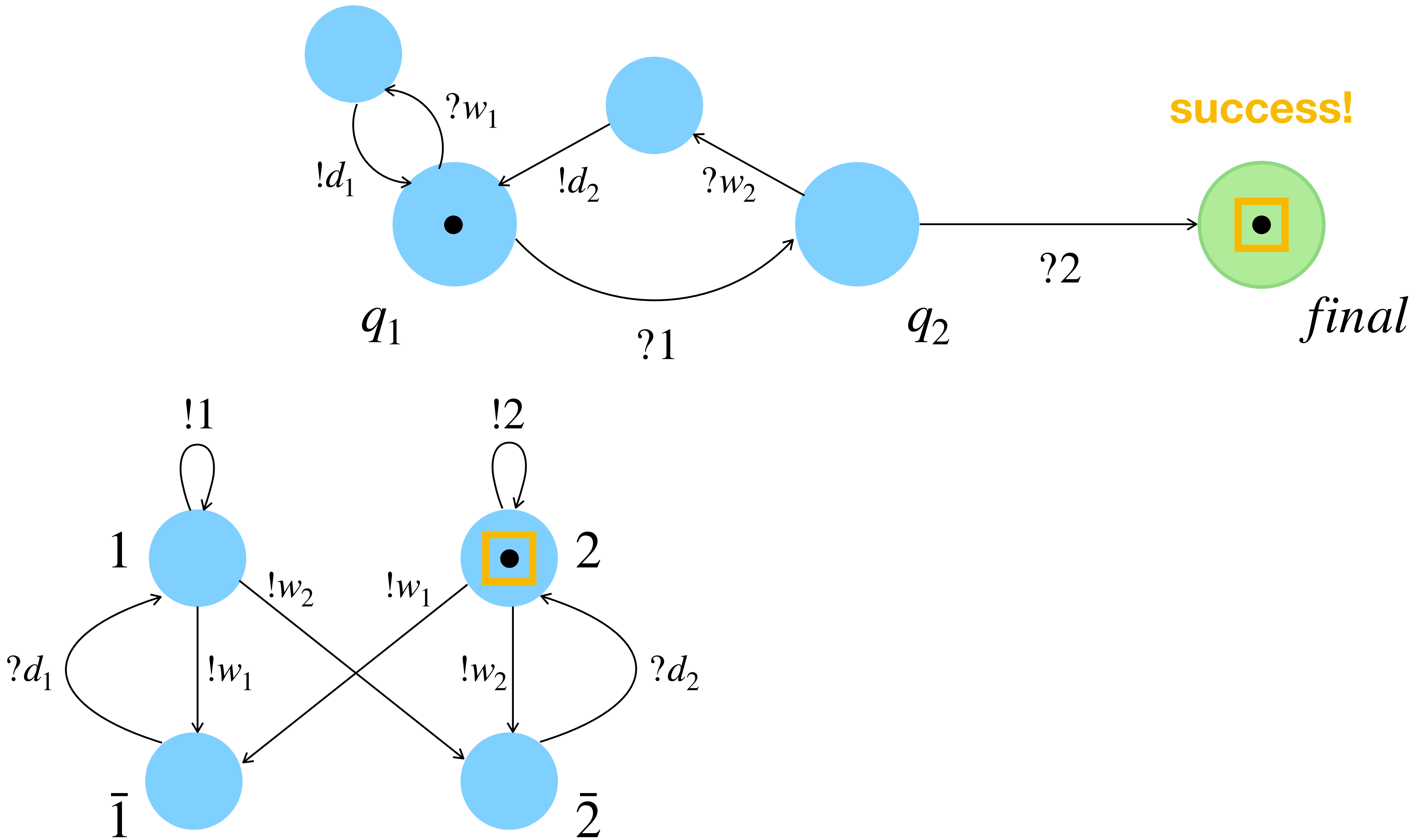


RBN simulates ASMS

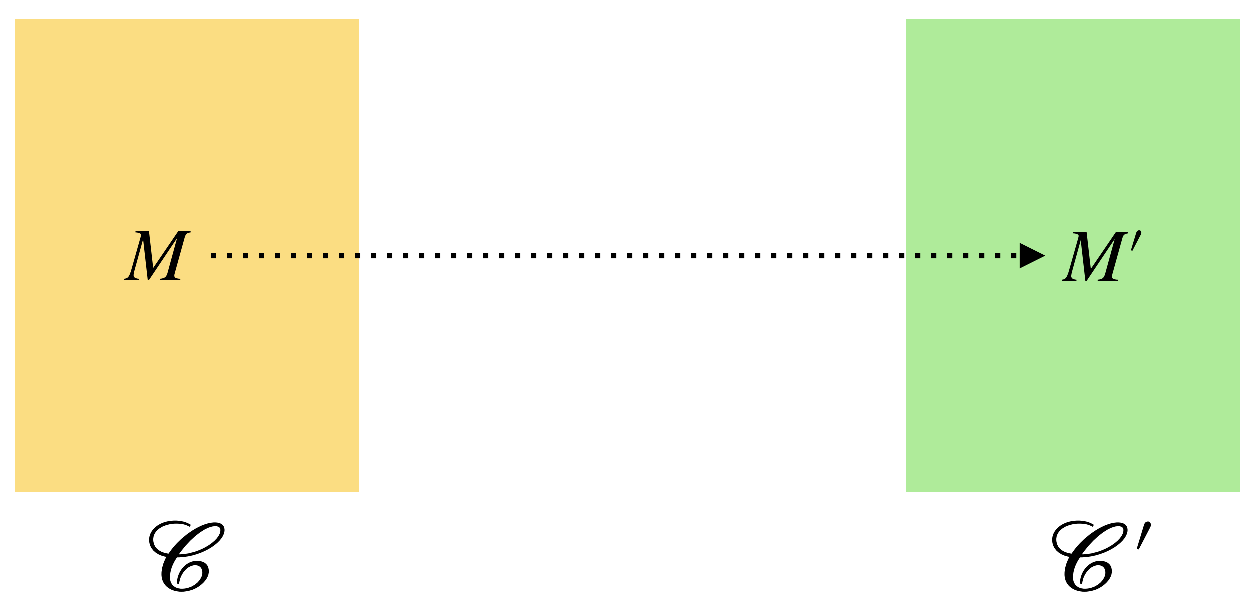
Simulation idea #2



Simulation

number of processes in q

A **cube** is a boolean combination of constraints $\underset{\in \mathbb{N}}{a} \leq \#q \leq \underset{\in \mathbb{N} \cup \infty}{b}$



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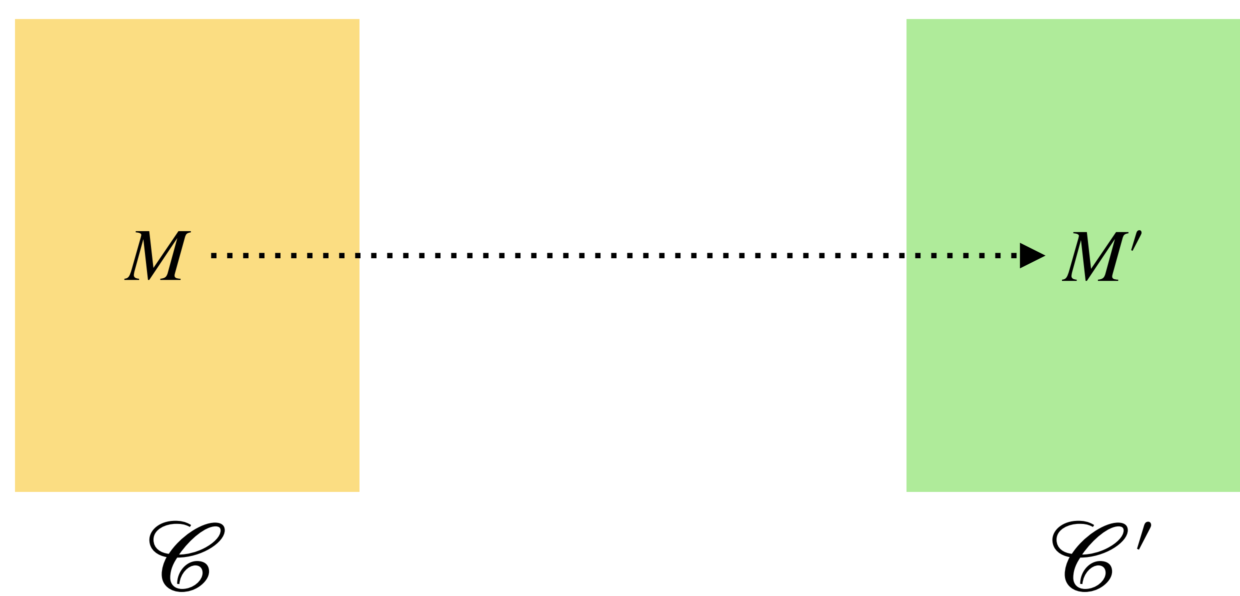
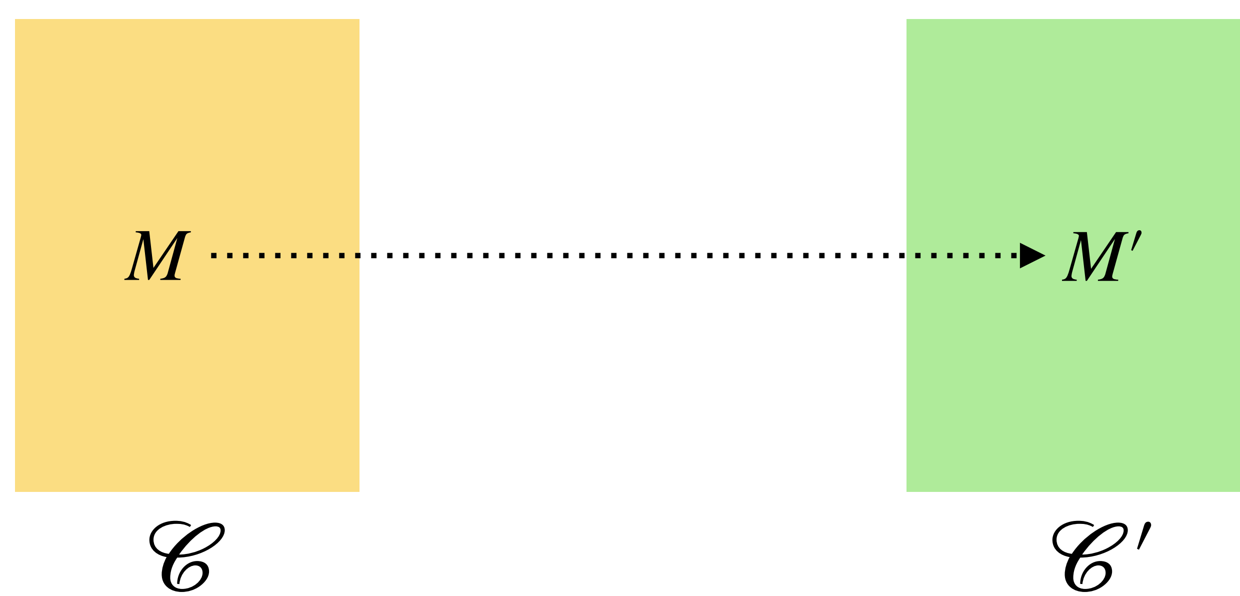


cube-reachability: given cubes $\mathscr{C}$ and $\mathscr{C}'$, does there exist $M \in \mathscr{C}$ and $M' \in \mathscr{C}'$ such that M reaches M' ?

Simulation

RBN and ASMS are polynomial-time equivalent w.r.t. to cube-reachability



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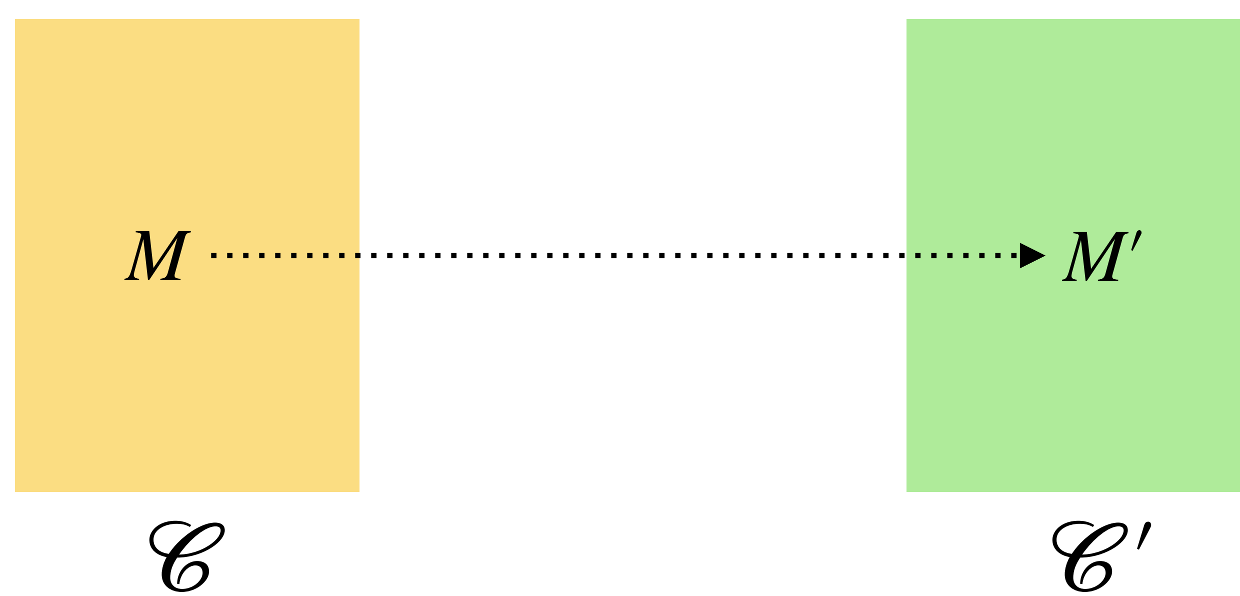
Transfer of results

[Delzanno et al., FSTTCS ’12]

Unbounded initial cube reachability is PSPACE-complete for RBN



is a combination of constraints of the form

$0 \leq \#q \leq 0$ and $0 \leq \#q < \infty$

Transfer of results

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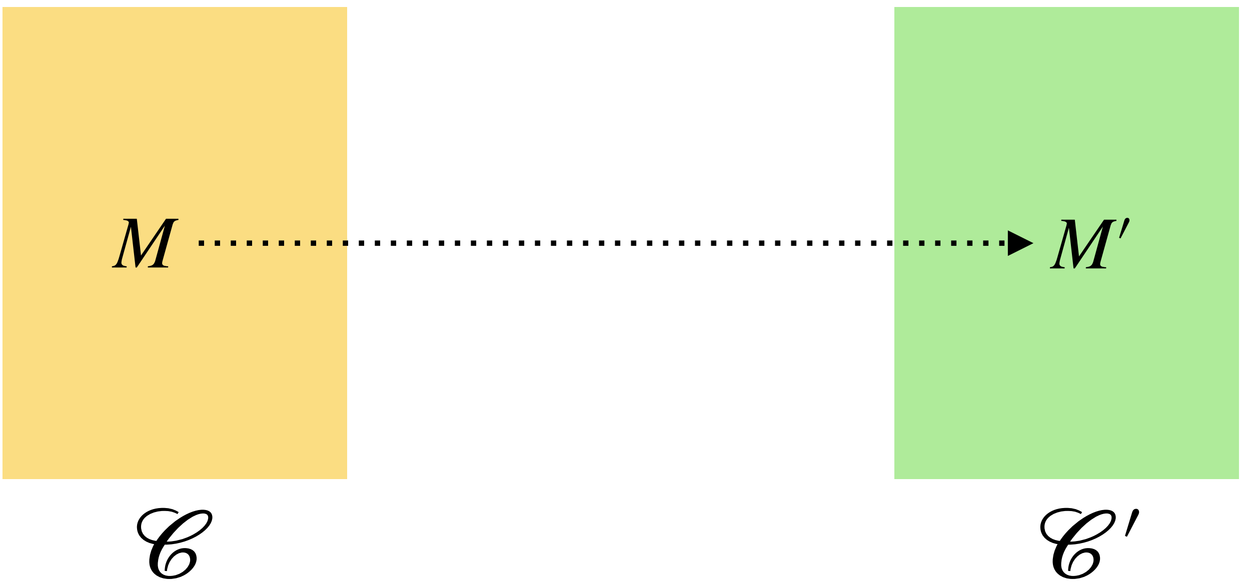

PSPACE-complete for ASMS

Transfer of results

[Bouyer et al., ICALP ’16]

In ASMS, $(\{k \cdot init\}, r)$ **almost-surely covers** $final$

if it covers $final$ with probability 1 under a uniform stochastic scheduler

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In ASMS, $(\{k \cdot init\}, r)$ **almost-surely covers** $final$
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- $k \geq 1$ is a **positive cut-off** if $(\{h \cdot init\}, r)$ almost-surely covers $final$ for all $h \geq k$
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All RBN have a positive or negative cut-off and this can be decided in **EXPSPACE**

Conclusion

Further

We also compare RBN / ASMS to **immediate observation nets (IO)**:

- anonymous, identical processes which can communicate by observation.
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Thank you!

Parameterized problems

A **cube** is a boolean combination of constraints $\underset{\in \mathbb{N}}{a} \leq \#q \leq \underset{\in \mathbb{N} \cup \infty}{b}$

parameterized problems: verifying predicates using boolean operators and reachability operators pre^* and $post^*$ over cubes

PSPACE

$pre^*(\mathscr{C})$ is the set of markings that can reach $\mathscr{C}$

$post^*(\mathscr{C})$ is the set of markings that $\mathscr{C}$ can reach

e.g. reachability from cube $\mathscr{C}$ to cube $\mathscr{C}'$: $post^*(\mathscr{C}) \cap \mathscr{C}' \neq \varnothing$

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e.g. almost-sure reachability from cube $\mathscr{C}_{init}$ *to cube* $\mathscr{C}_{final}$

$$post^*(\mathscr{C}_{init}) \subseteq pre^*(\mathscr{C}_{final})$$