Regular Model Checking without Transducers

Parosh Aziz Abdulla

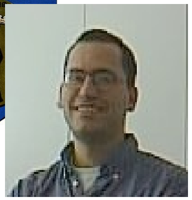
Giorgio Delzanno

Noomene Ben Henda

Ahmed Rezine

Regular Model Checking without Transducers

Parosh Aziz Abdulla



Giorgio Delzanno

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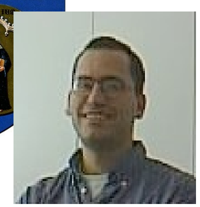
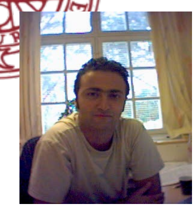


Giorgio Delzanno



Noomene Ben Henda

Ahmed Rezine

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- Transition System
- Safety
- Monotonicity and Approximation
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- Conclusion

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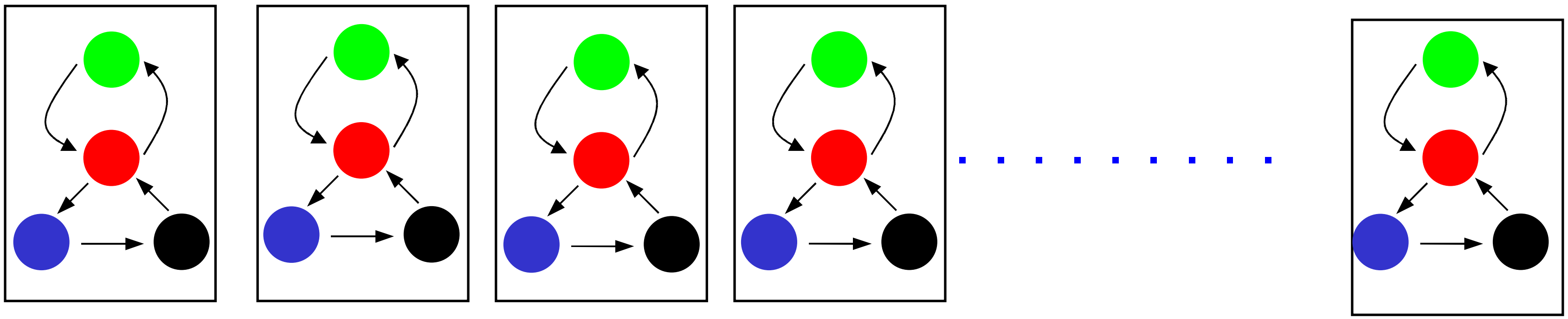
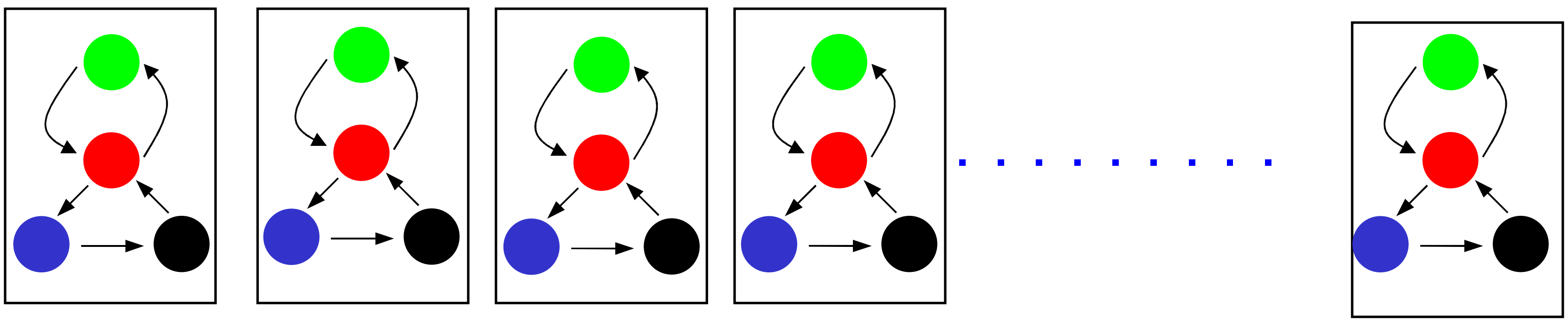
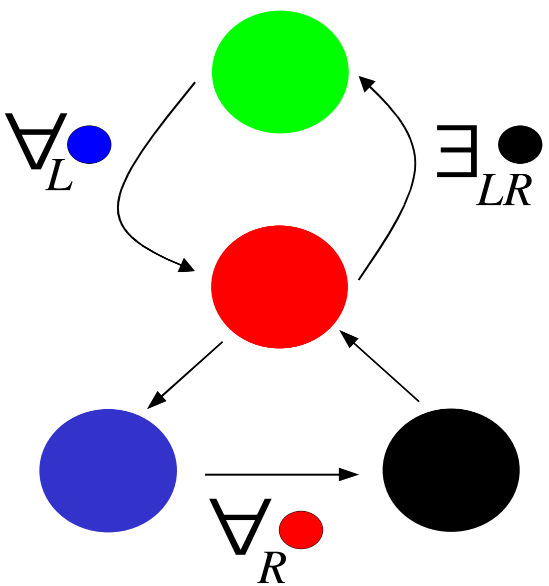
Basic Model

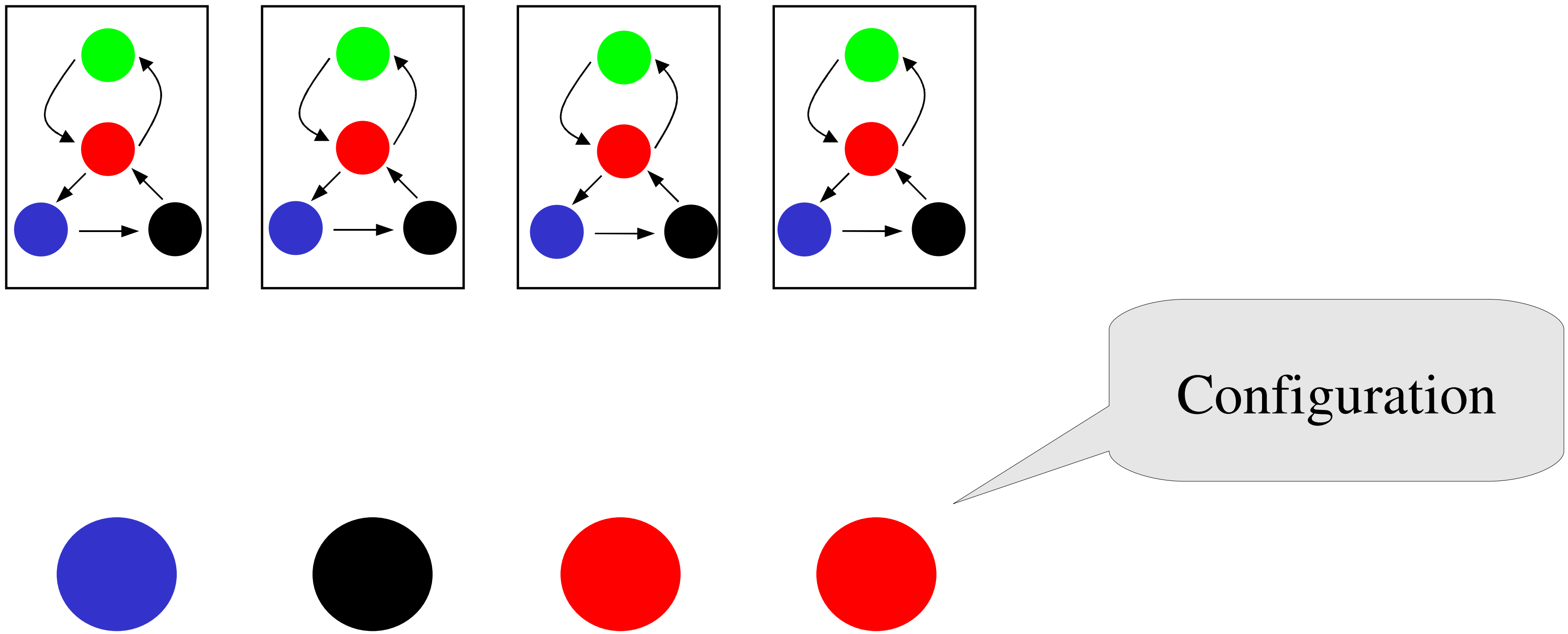


Basic Model

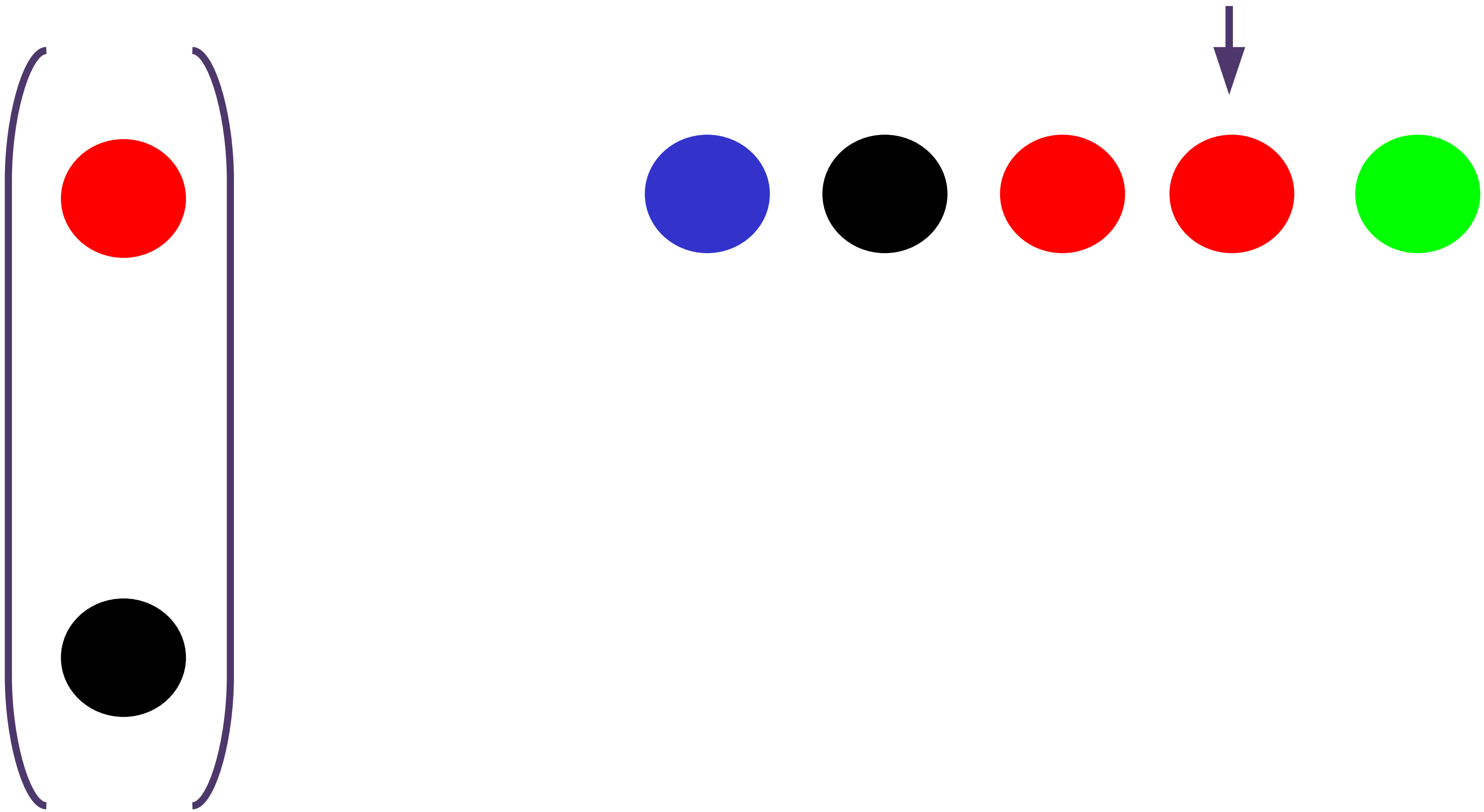




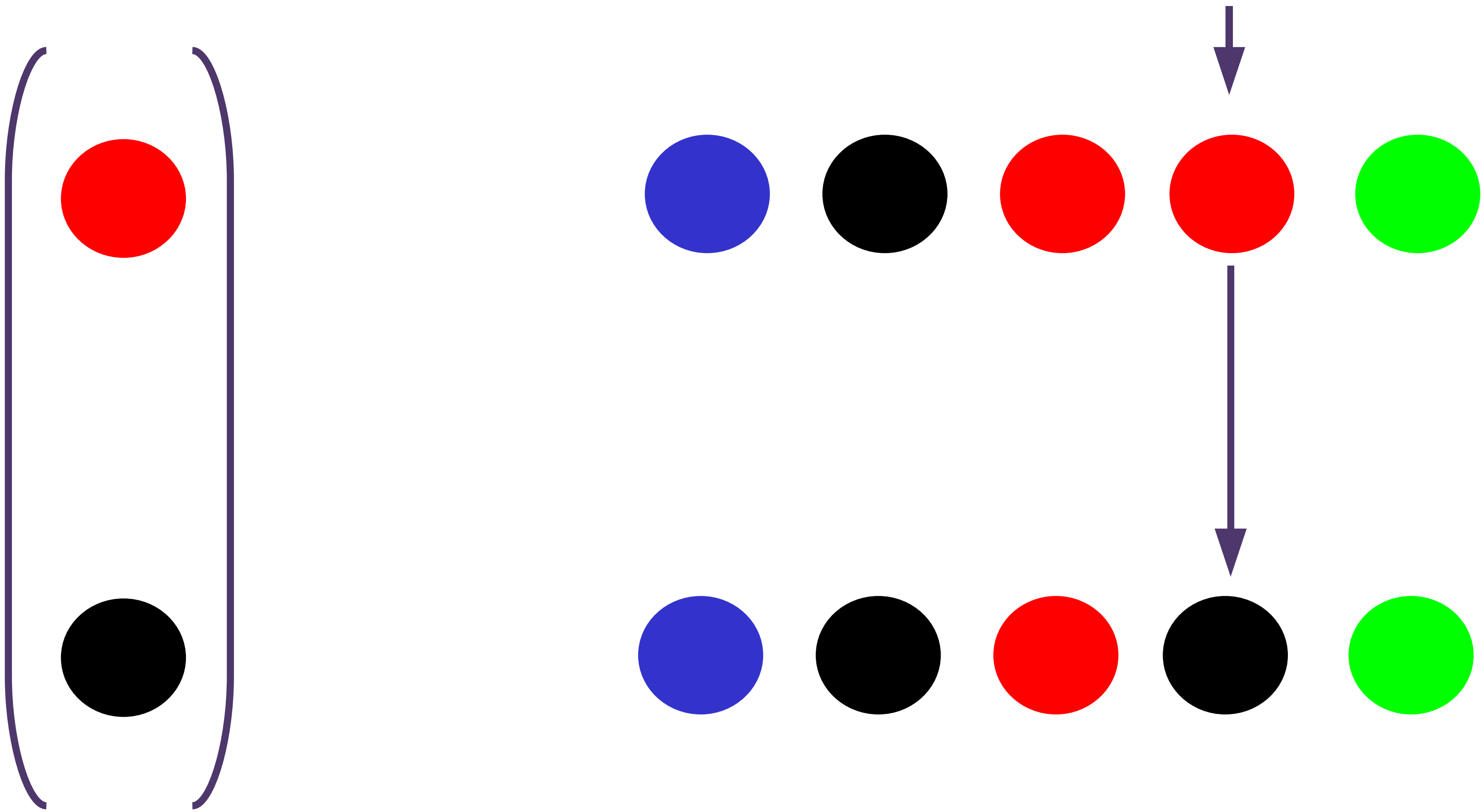
Transition Systems



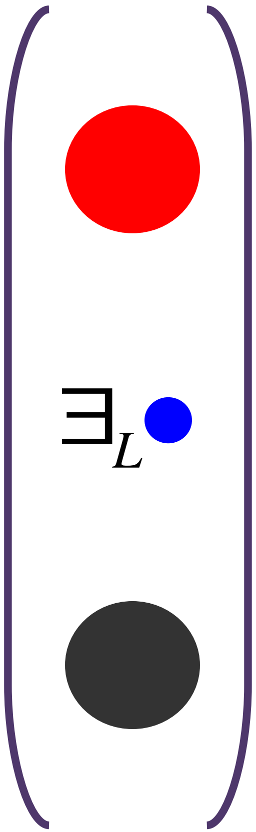
Transitions : Local

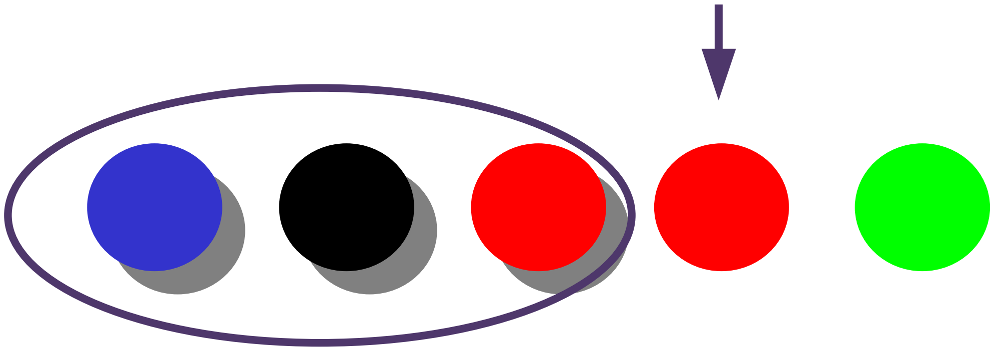


Transitions : Local

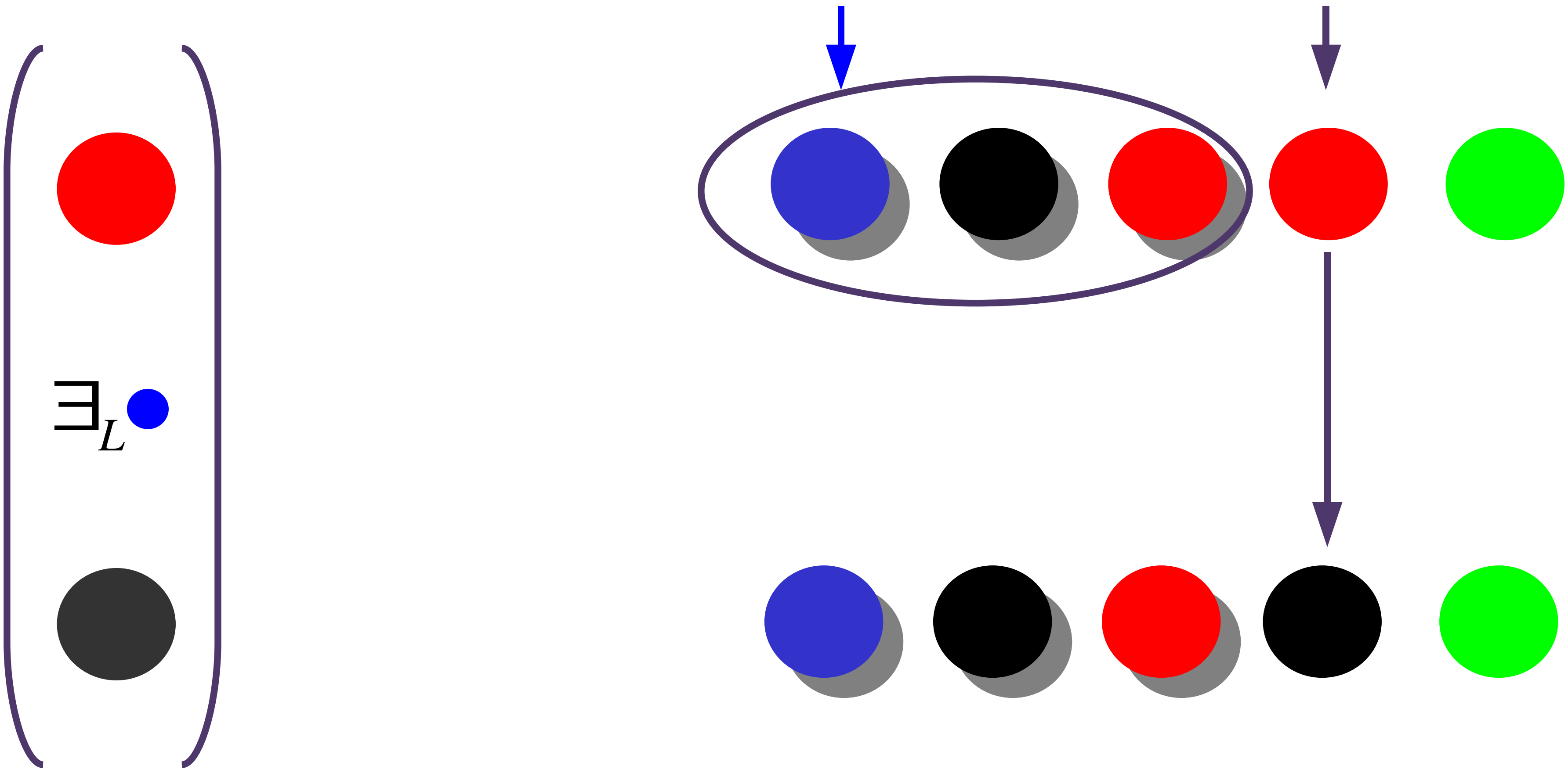


Transitions : Existential

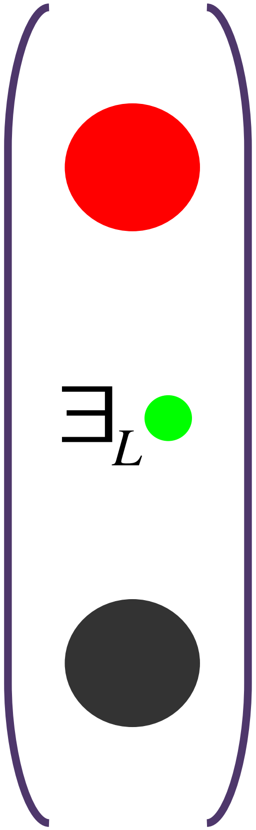


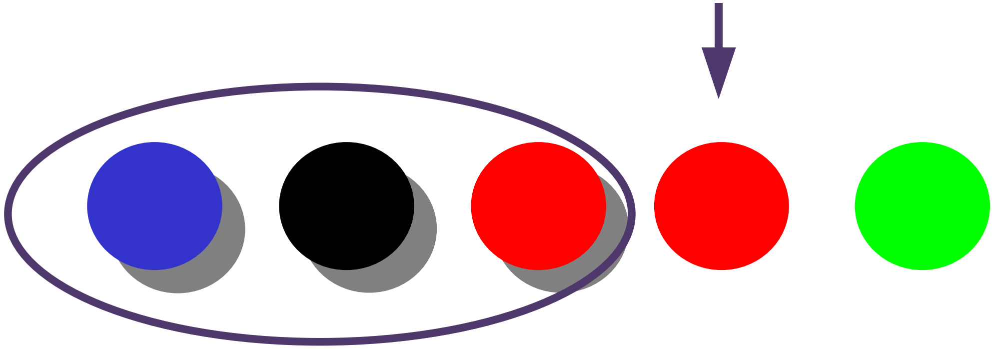


Transitions : Existential

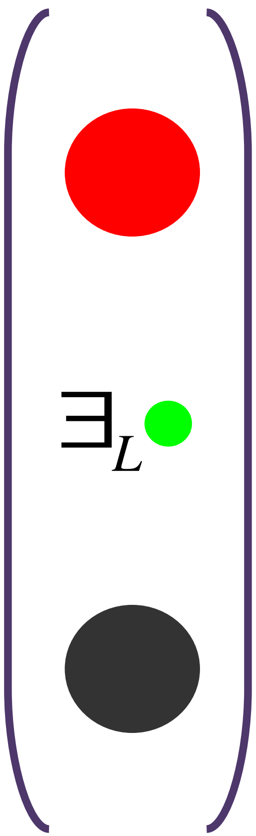


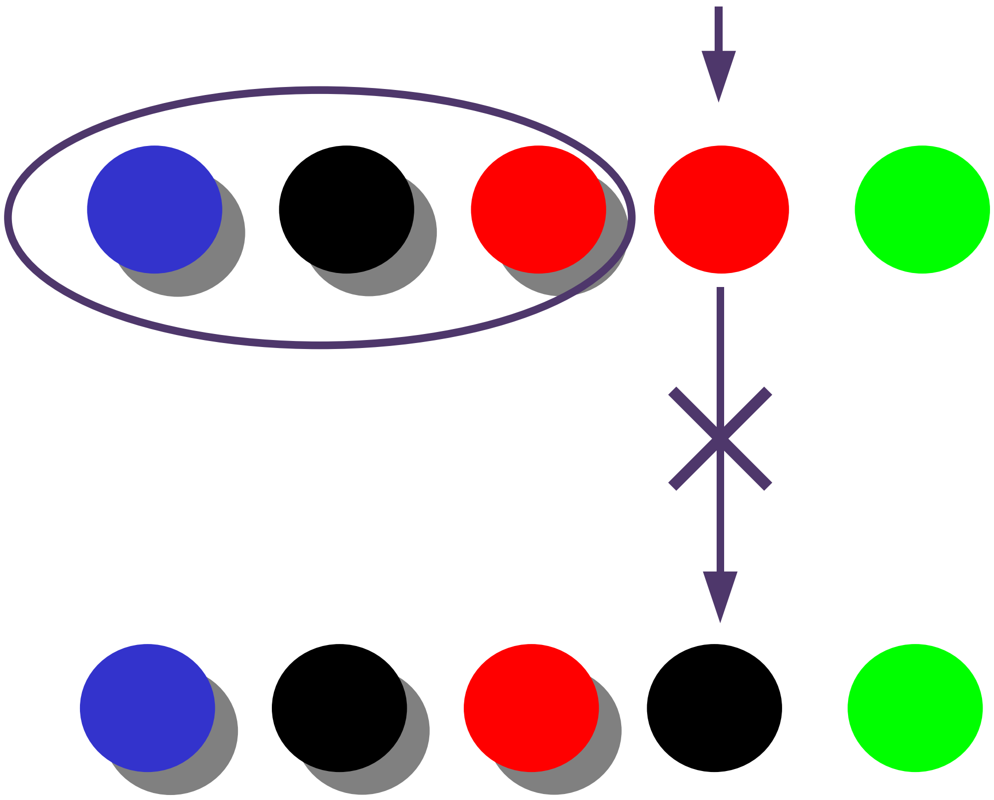
Transitions : Existential



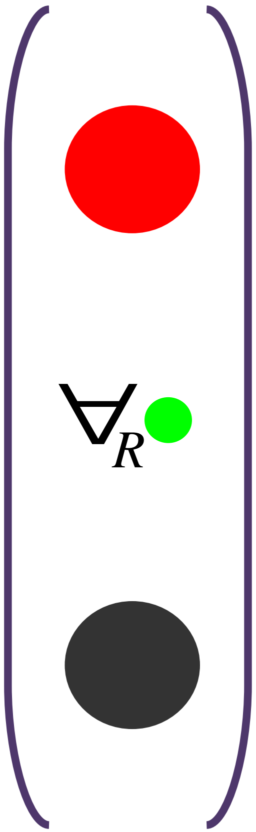


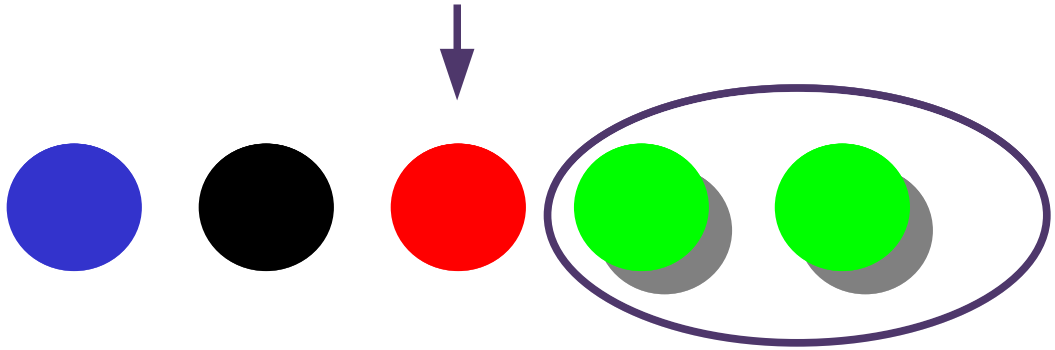
Transitions : Existential





Transitions : Universal





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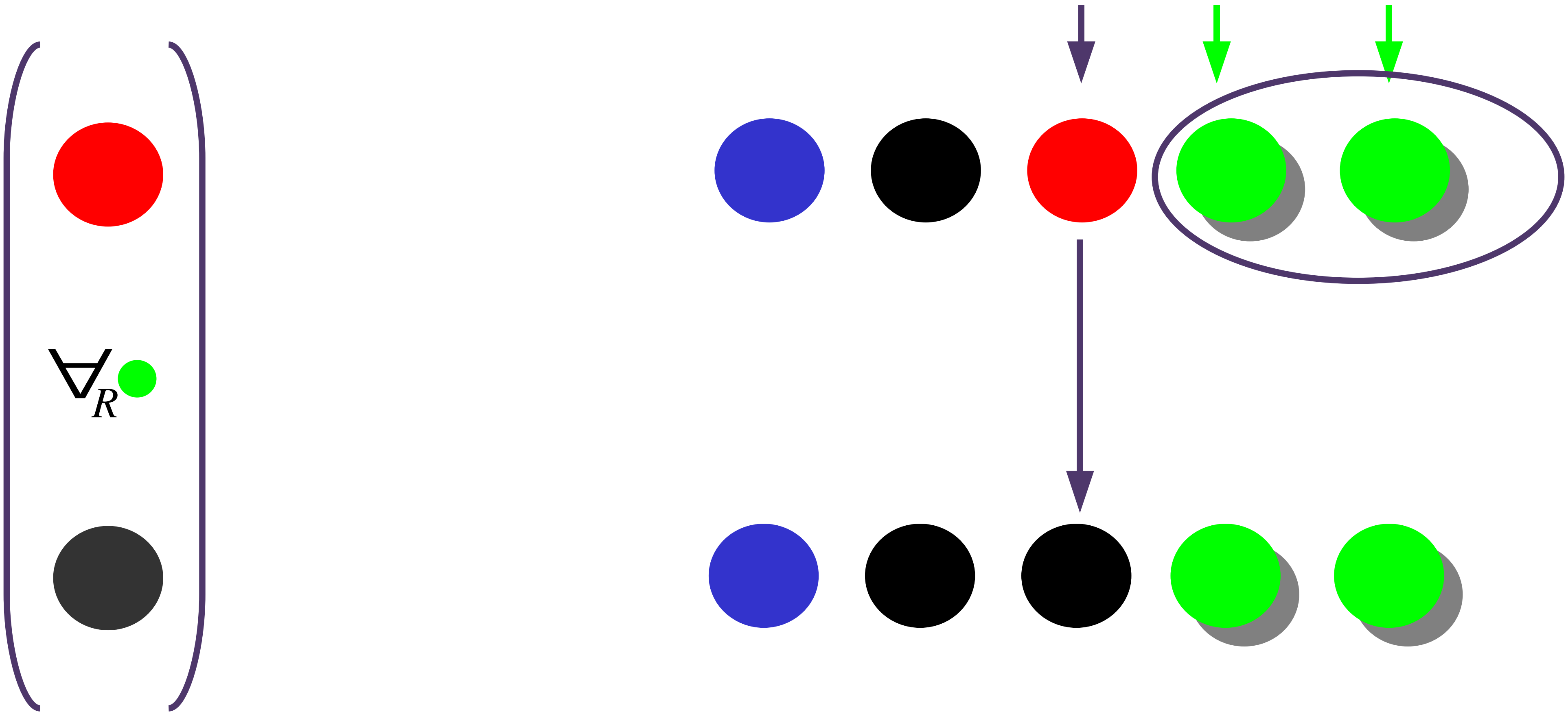
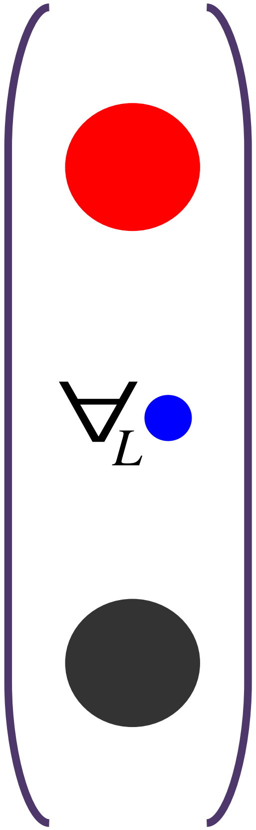
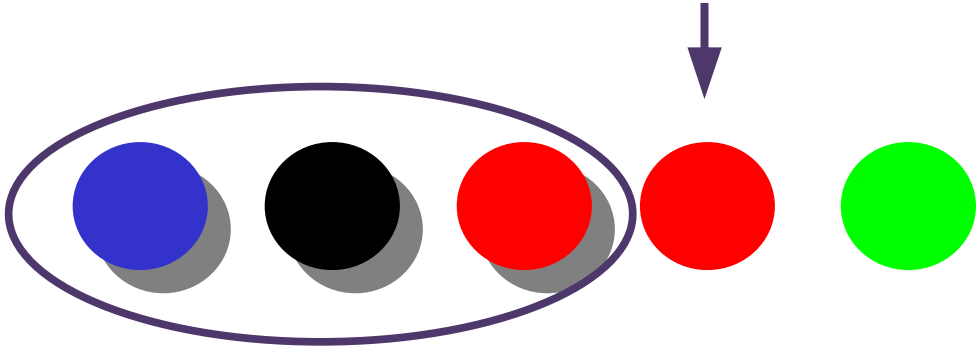


Transitions : Universal





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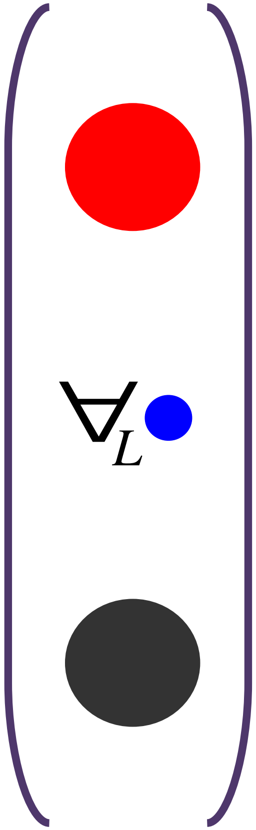
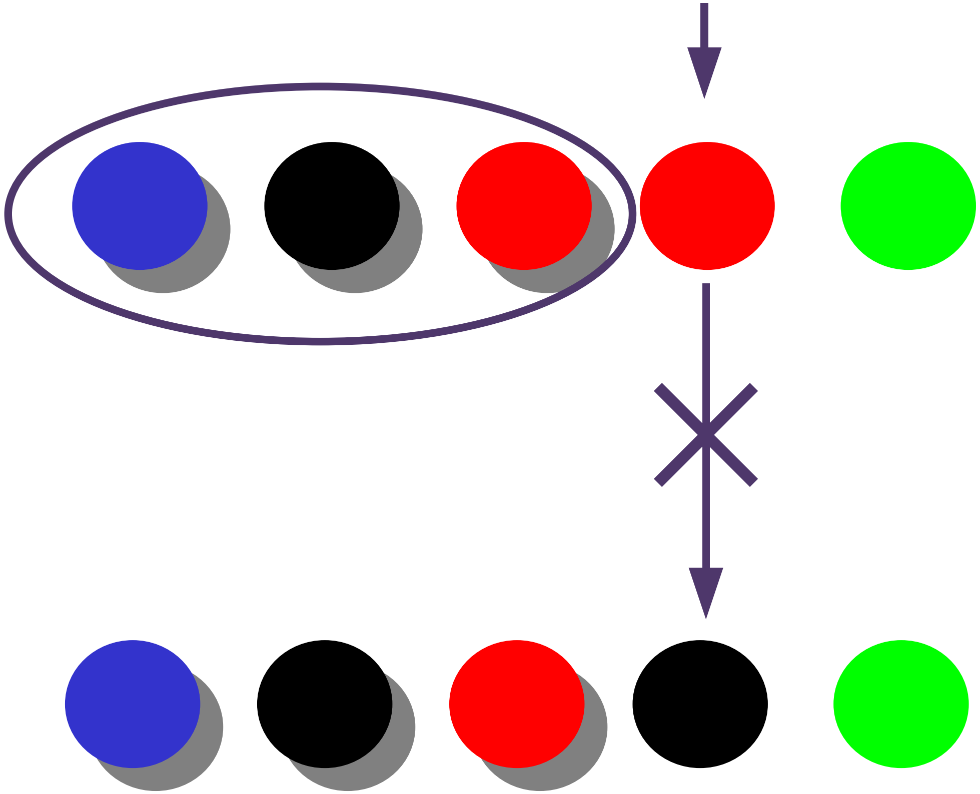
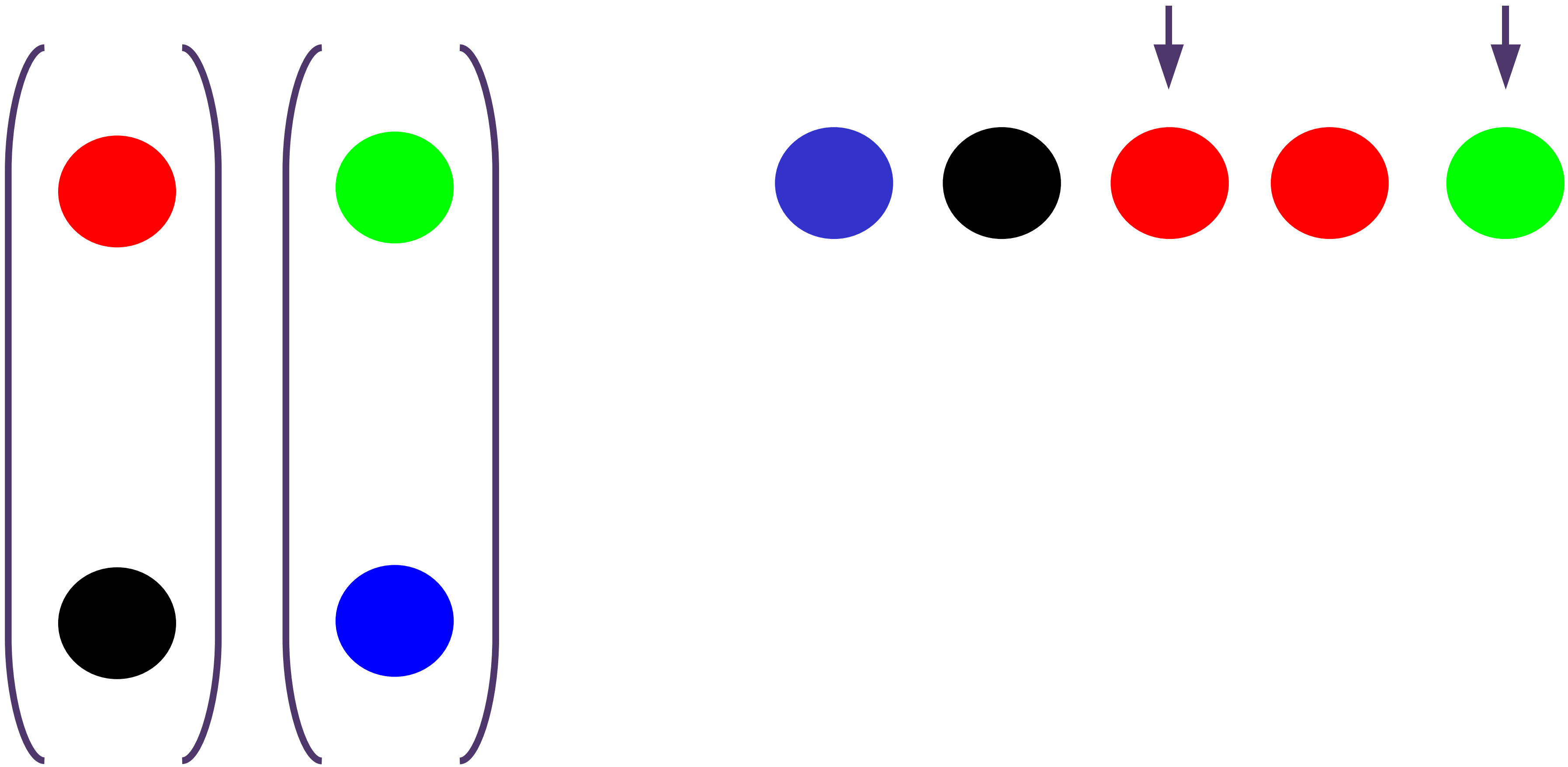
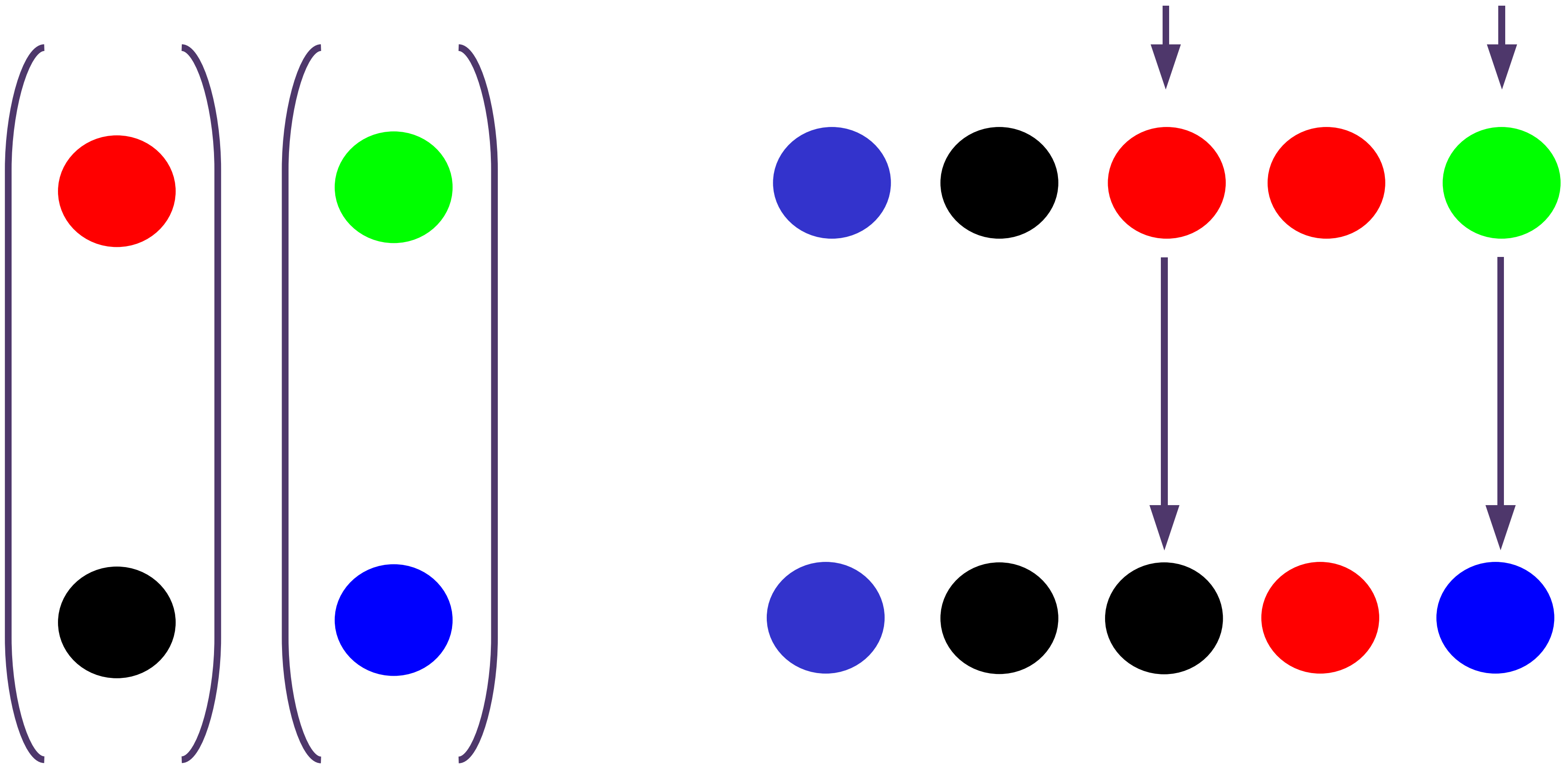




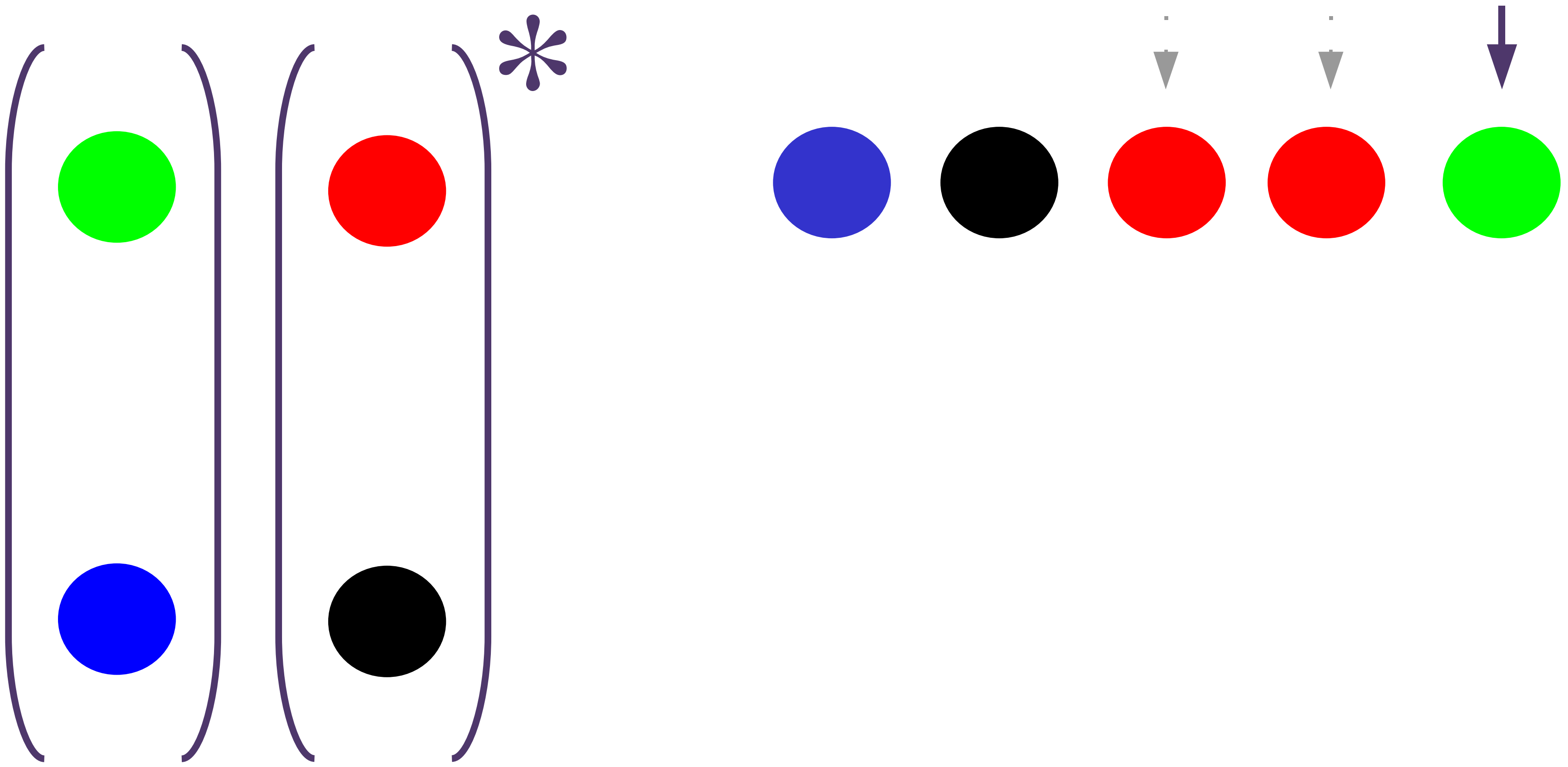
Transitions : Binary Communication



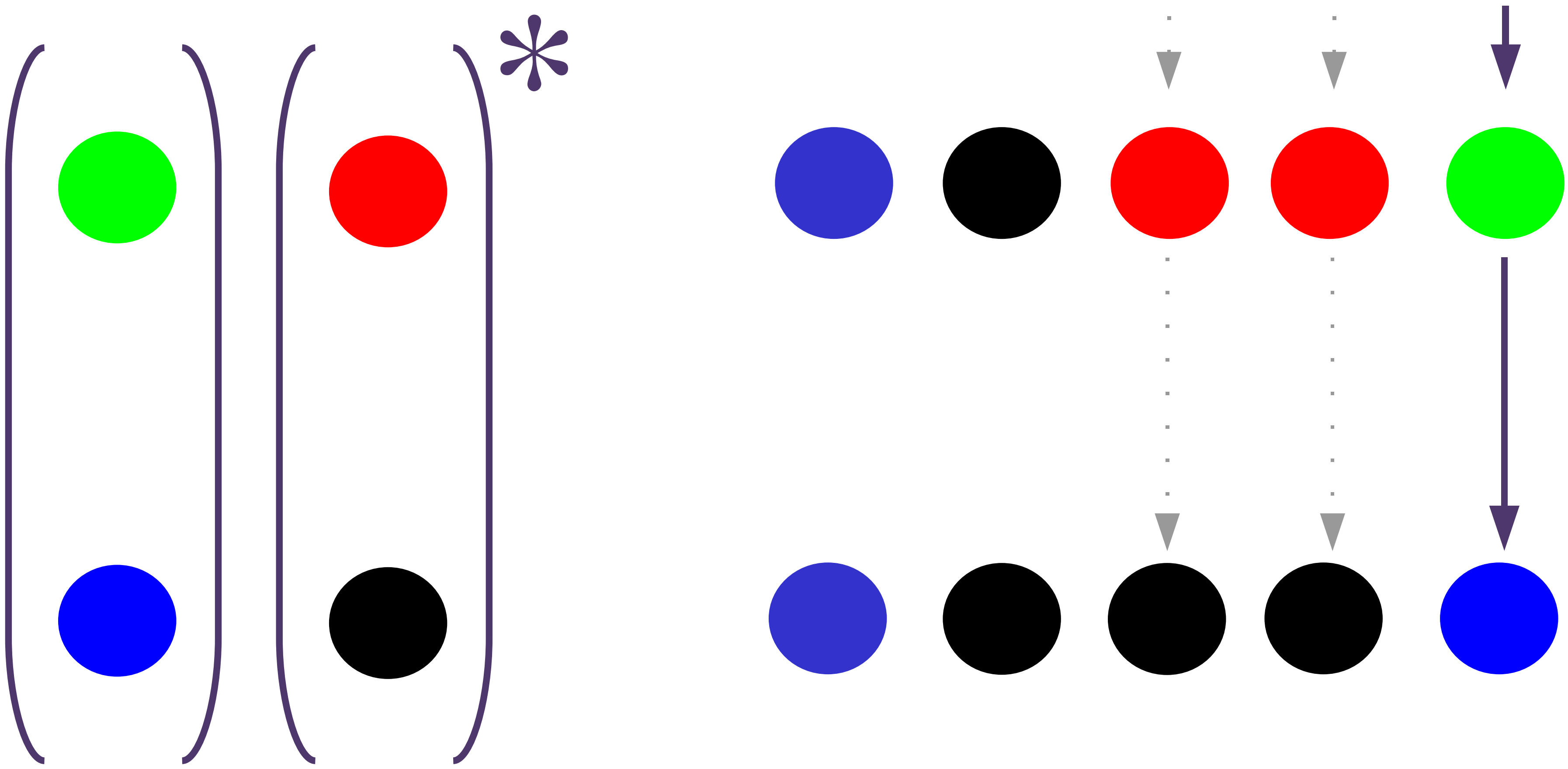
Transitions : Binary Communication



Transitions : Broadcast



Transitions : Broadcast



Examples

- Mutual exclusion algorithms by:

  Burns, Szymanski, Dijkstra ...

- Cache coherence protocols:

  Mesi, Illinois, Futurebus, German, ...

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Safety

- Reachability of bad configurations.

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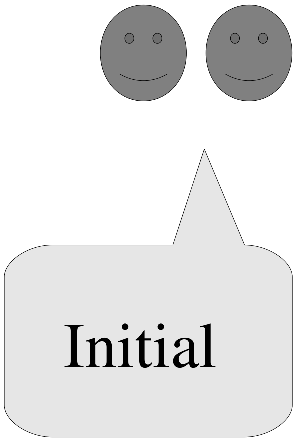

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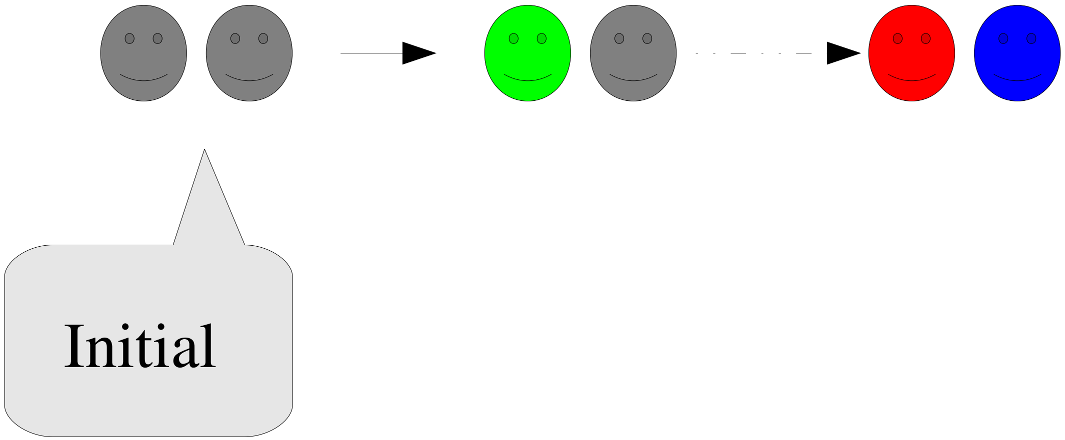

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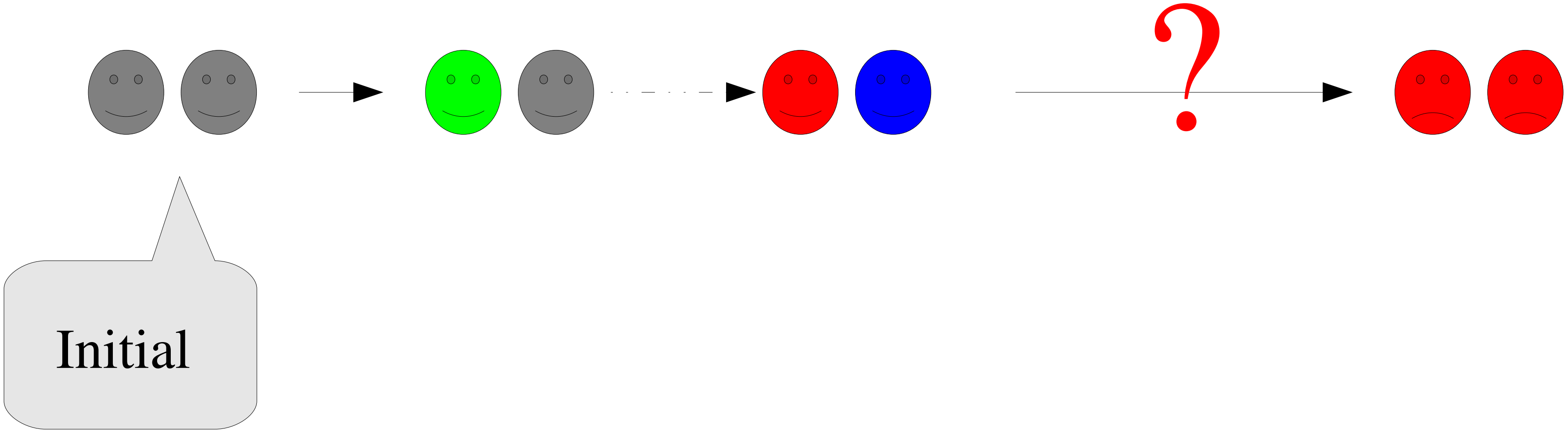

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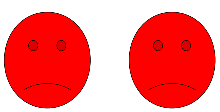

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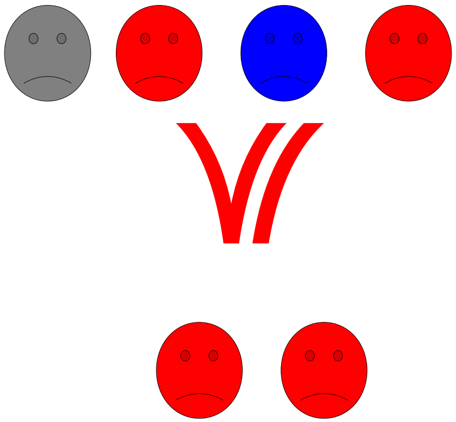

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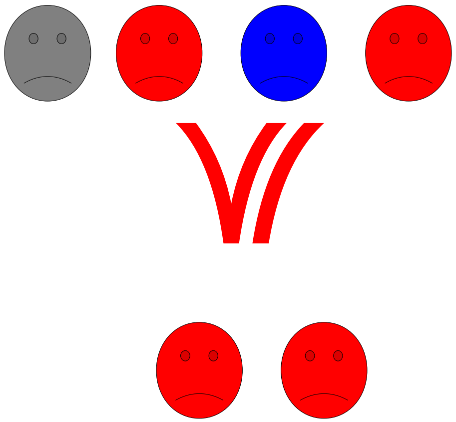

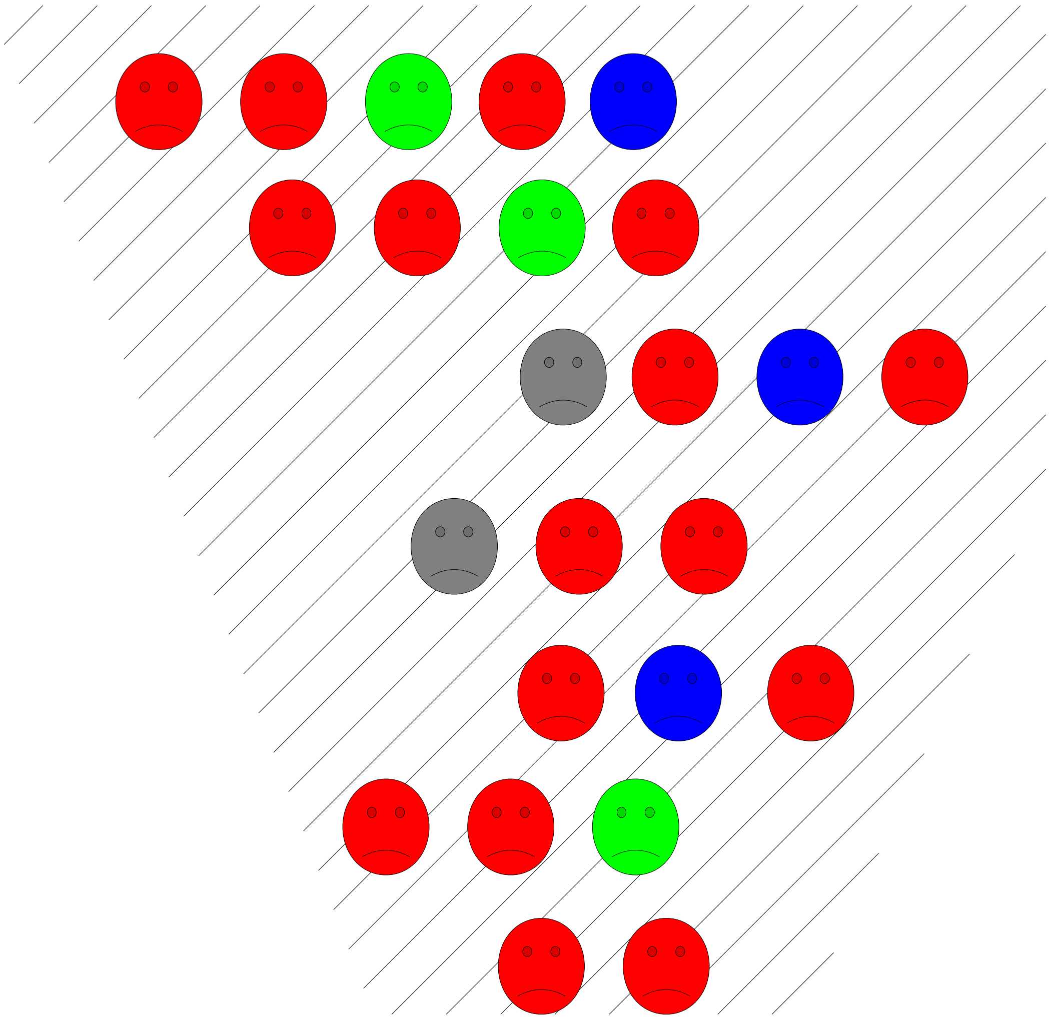

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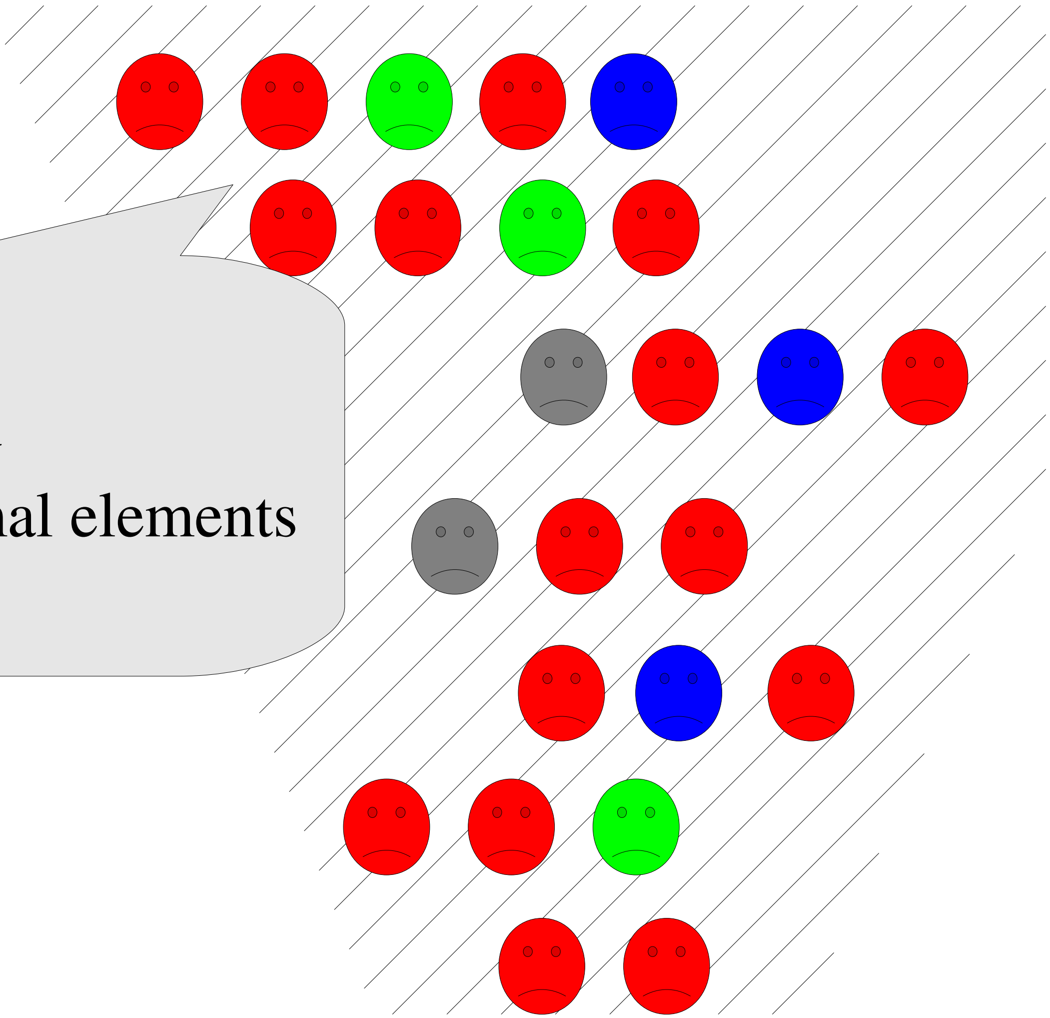
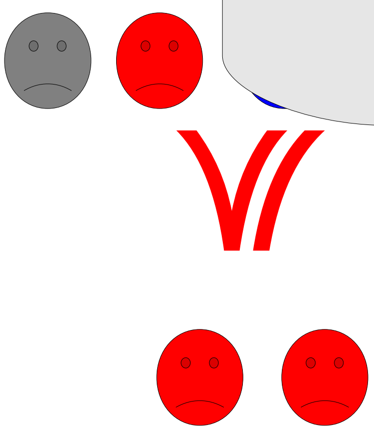
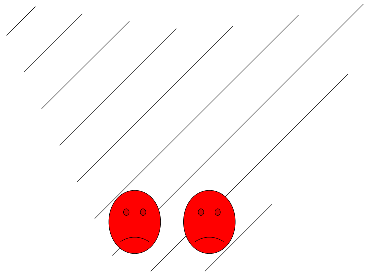




- Bad = Upward Closed
- represented by minimal elements

Safety



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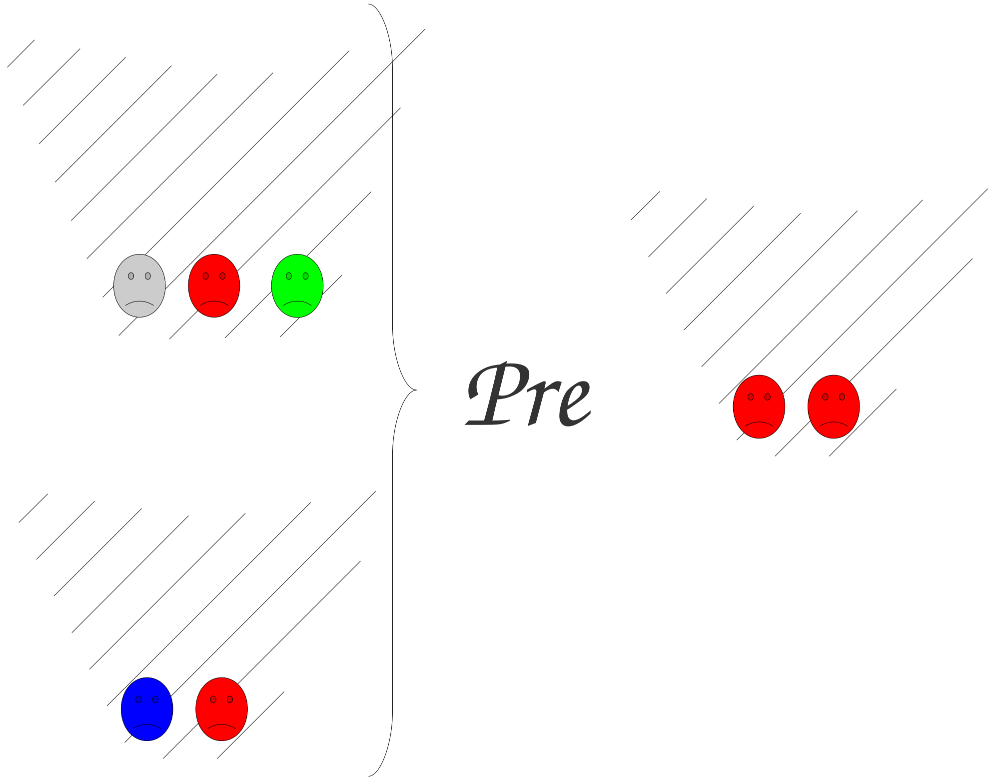

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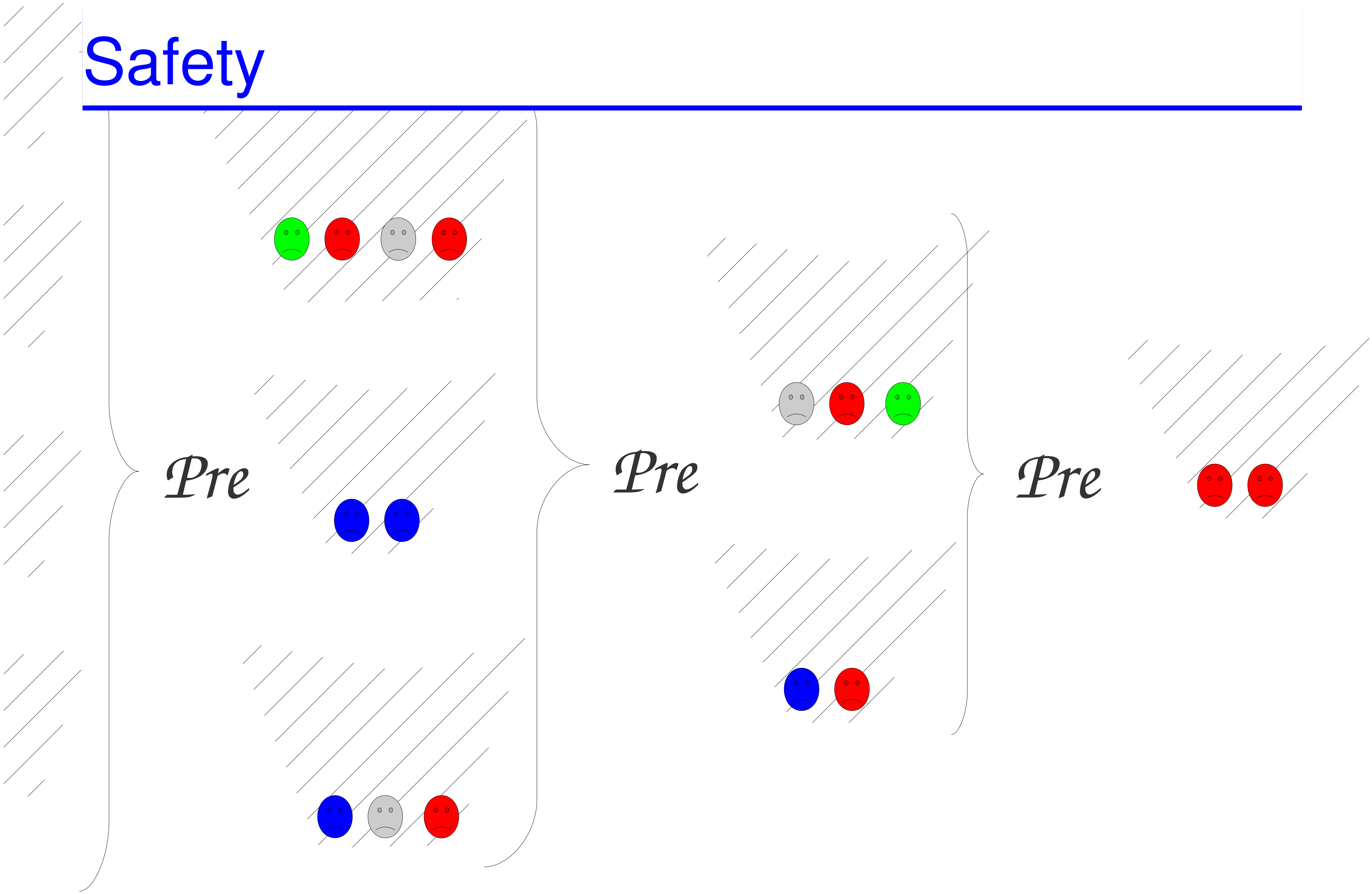

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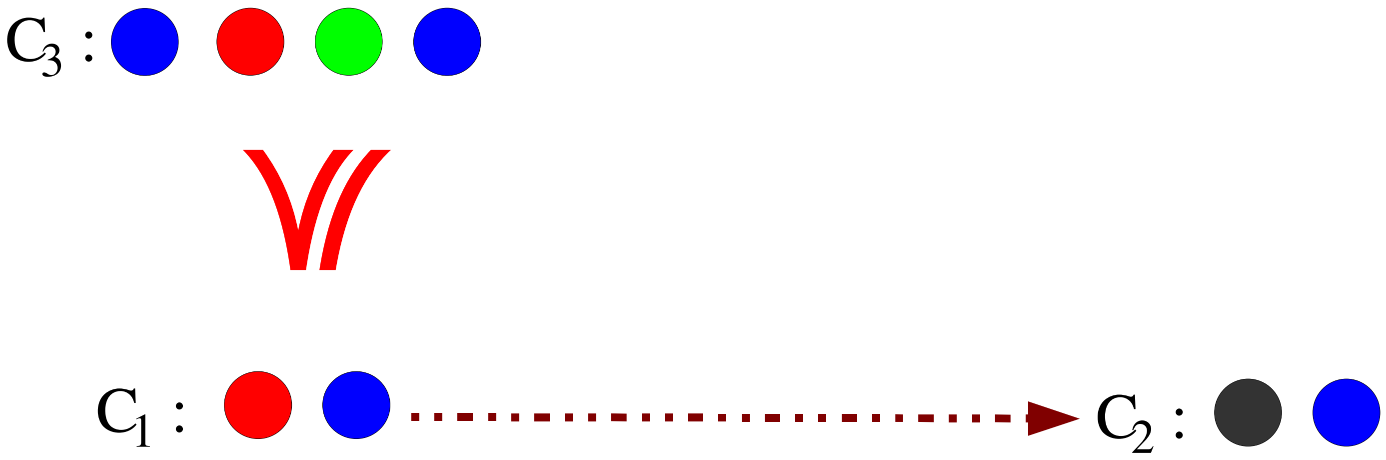
Monotonicity



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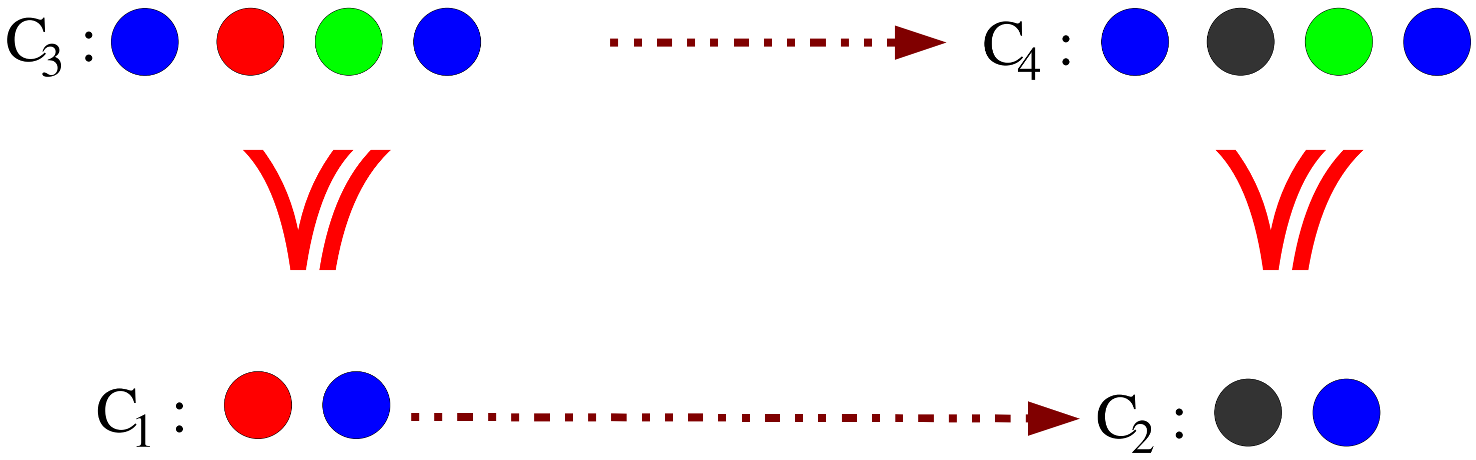

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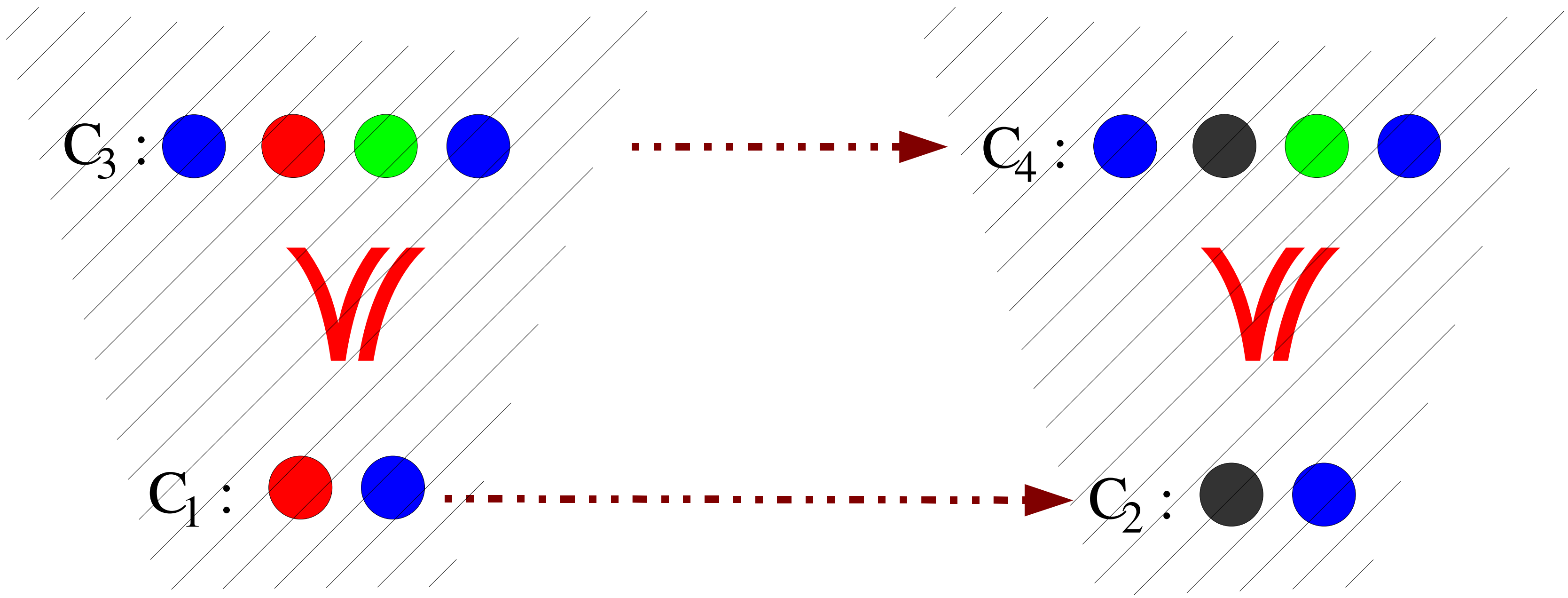
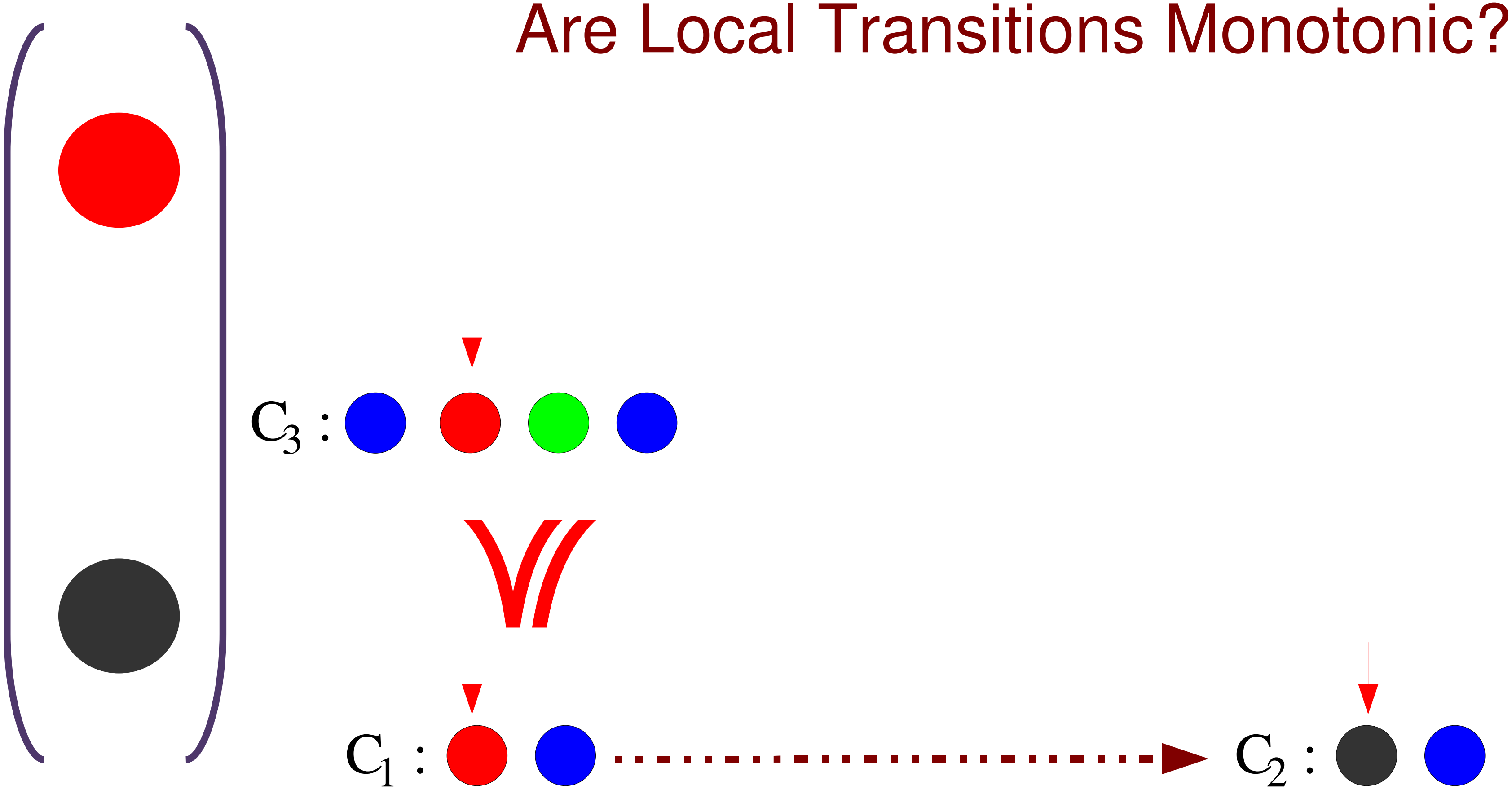


Monotonicity

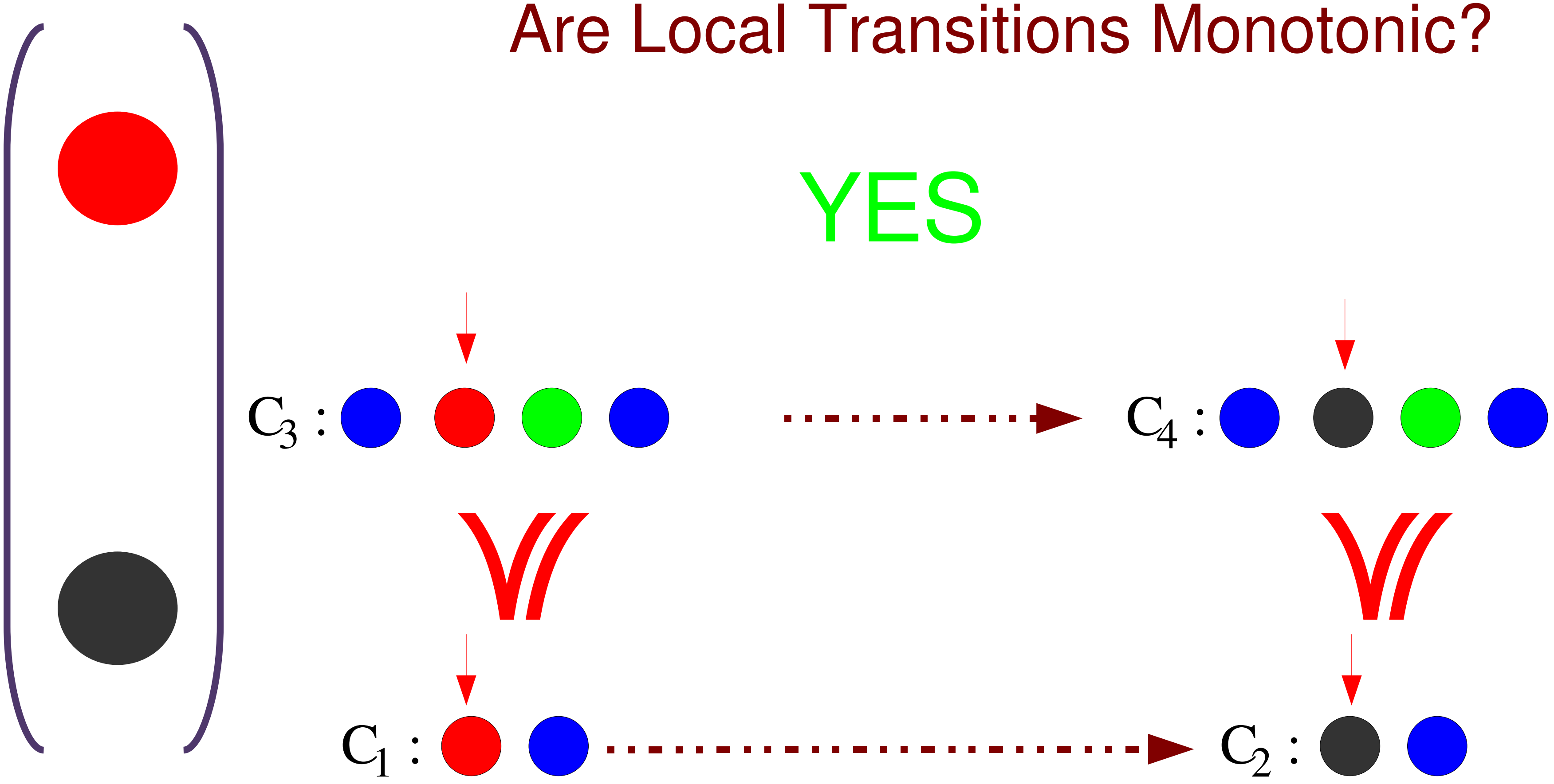
Are Local Transitions Monotonic?



Monotonicity

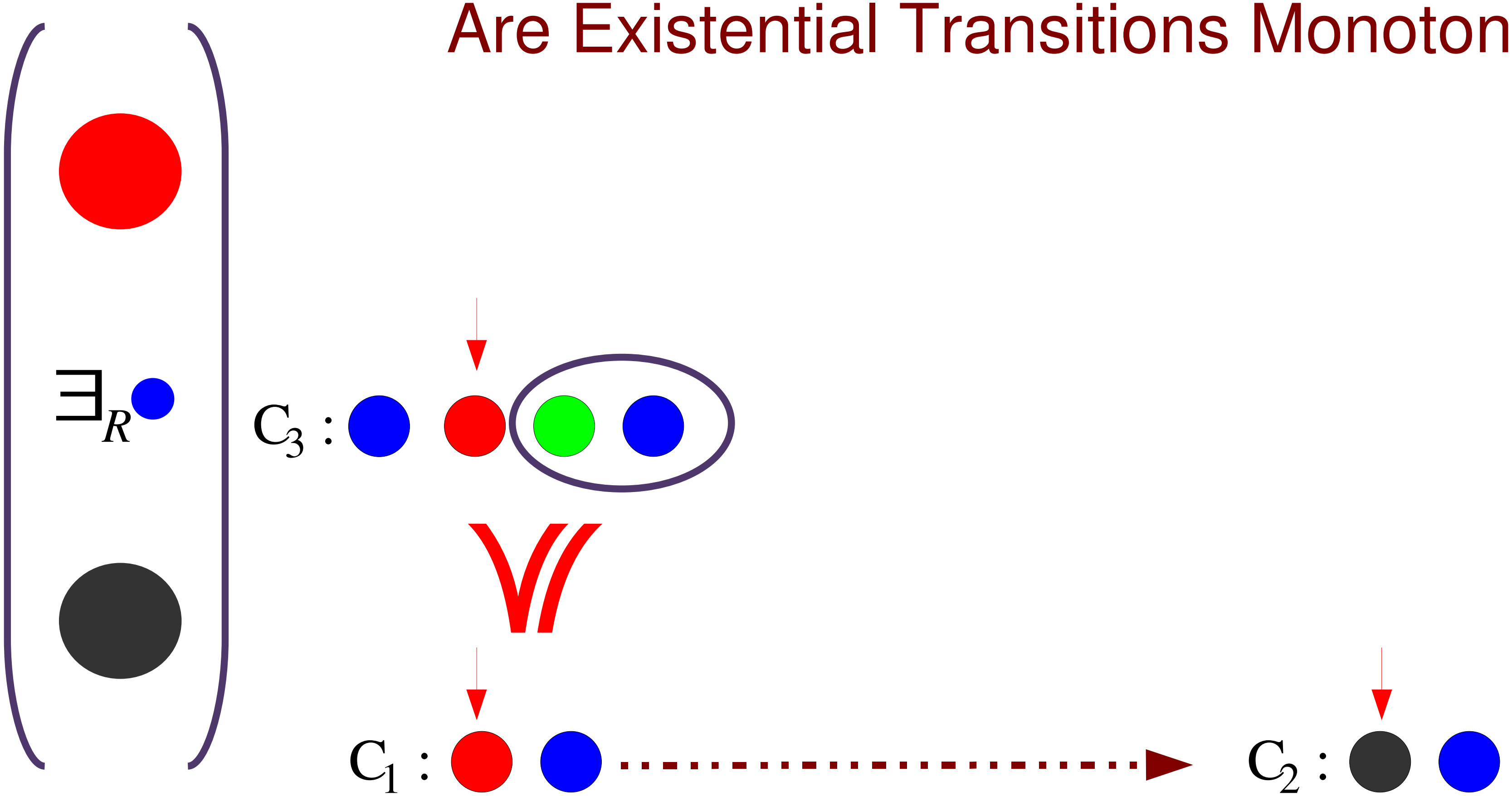
Are Local Transitions Monotonic?

YES



Monotonicity

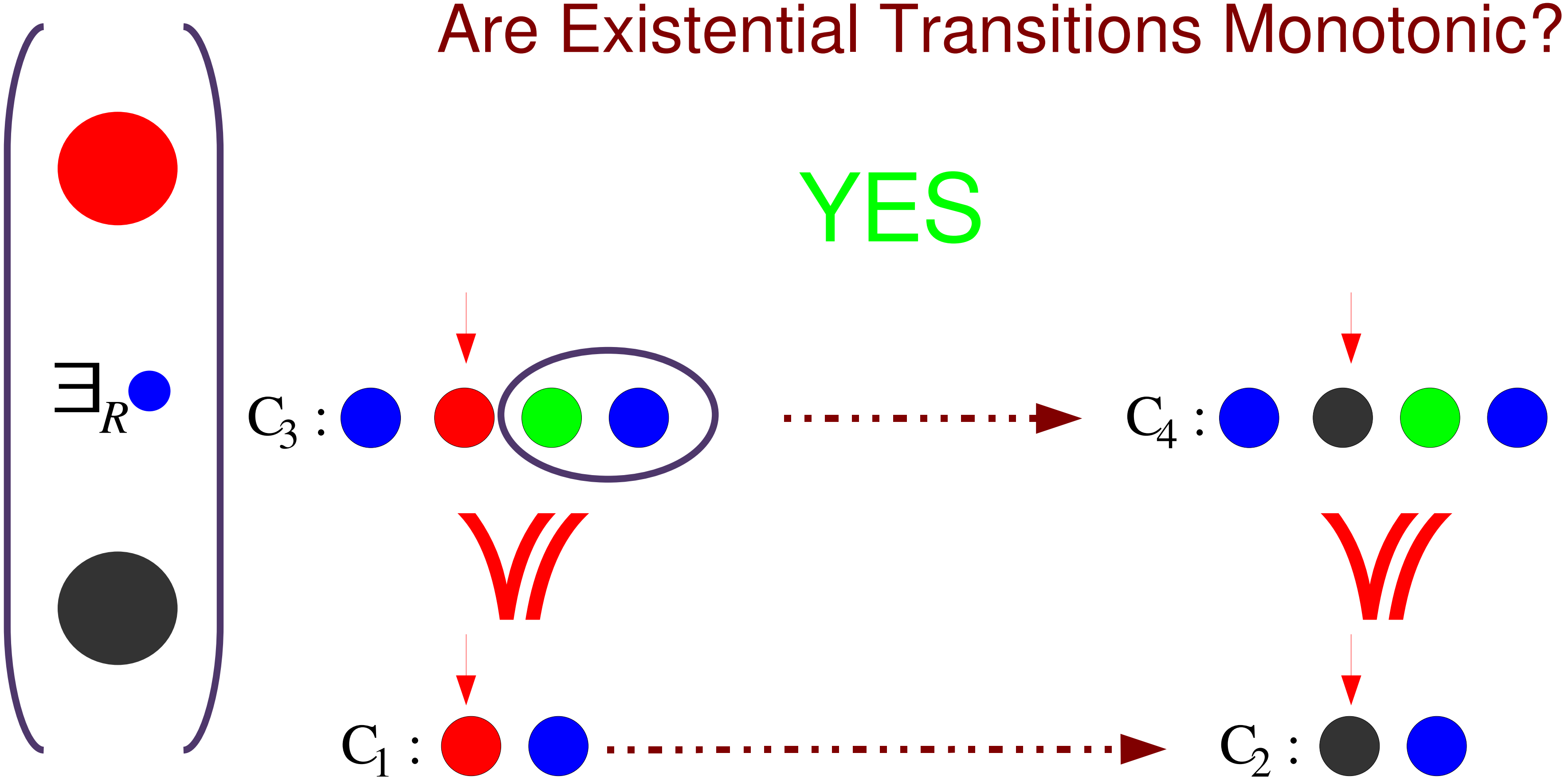
Are Existential Transitions Monotonic?



Monotonicity

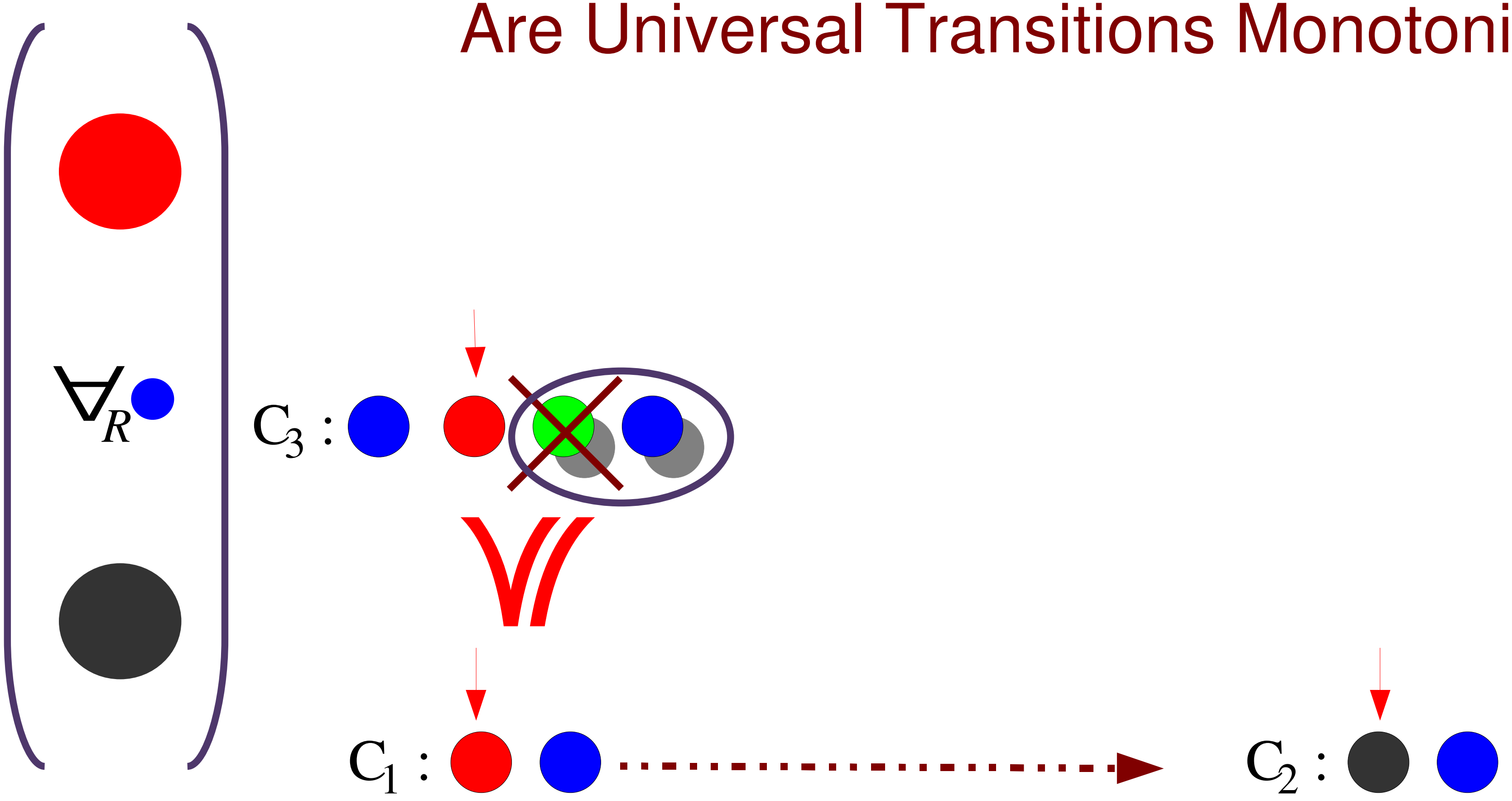
Are Existential Transitions Monotonic?

YES



Monotonicity

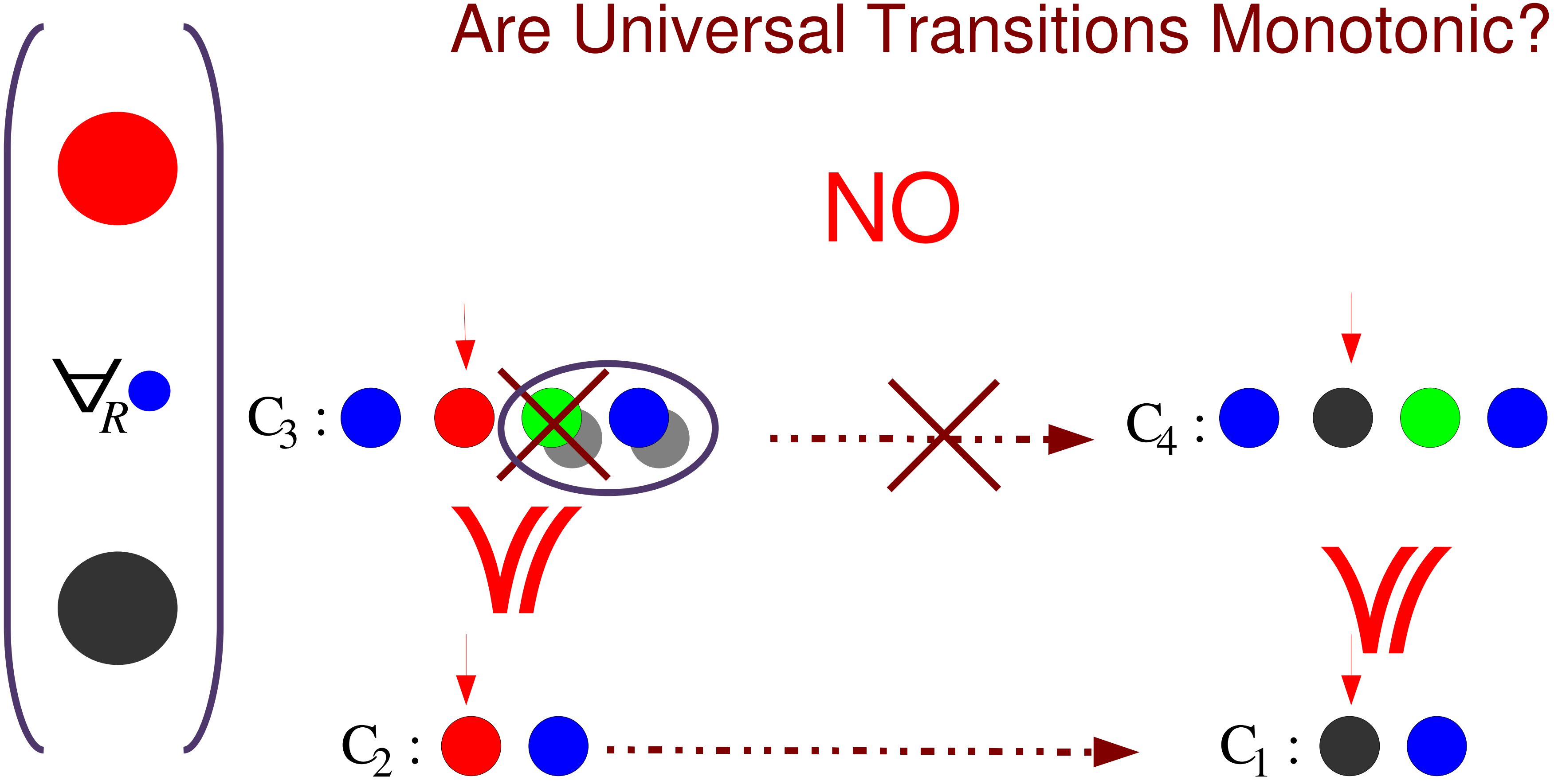
Are Universal Transitions Monotonic?



Monotonicity

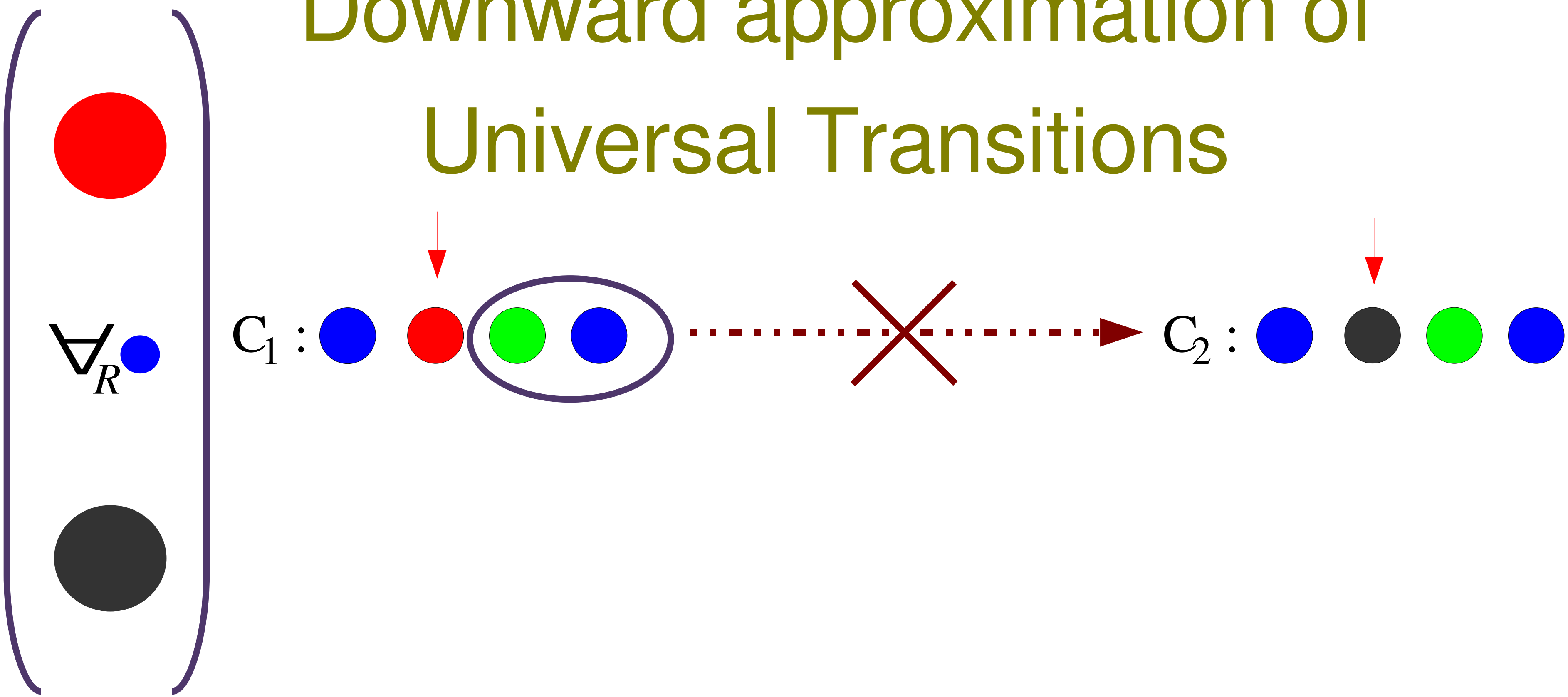
Are Universal Transitions Monotonic?

NO



Approximation

Downward approximation of Universal Transitions



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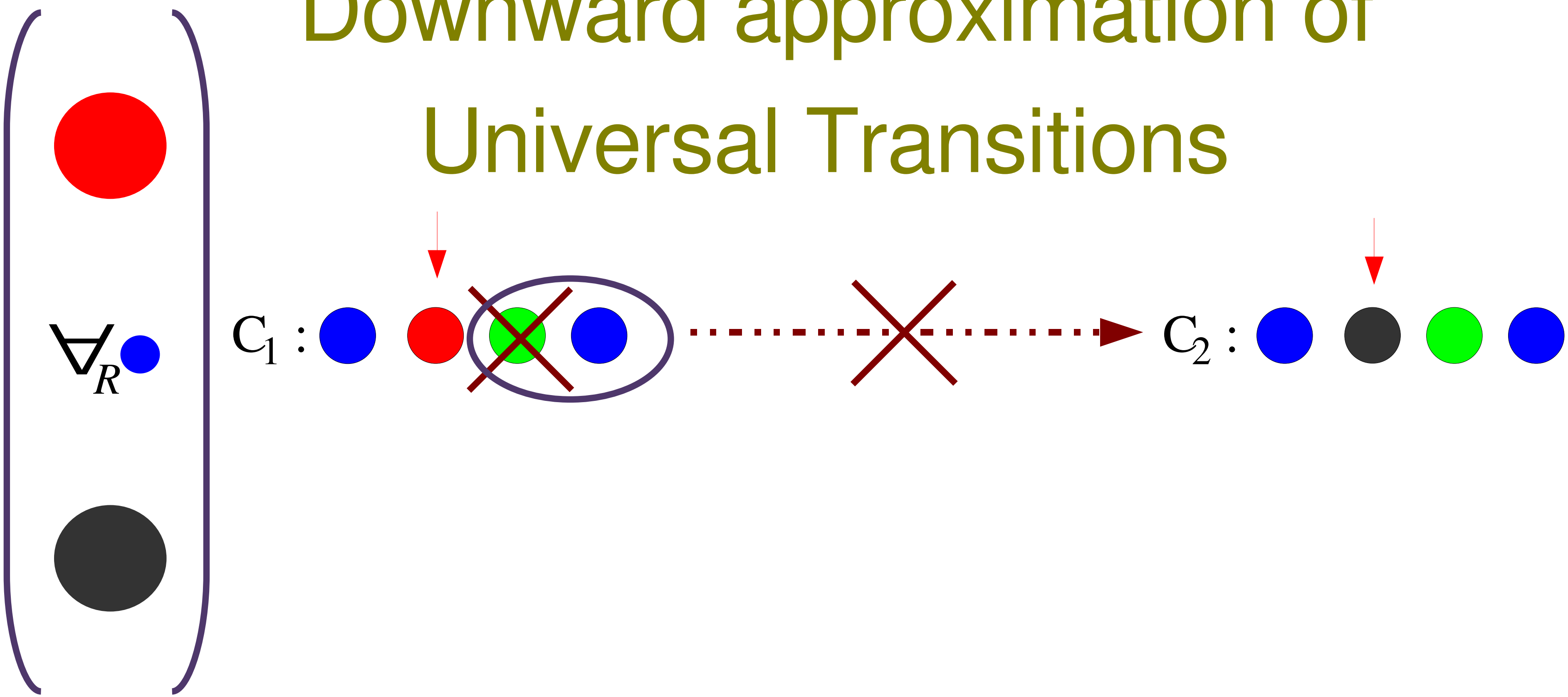

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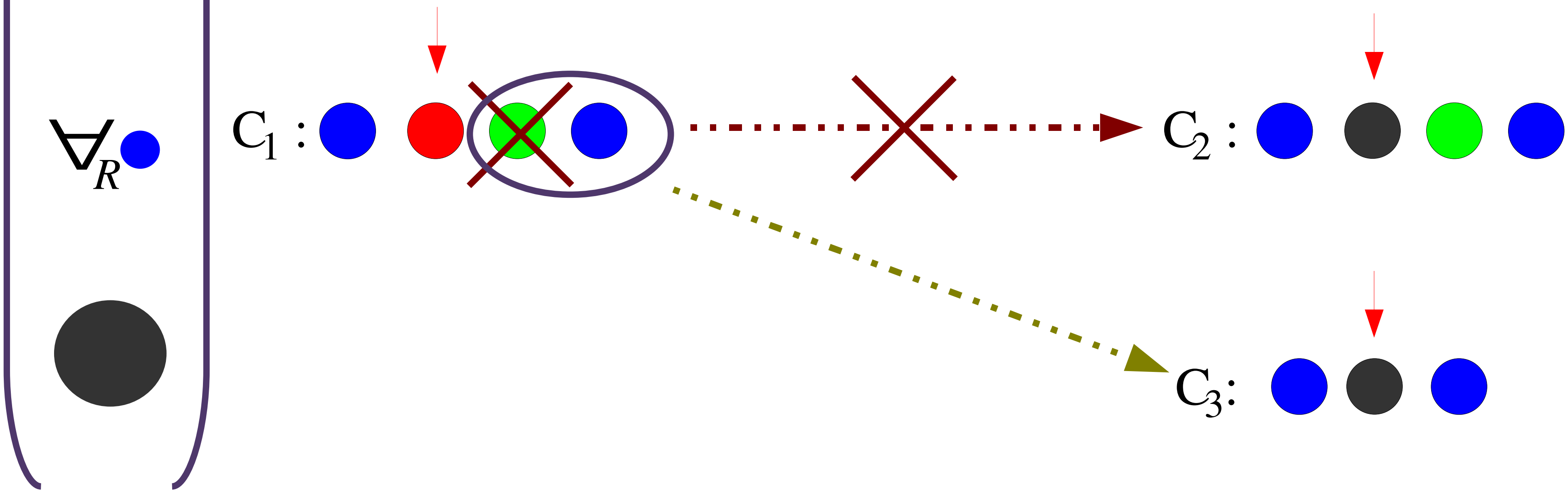

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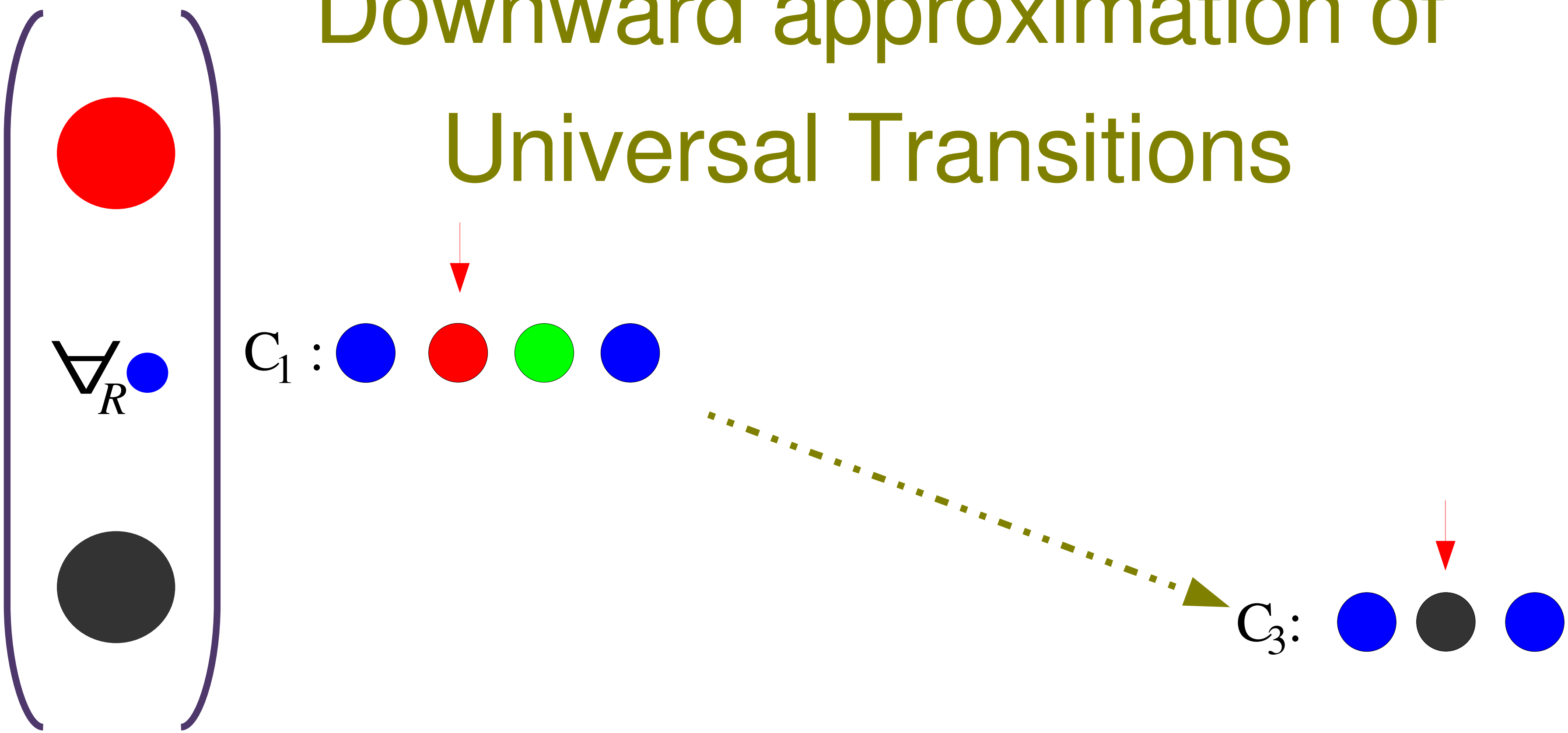

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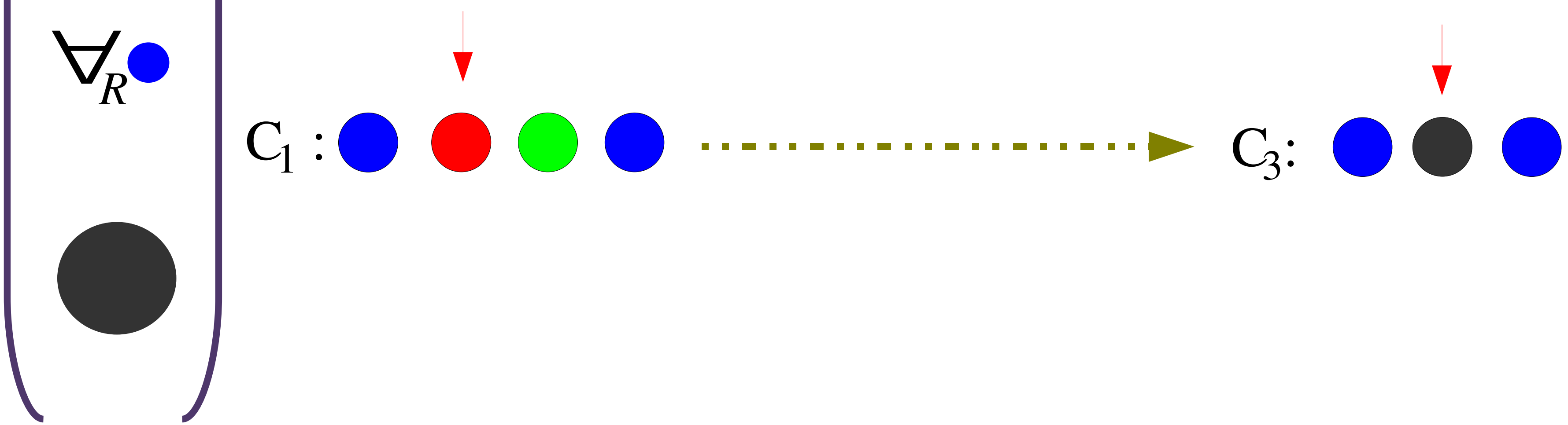
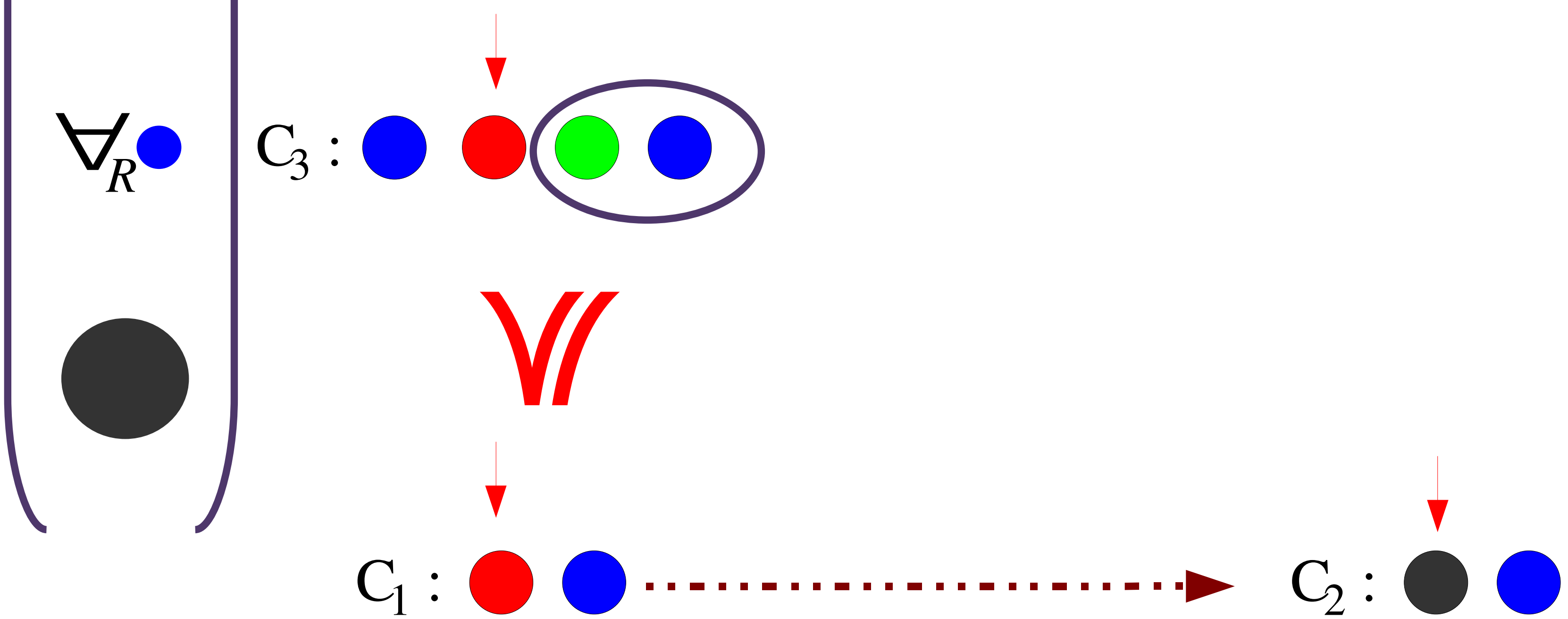


Approximation

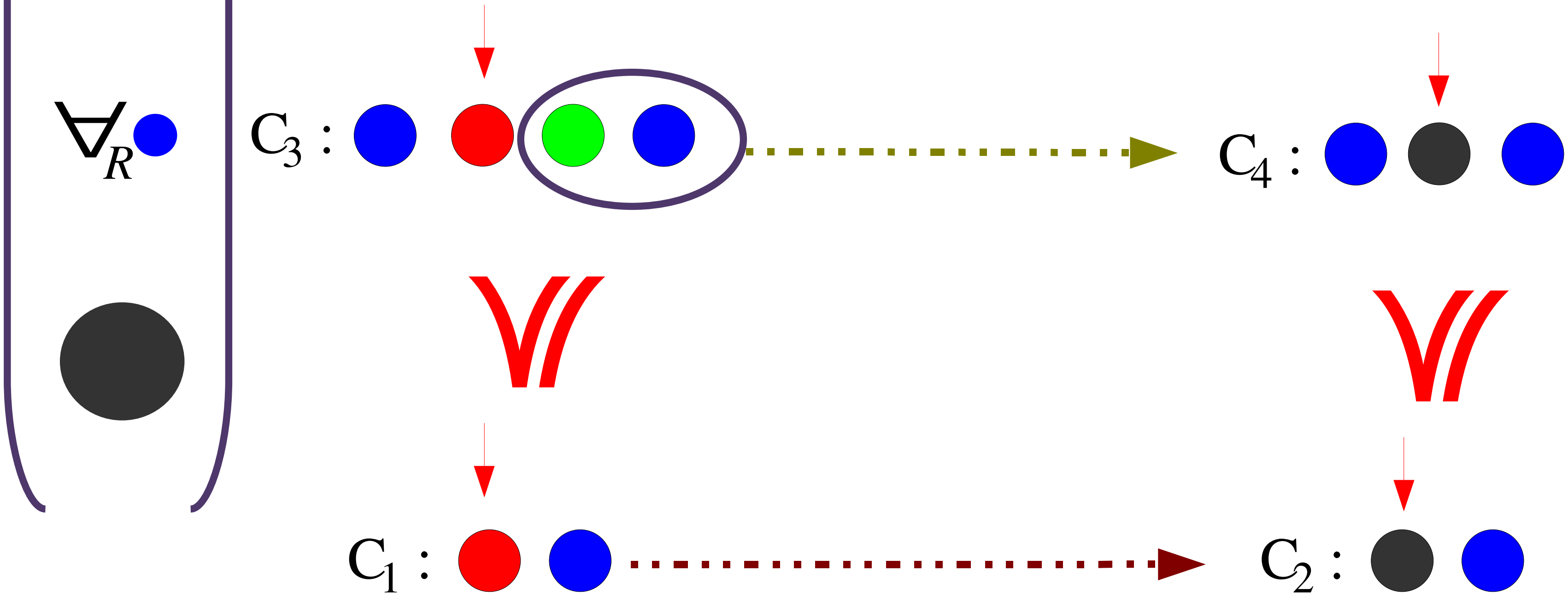
Are Downward Approximations of Universal Transitions Monotonic?



Approximation

Are Downward Approximations of Universal Transitions Monotonic?

YES



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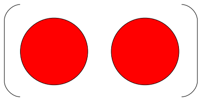
Algorithm



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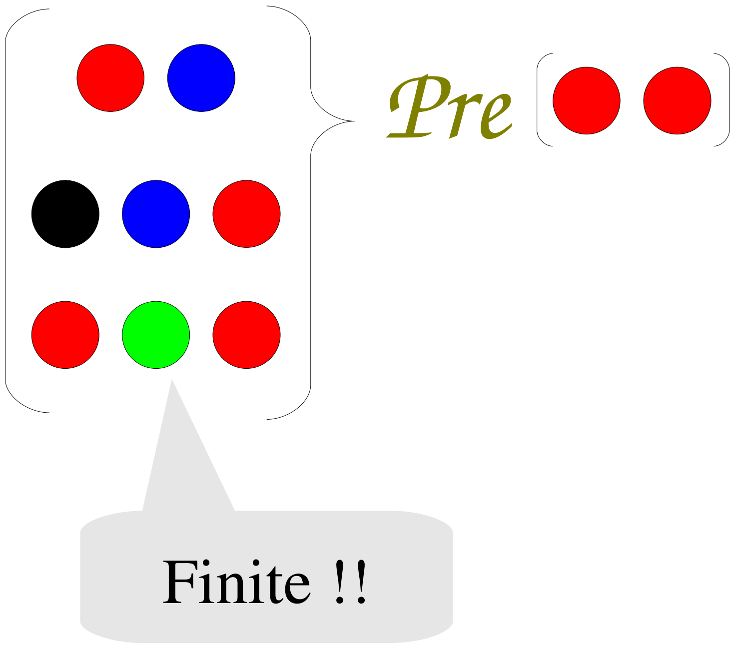

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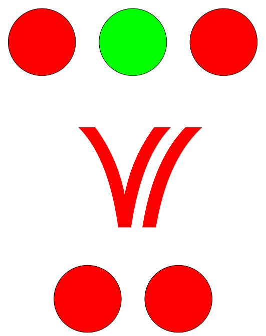

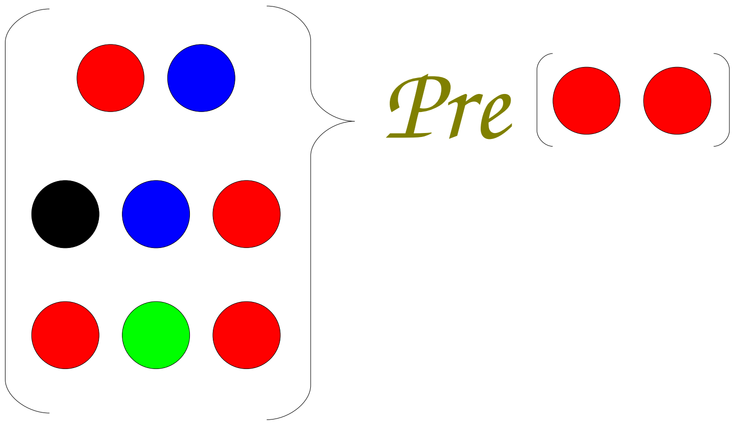

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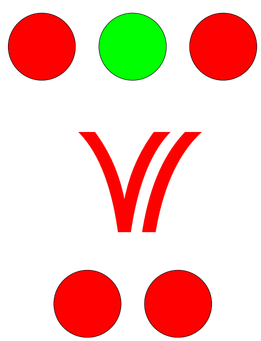

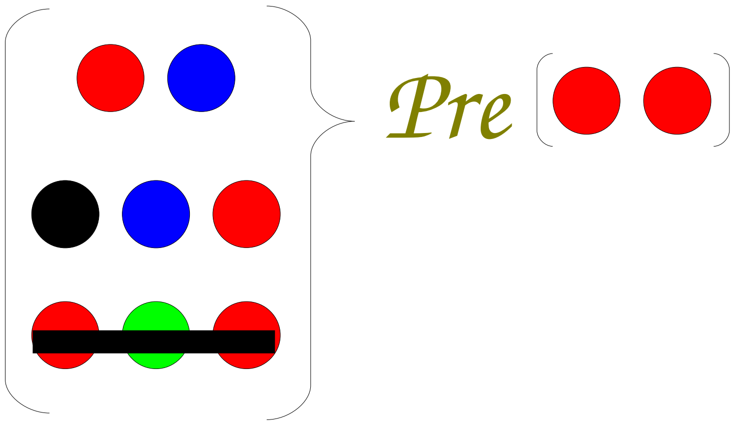

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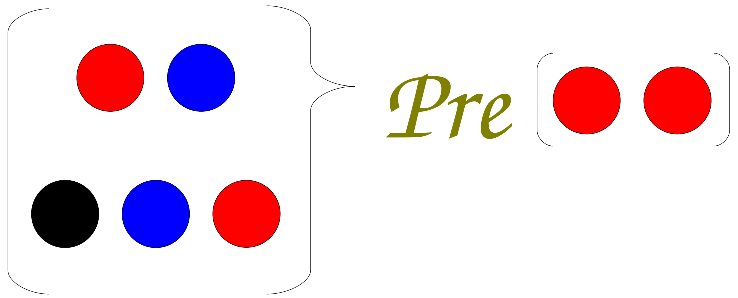

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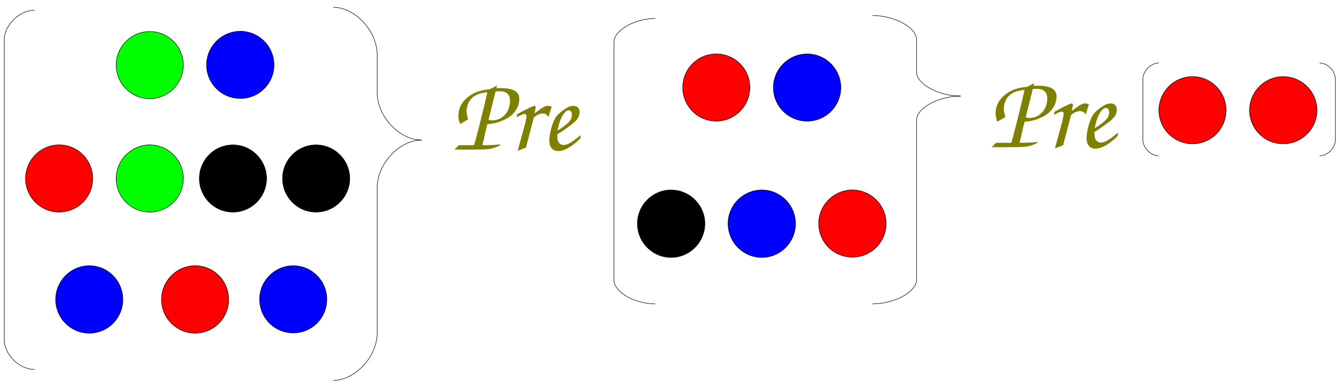

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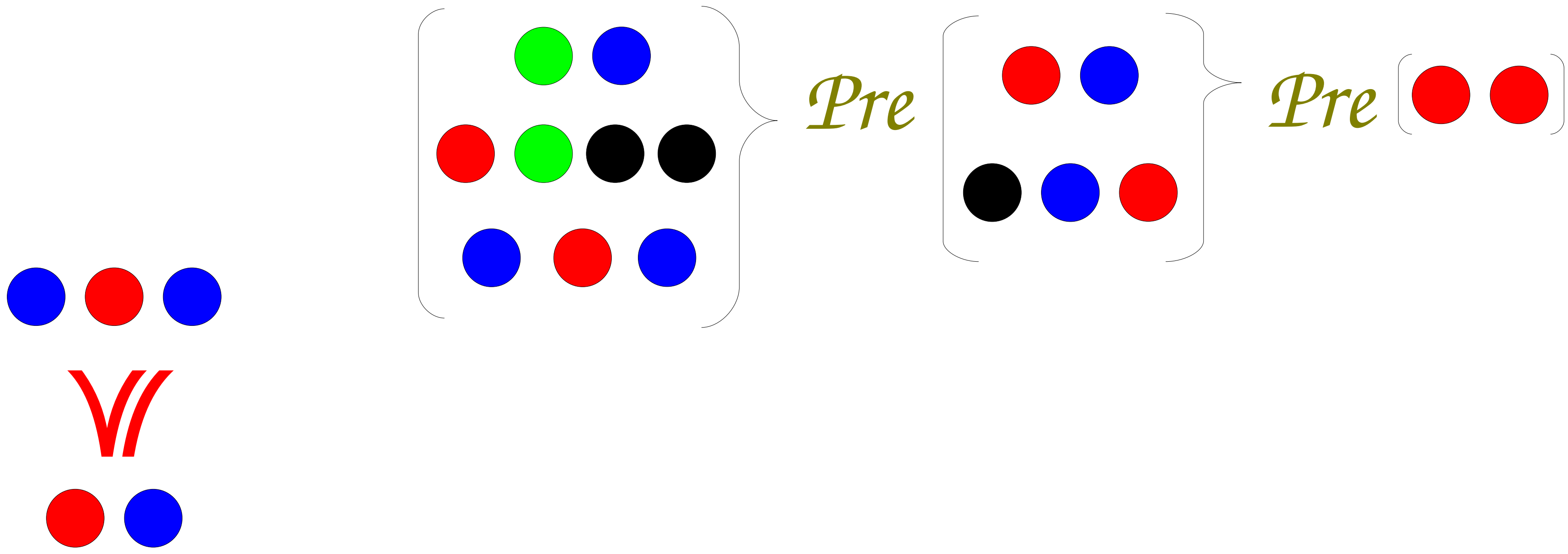

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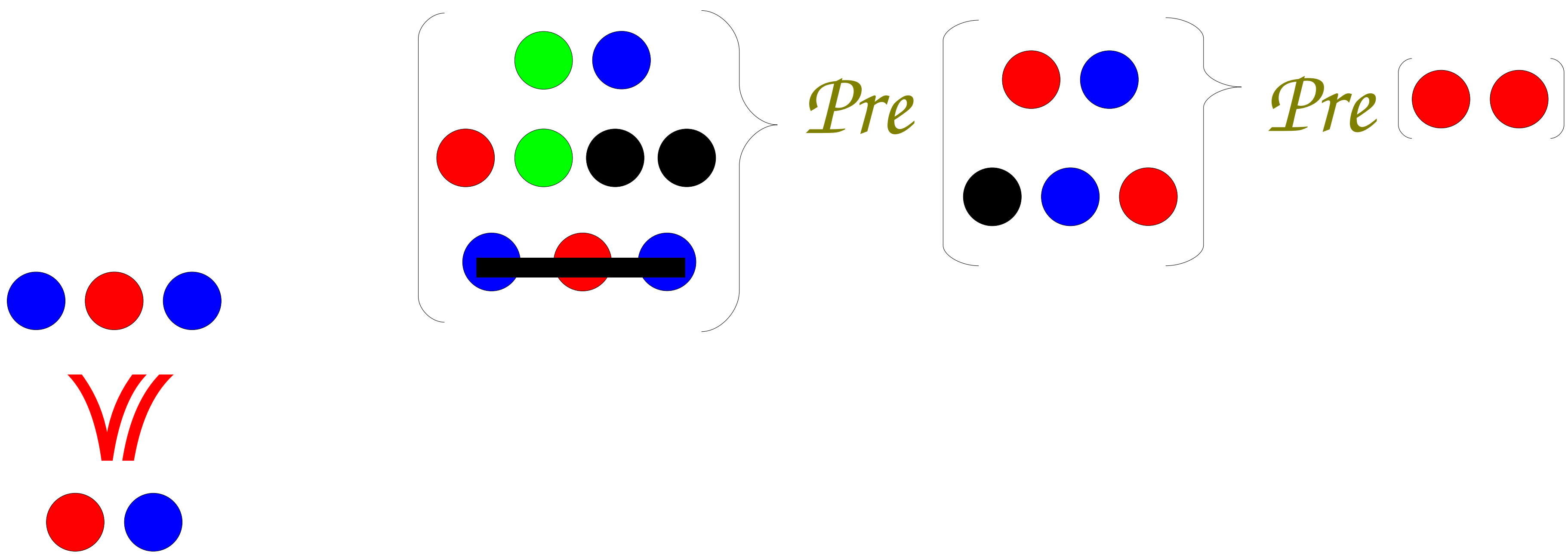

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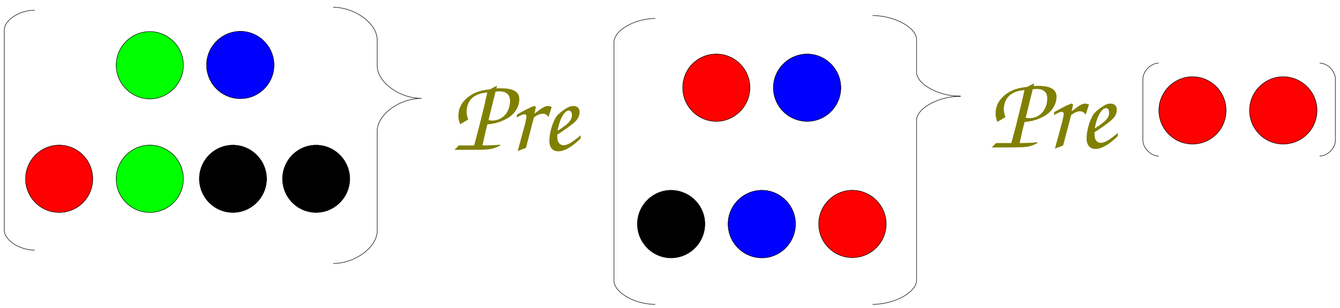

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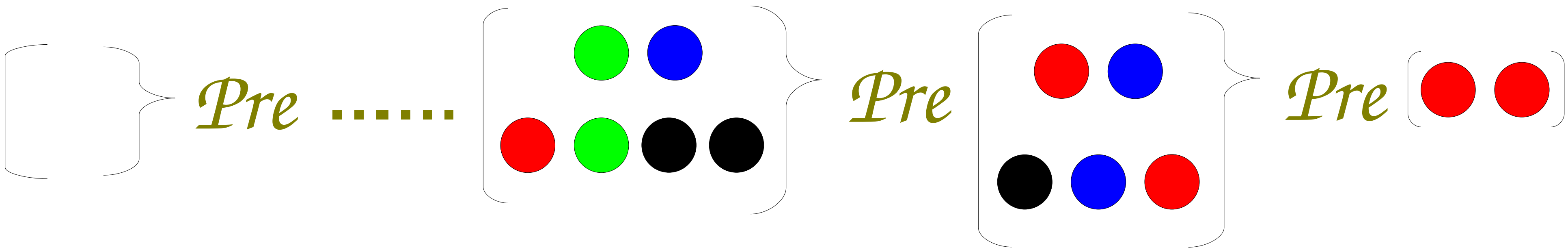
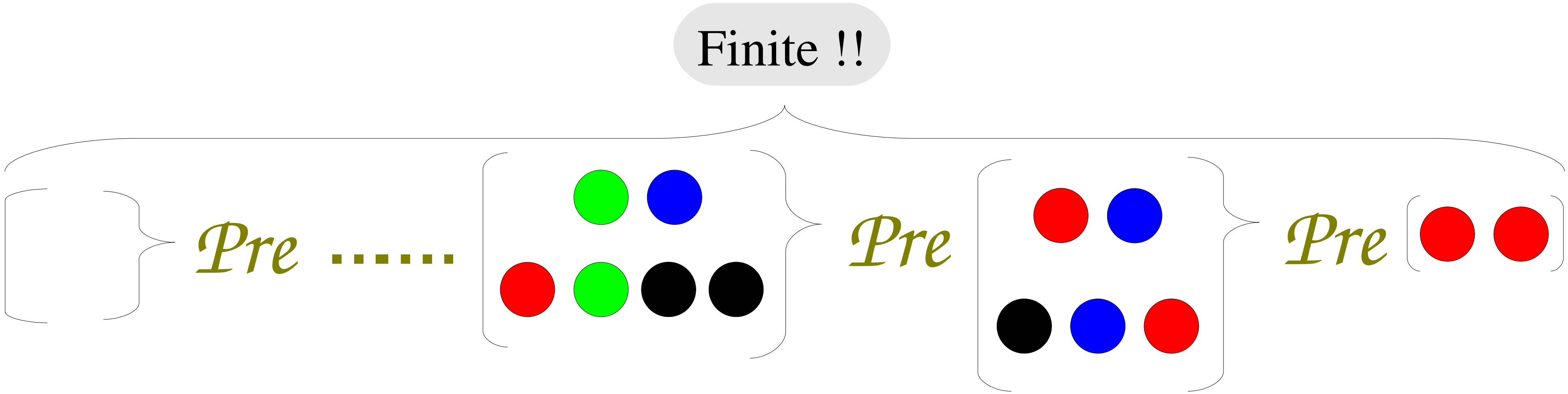


Well Quasi Ordering:

"For each infinite sequence $a_{0,} a_{1,} \dots$ there exists $i < j$ such that $a_i \preccurlyeq a_j$ "

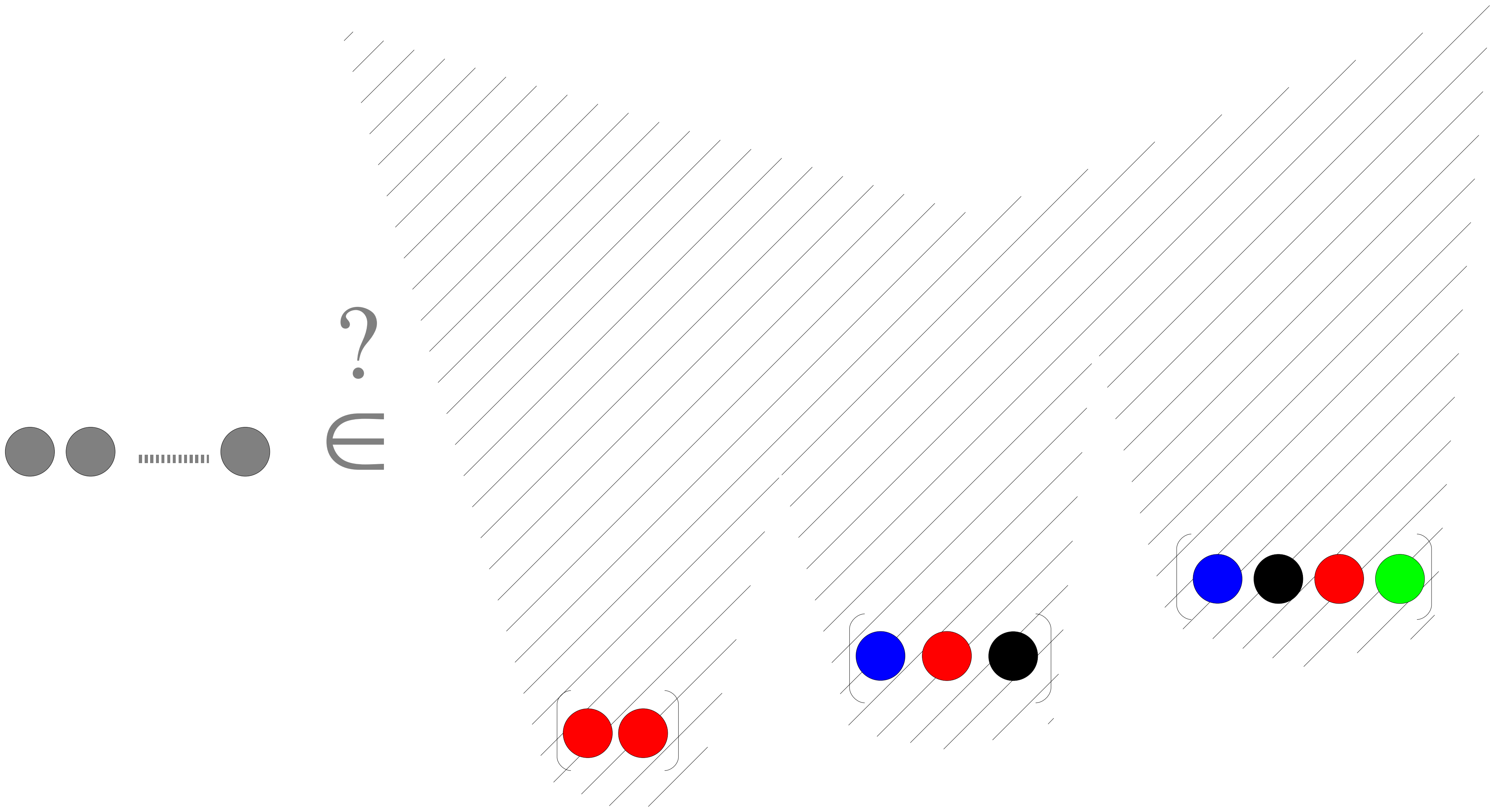
Algorithm



Well Quasi Ordering:

"No infinite sequence of upward closed"

Algorithm



Results

	#iter	#constr	T (ms)
Bakery	2	2	4
Bakery*	2	2	4
Burns	14	71	230
Burns*	9	21	32
Java M-lock	5	24	30
Java M-lock*	5	17	30
Dijkstra	13	150	1700
Dijkstra*	8	57	168
Szymanski	17	334	3880
Szymanski*	17	334	4080

Mutual Exclusion Algorithms

	#iter	#constr	t(ms)
Synapse	3	3	4
Berkley	2	6	8
Mesi	3	8	8
Moeisi	1	12	12
Dec Firefly	3	11	16
Xerox P.D	3	20	52
Illinois	5	33	80
Futurebus	7	153	300
German	44	14475	3h45mn

Cache Coherence Protocols

Conclusion

- A framework which can handle, e.g.
  - mutual exclusion and
  - cache coherence.
- Better performance than specialized tools
- Some of the examples are verified for the first time completely automatically (German, Java-Metalock)
- Can be extended to systems where the processes operate on unbounded variables (paper at CAV 2007)
- Simpler machinery compared to regular model checking (no transducers)
- Ongoing extensions to trees, graphs ...