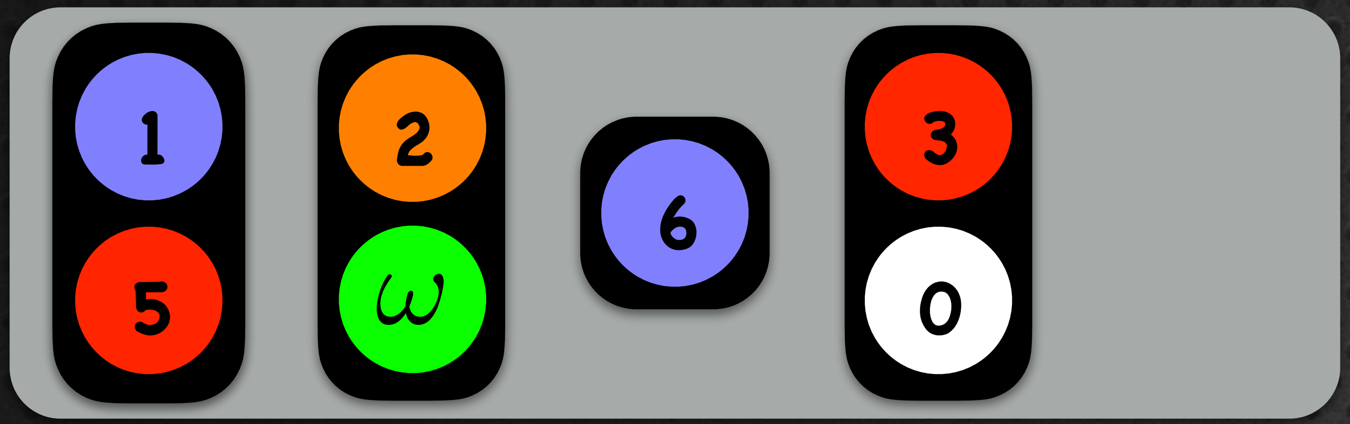
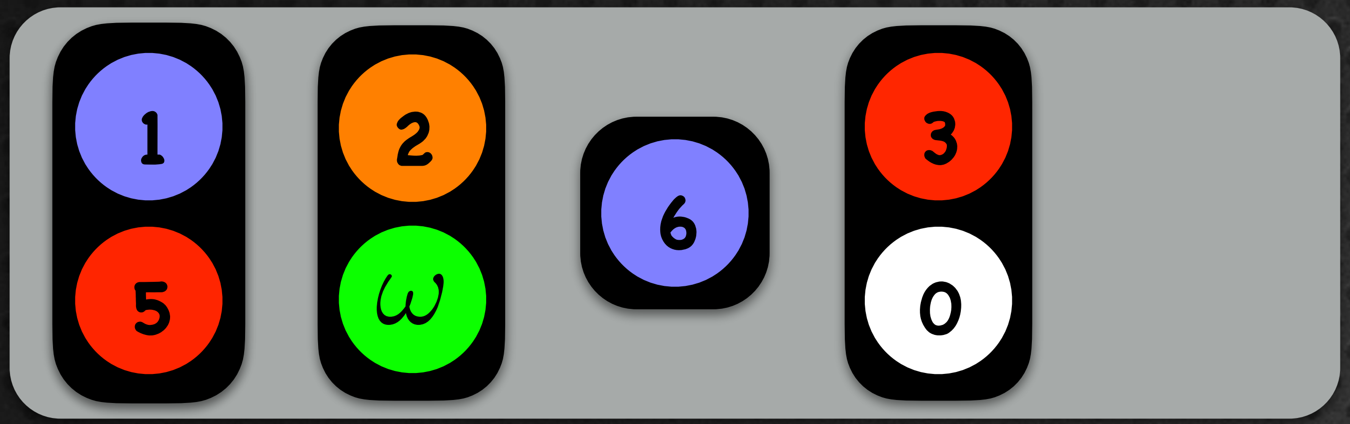
Timed Pe

Signatures



Timed Pe

Signatures



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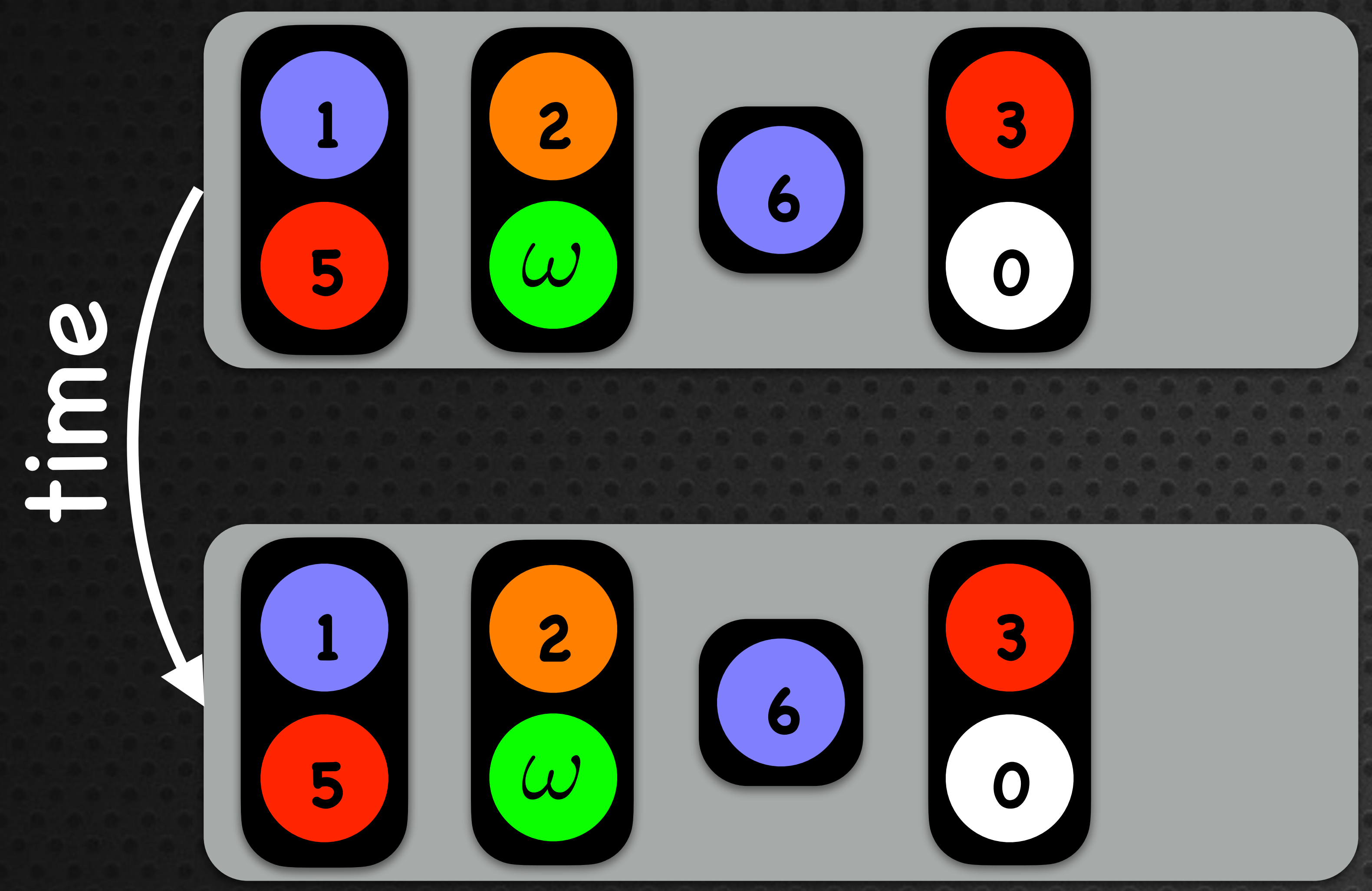

Timed Pe

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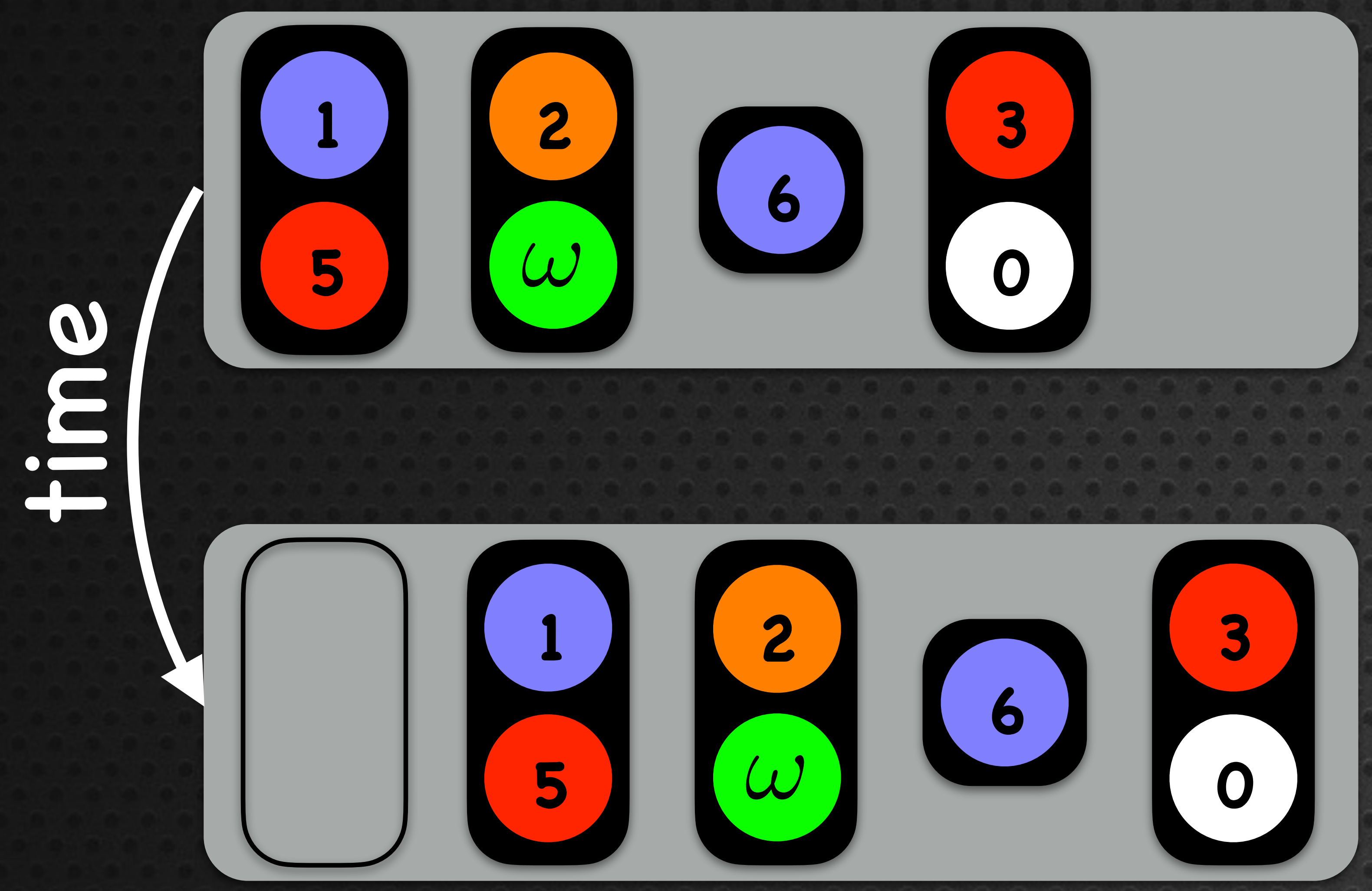

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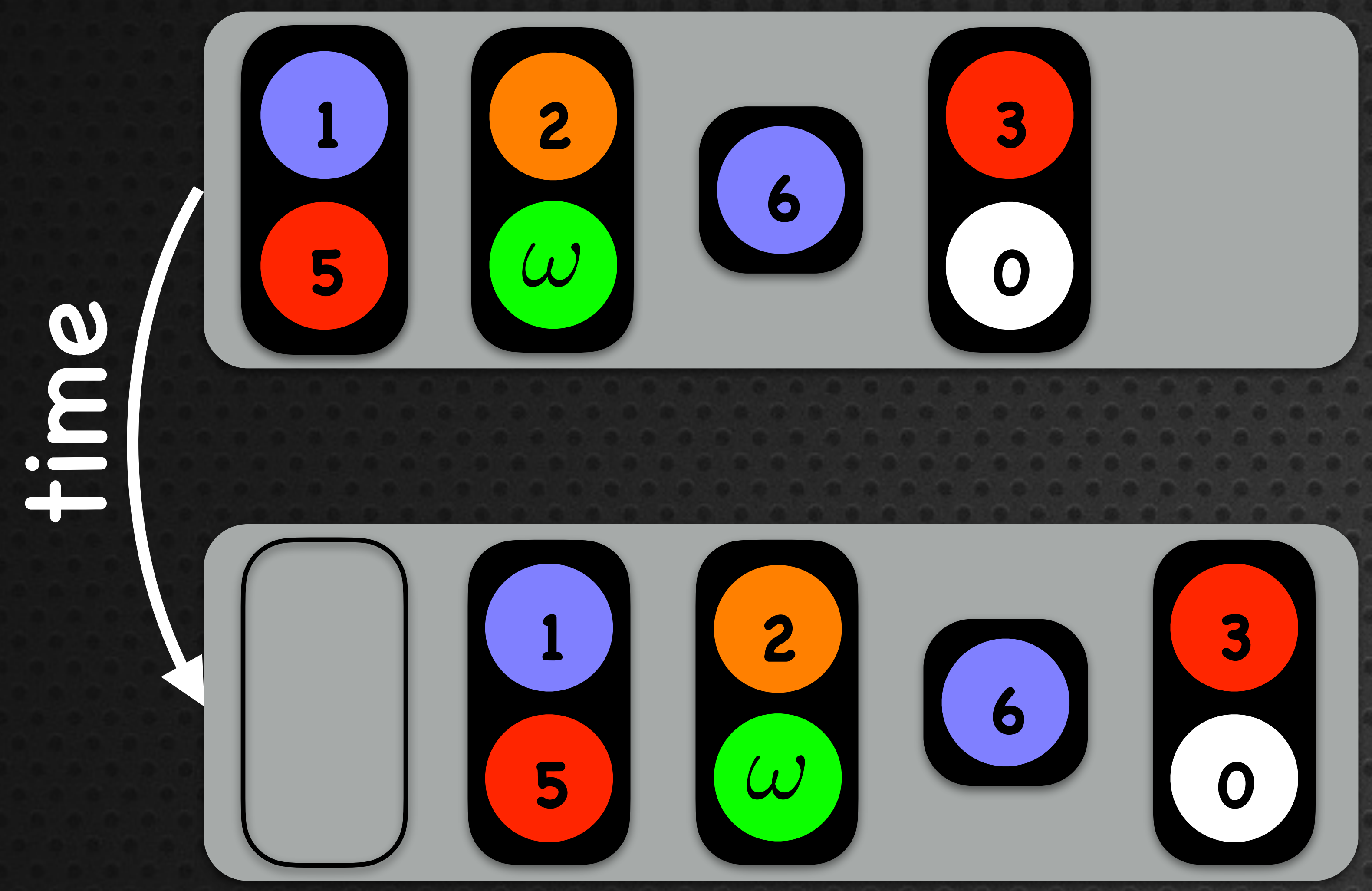

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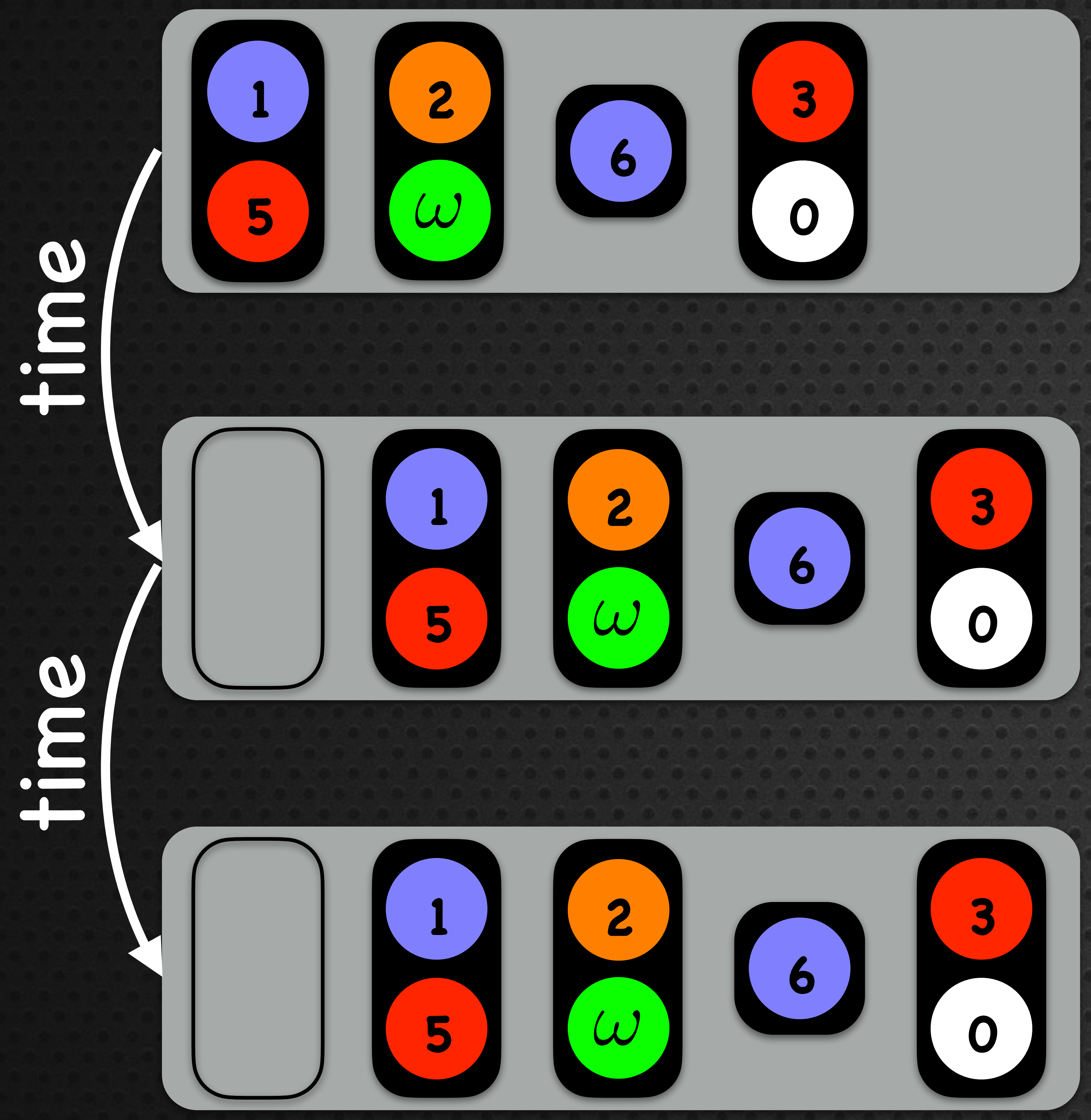
Signatures



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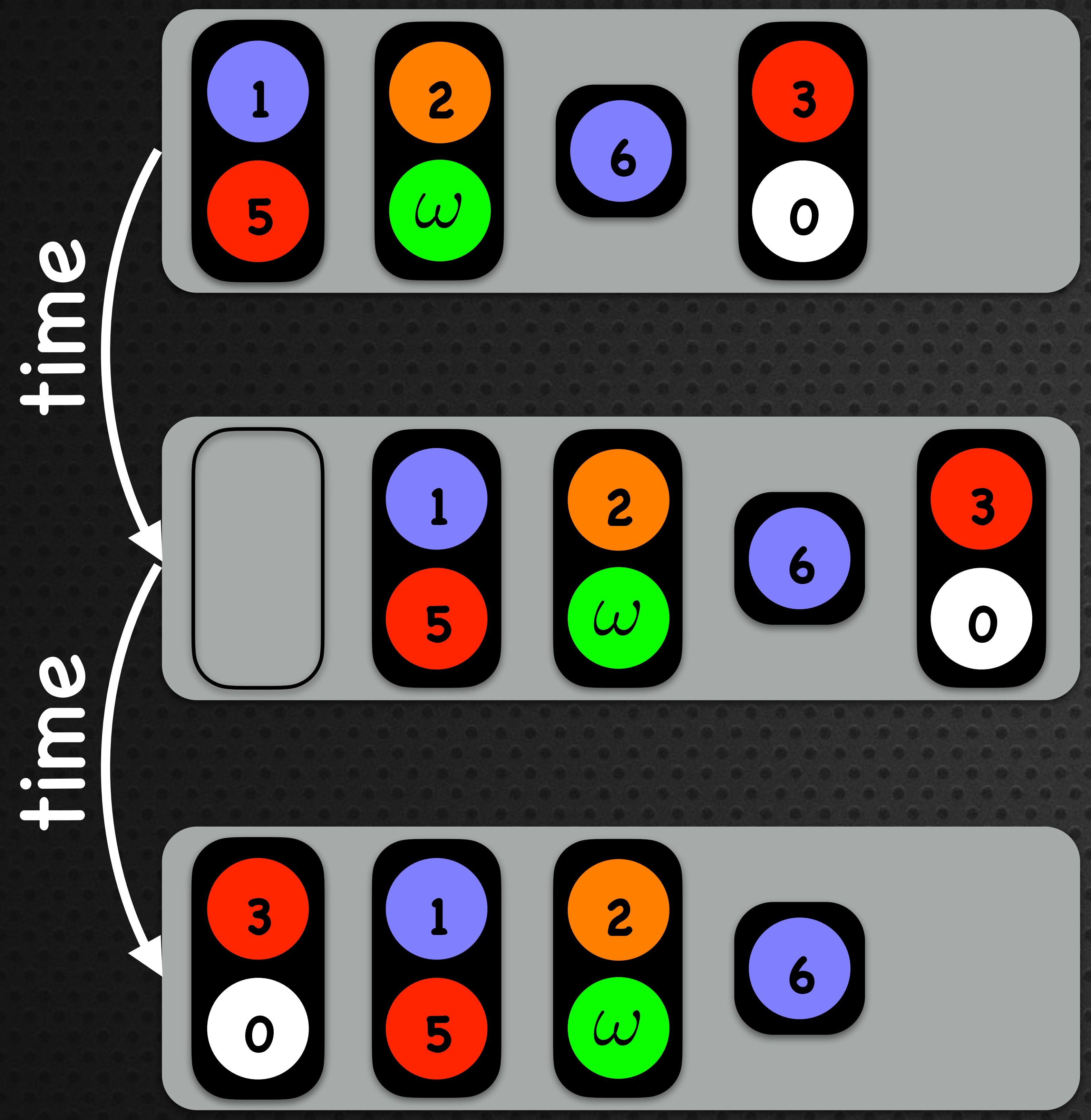

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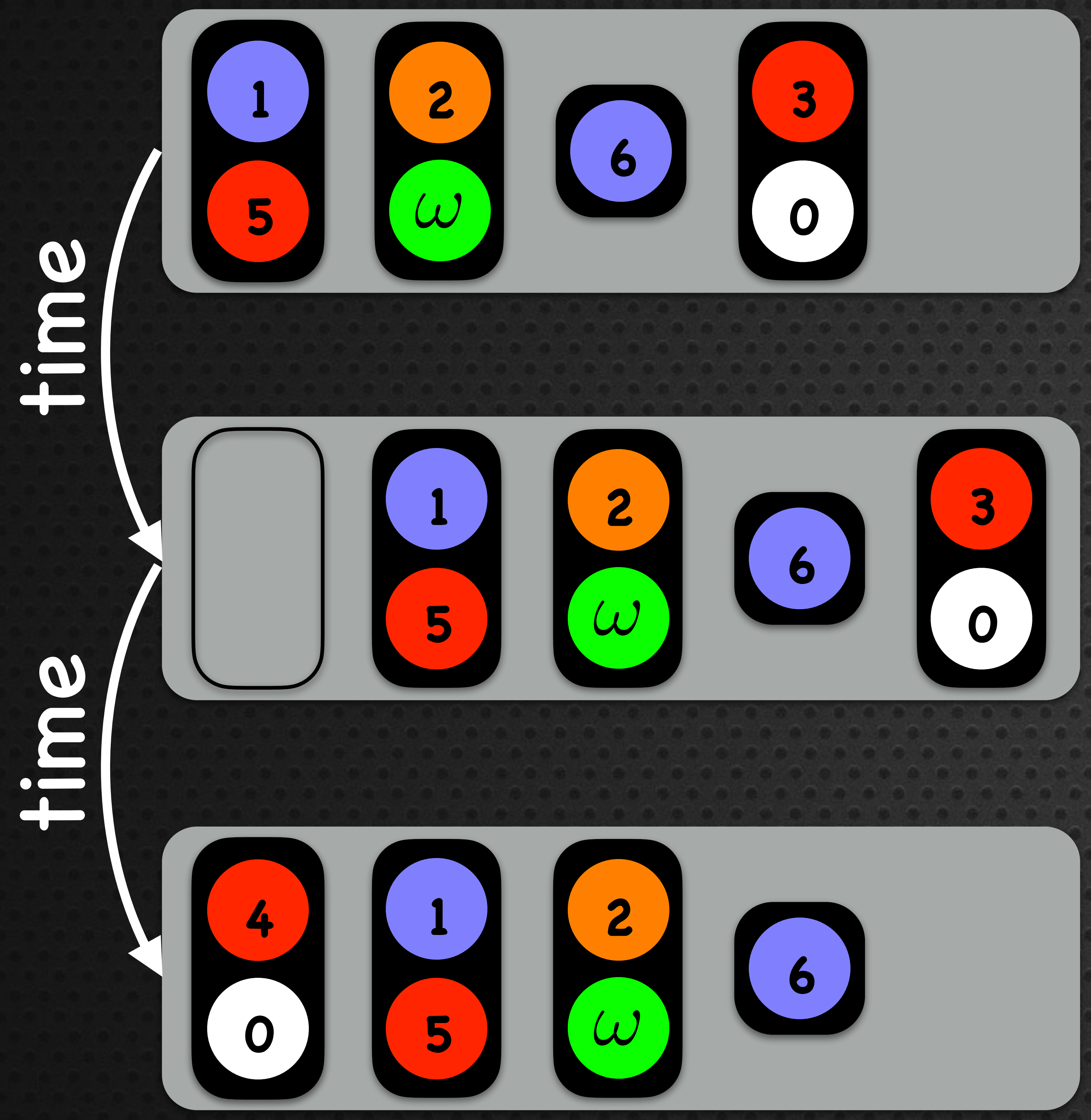

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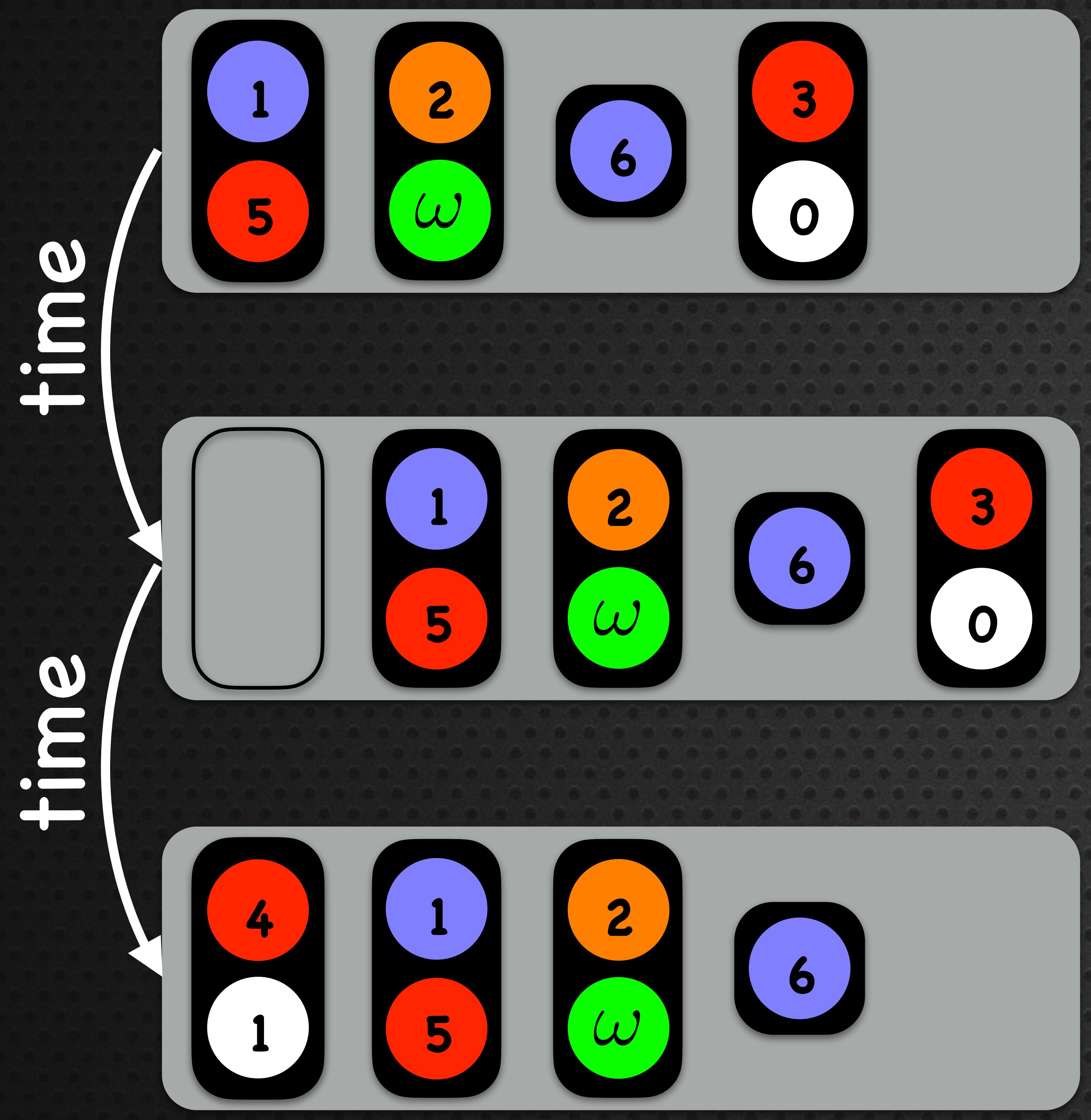

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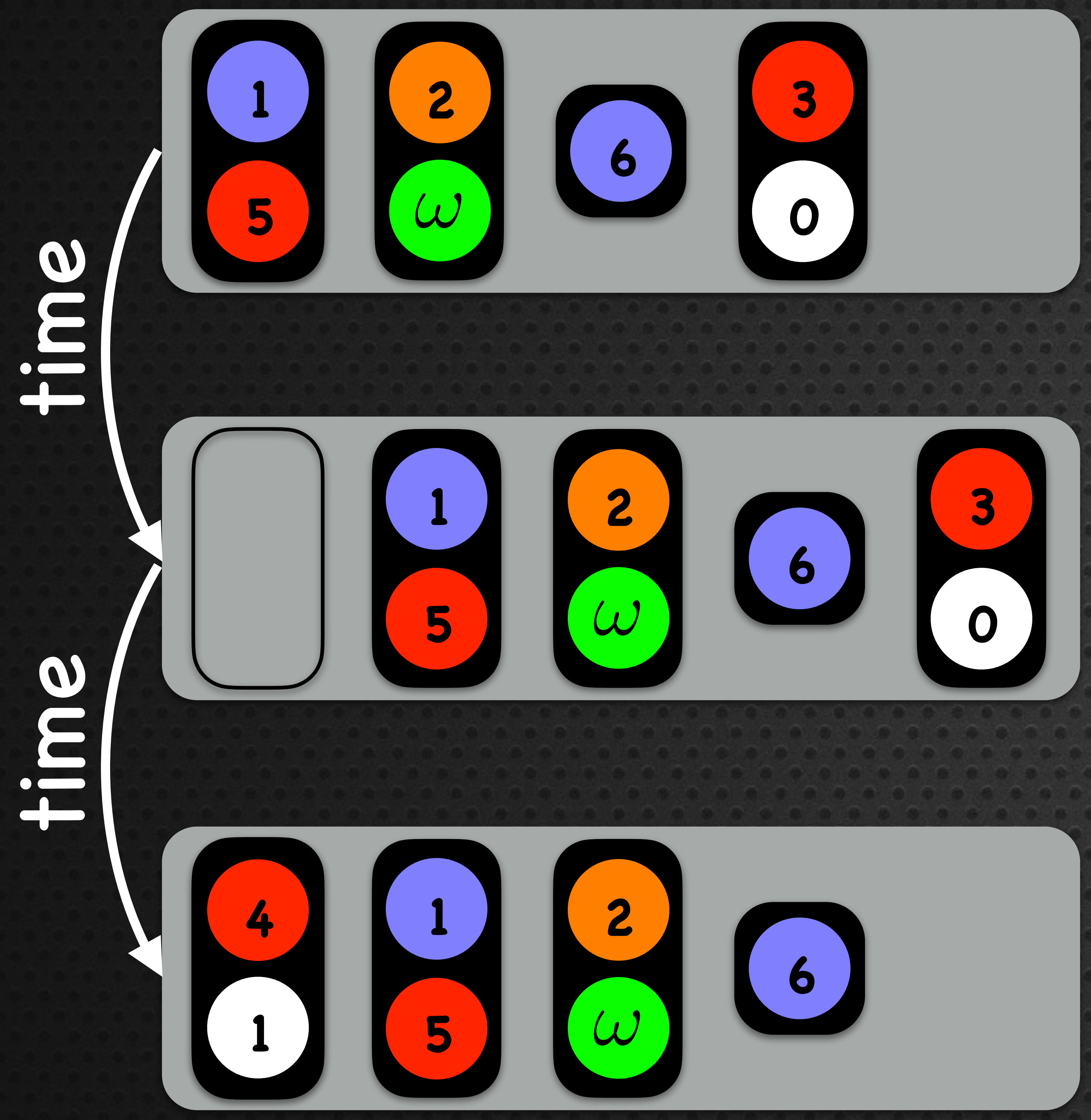

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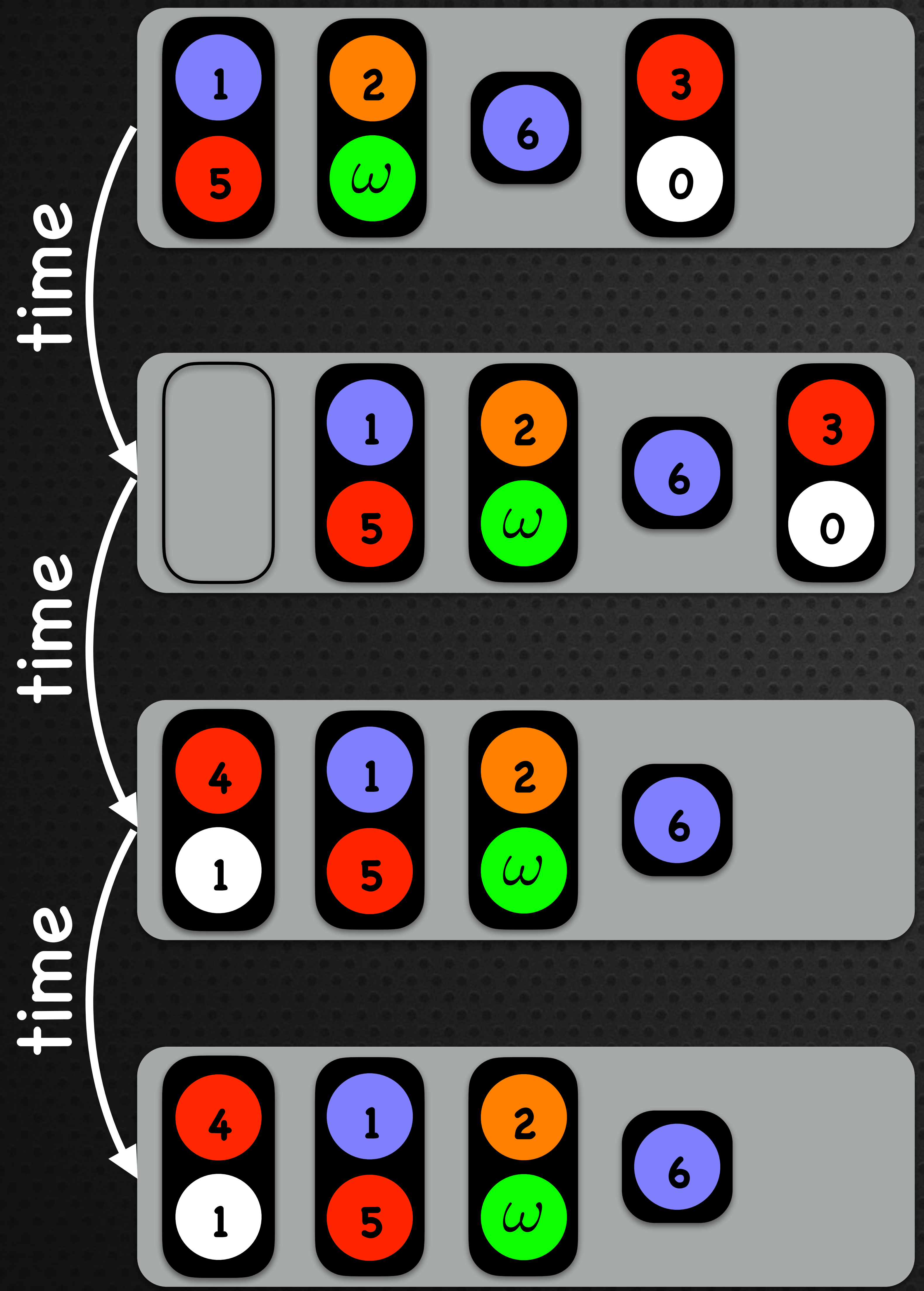

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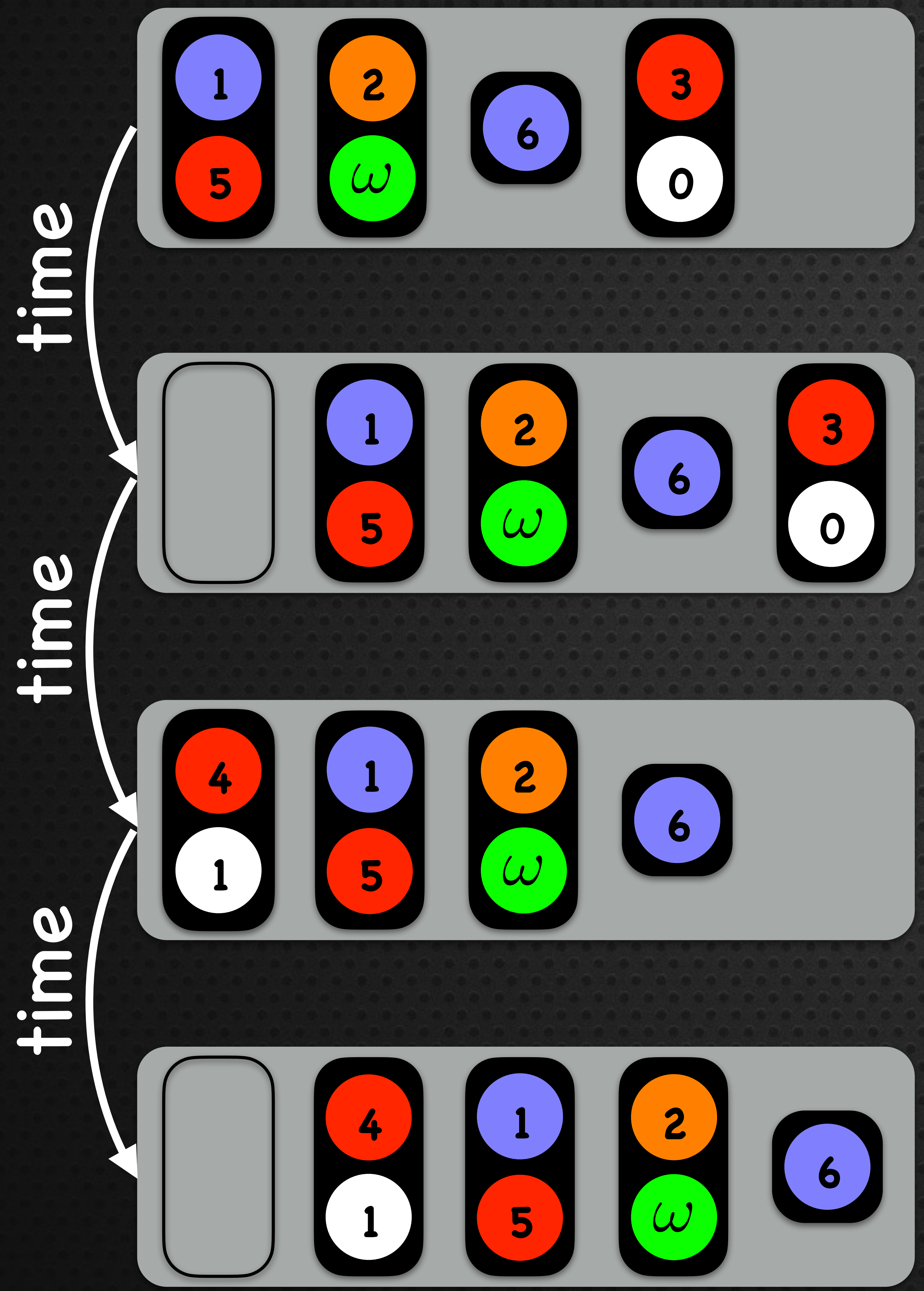

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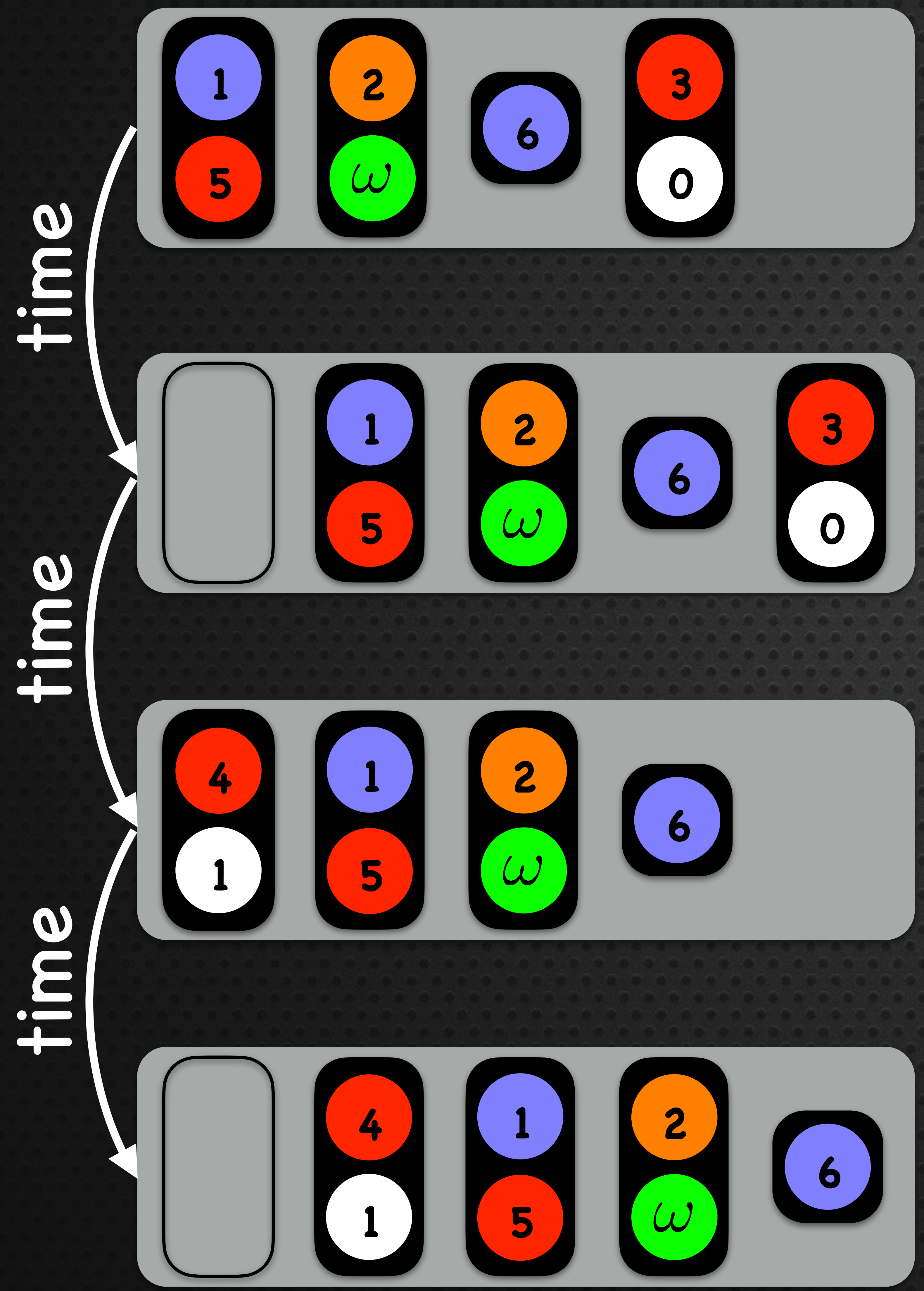

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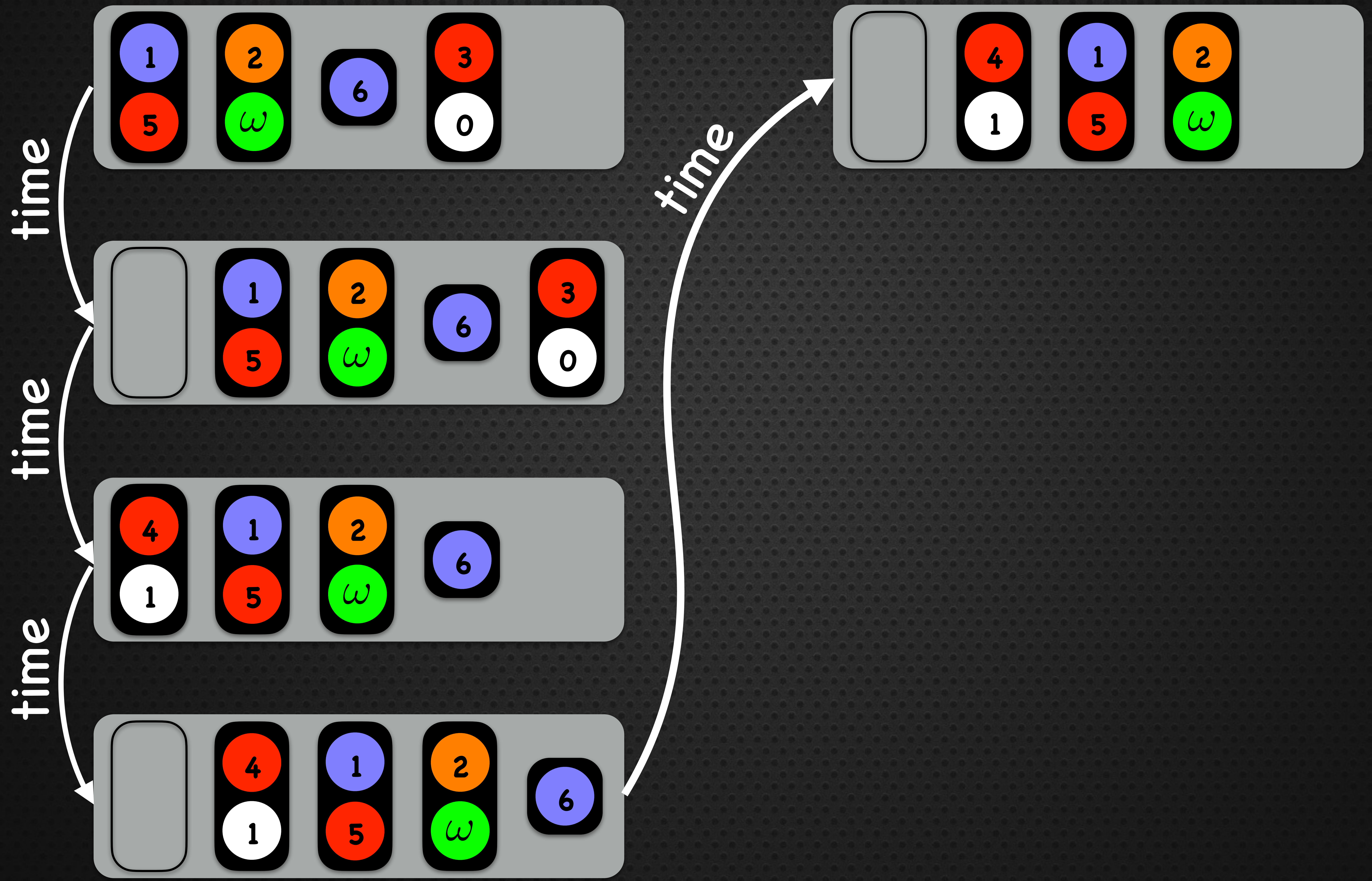

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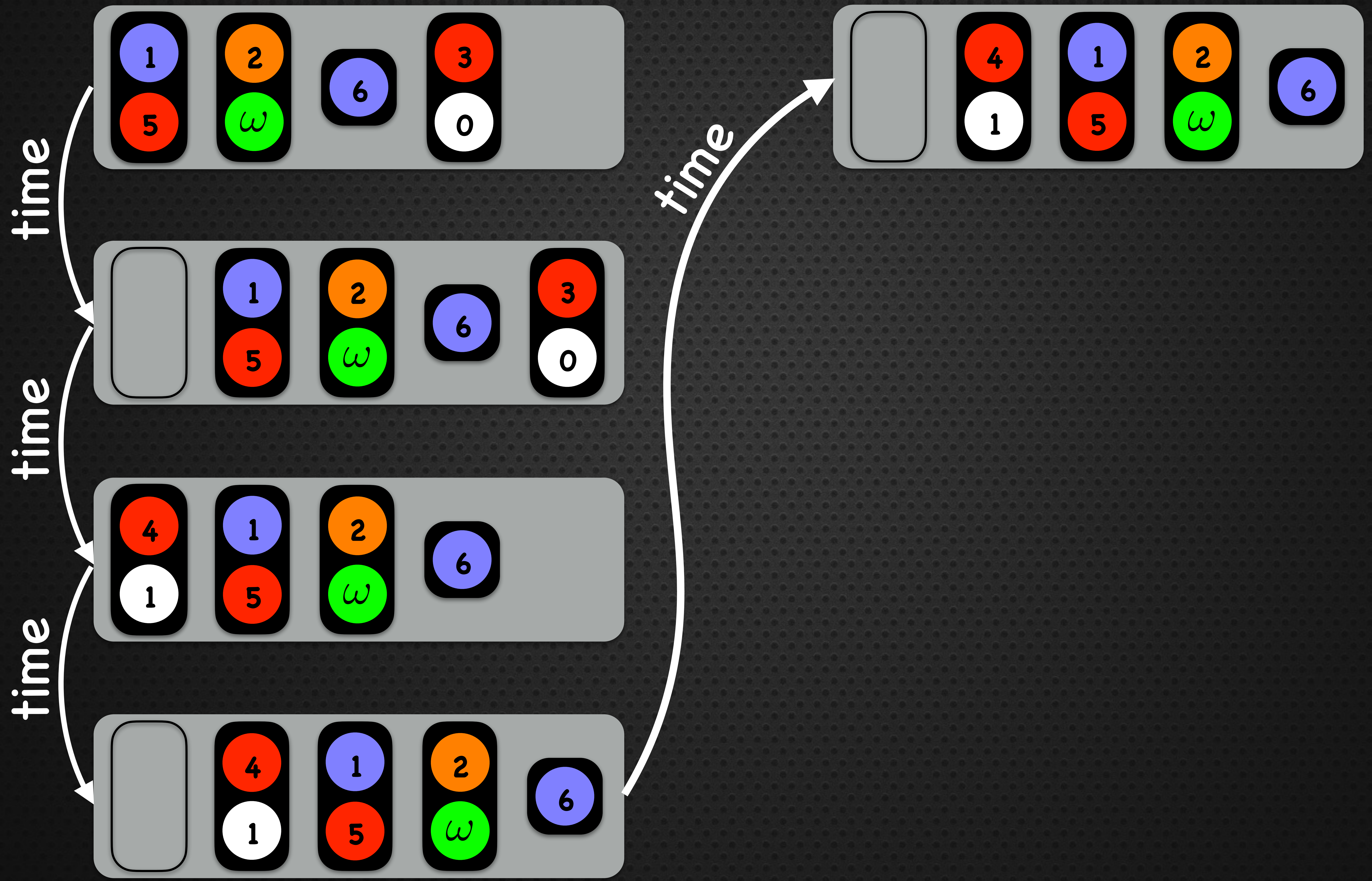

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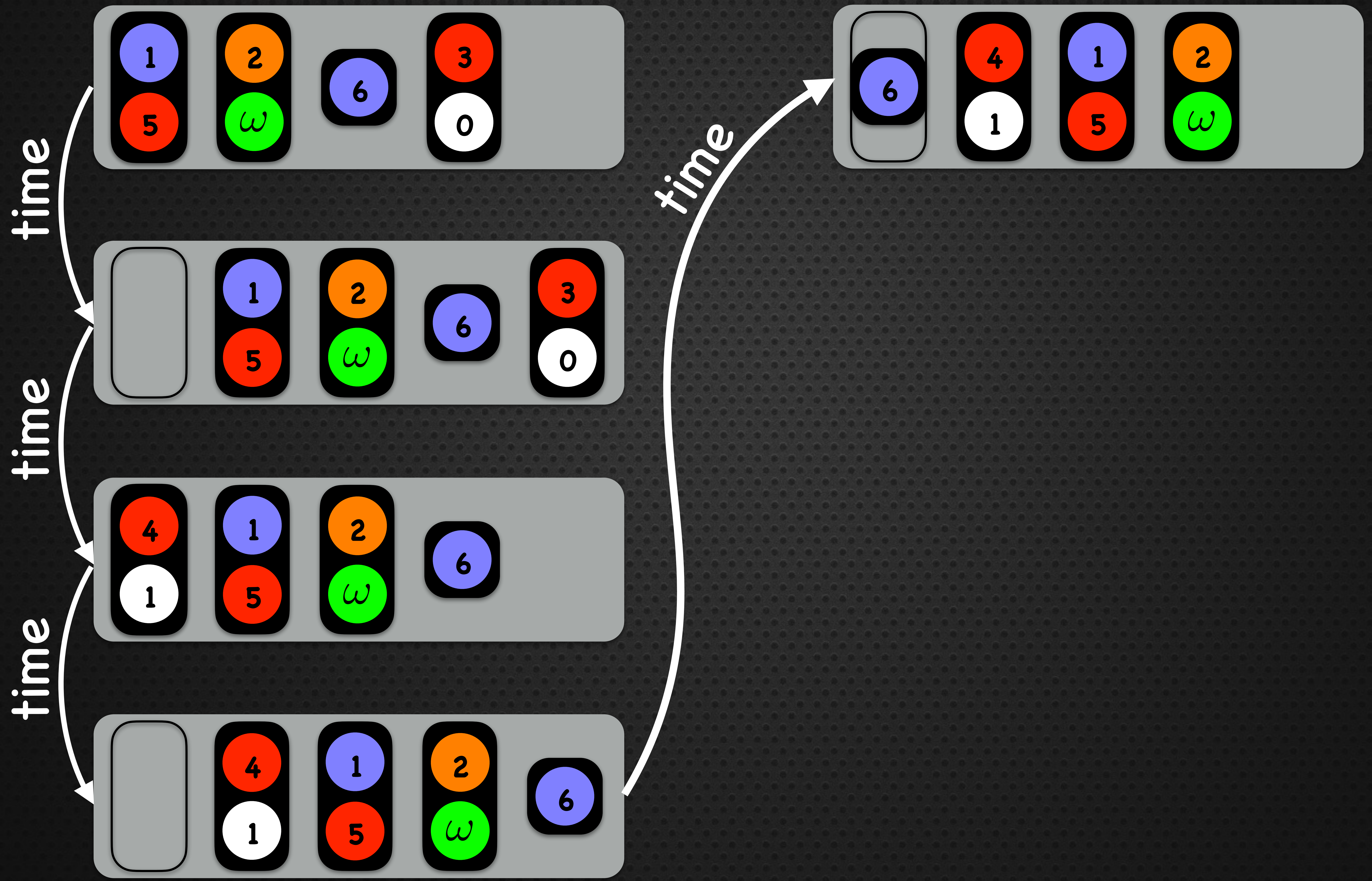

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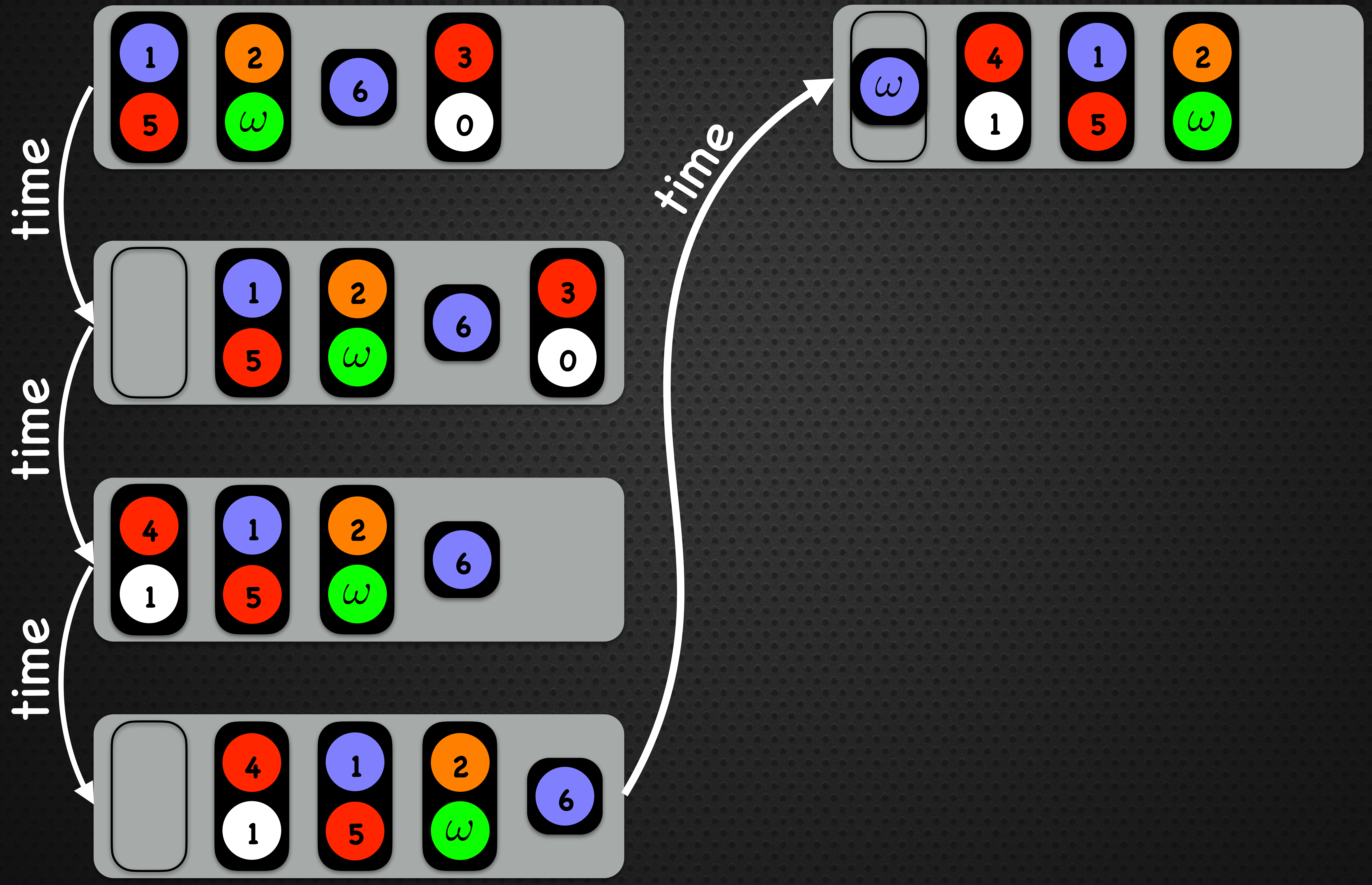

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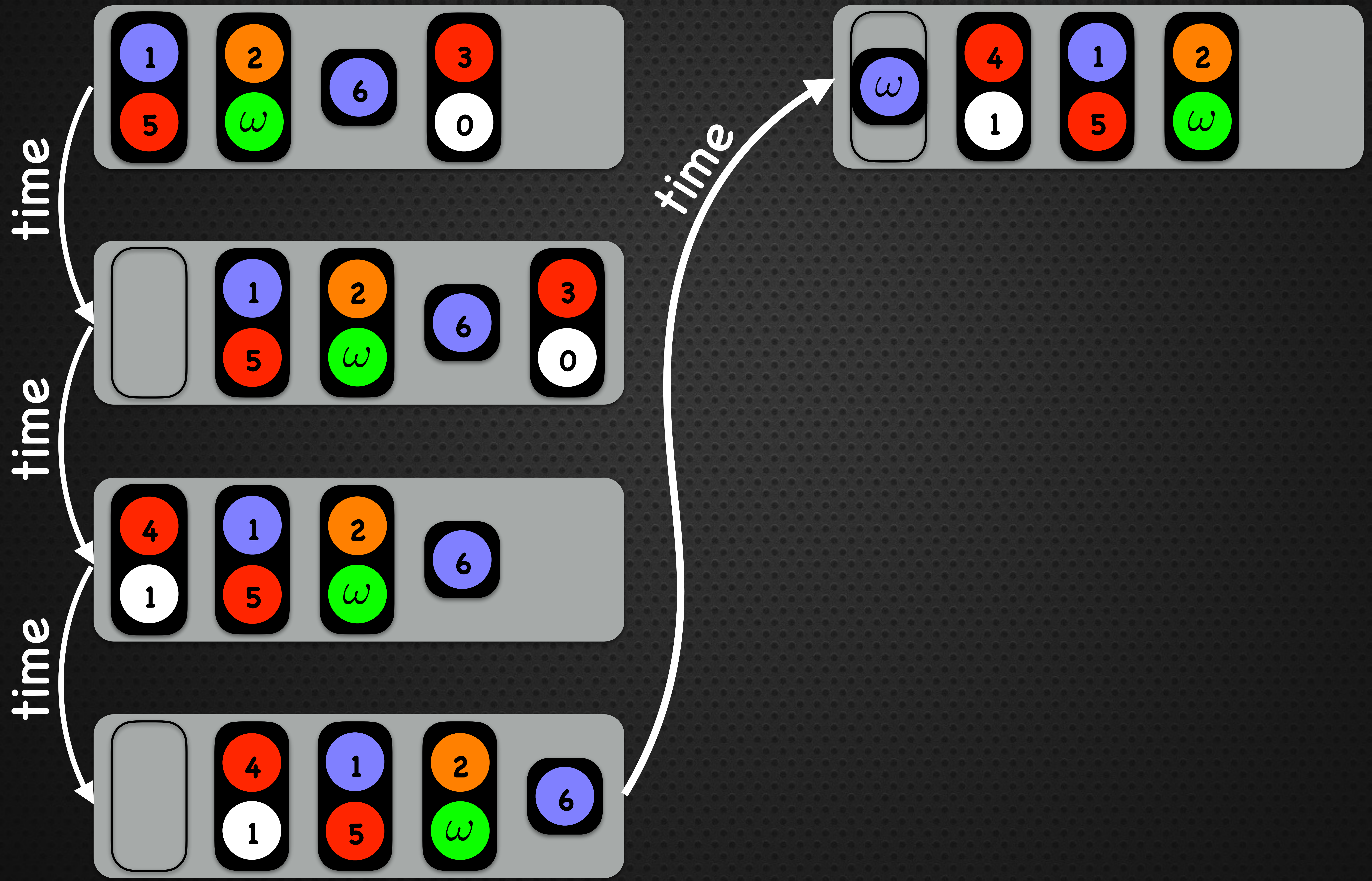

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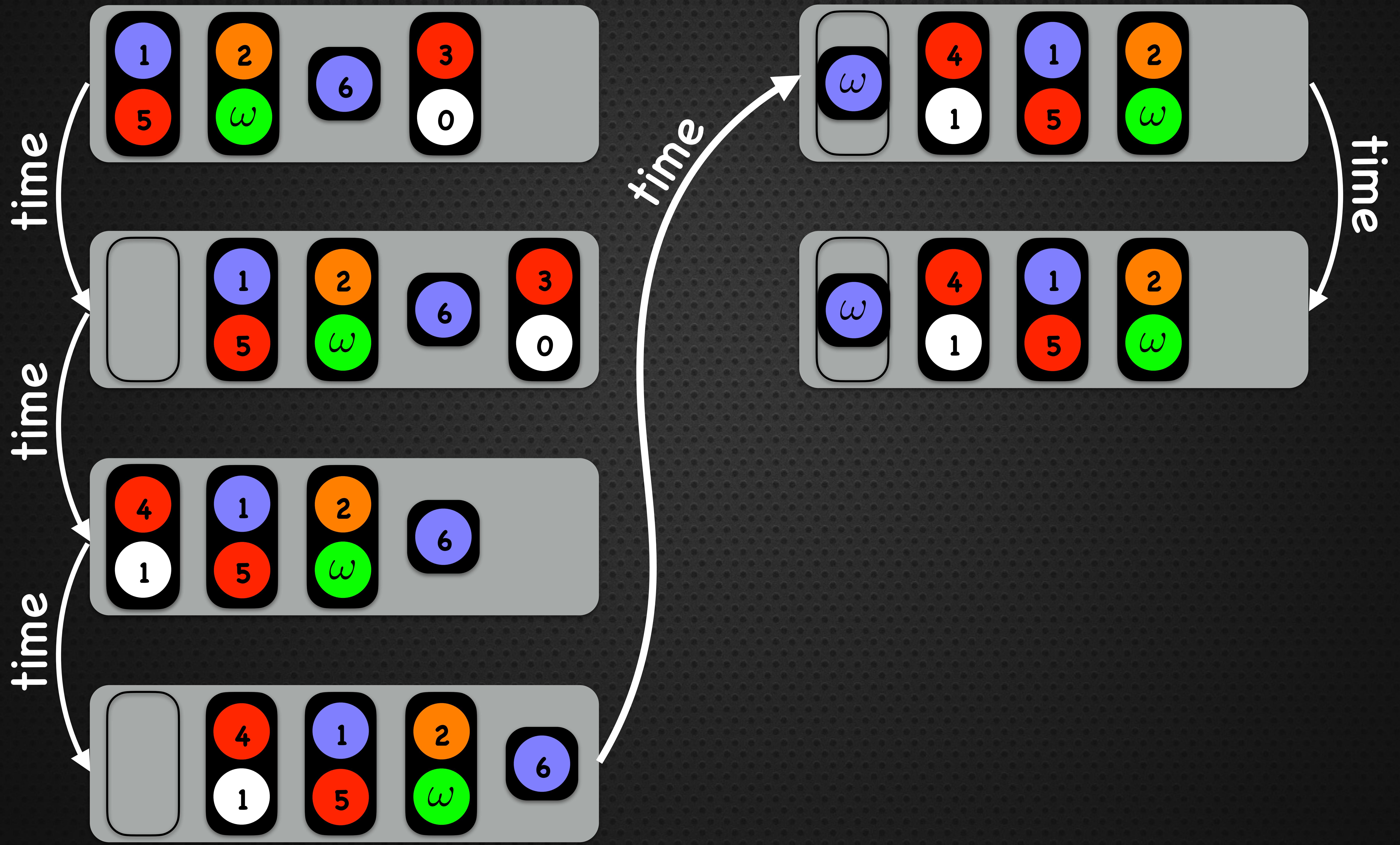
Signatures



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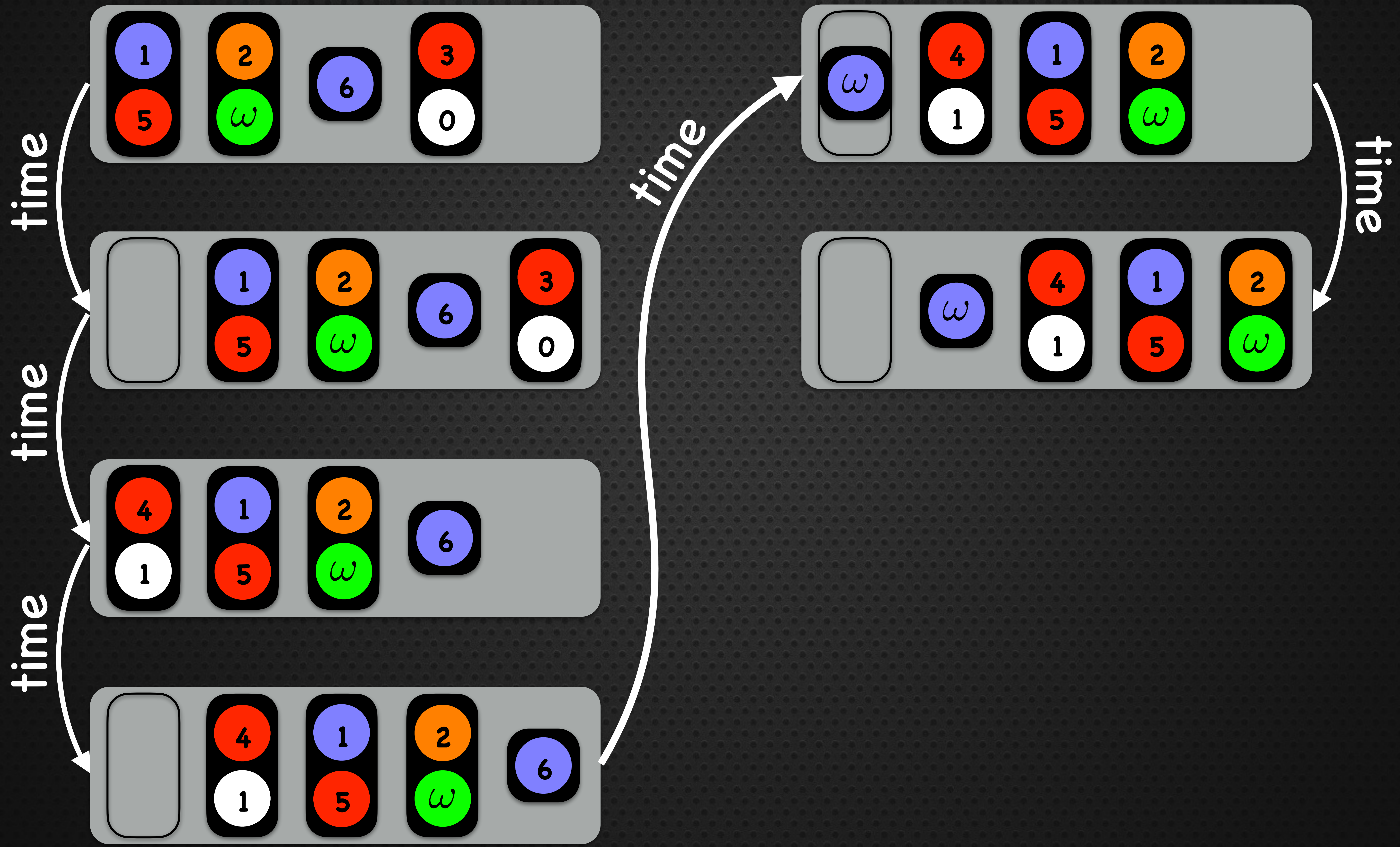

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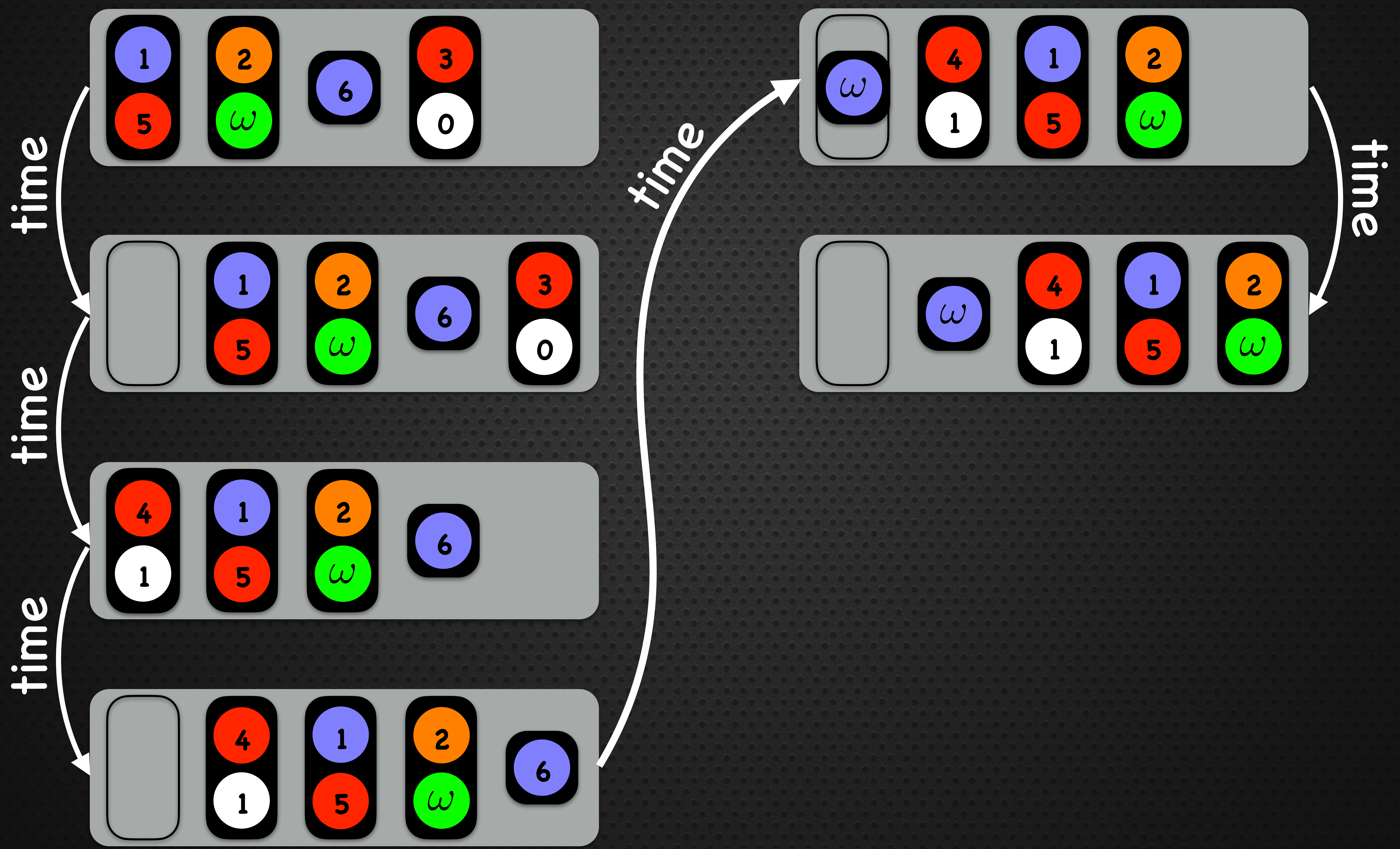
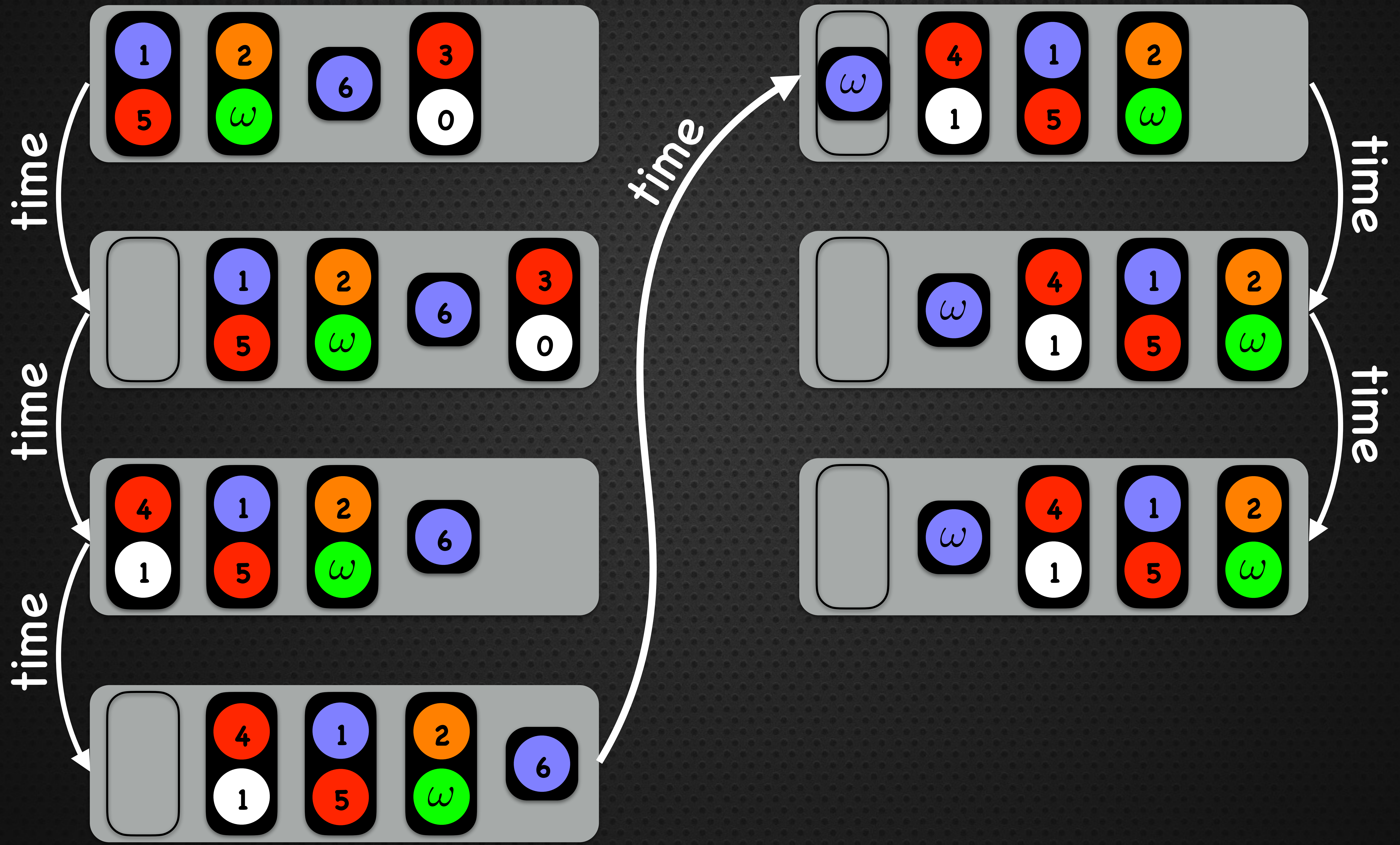


Timed Pe Signatures



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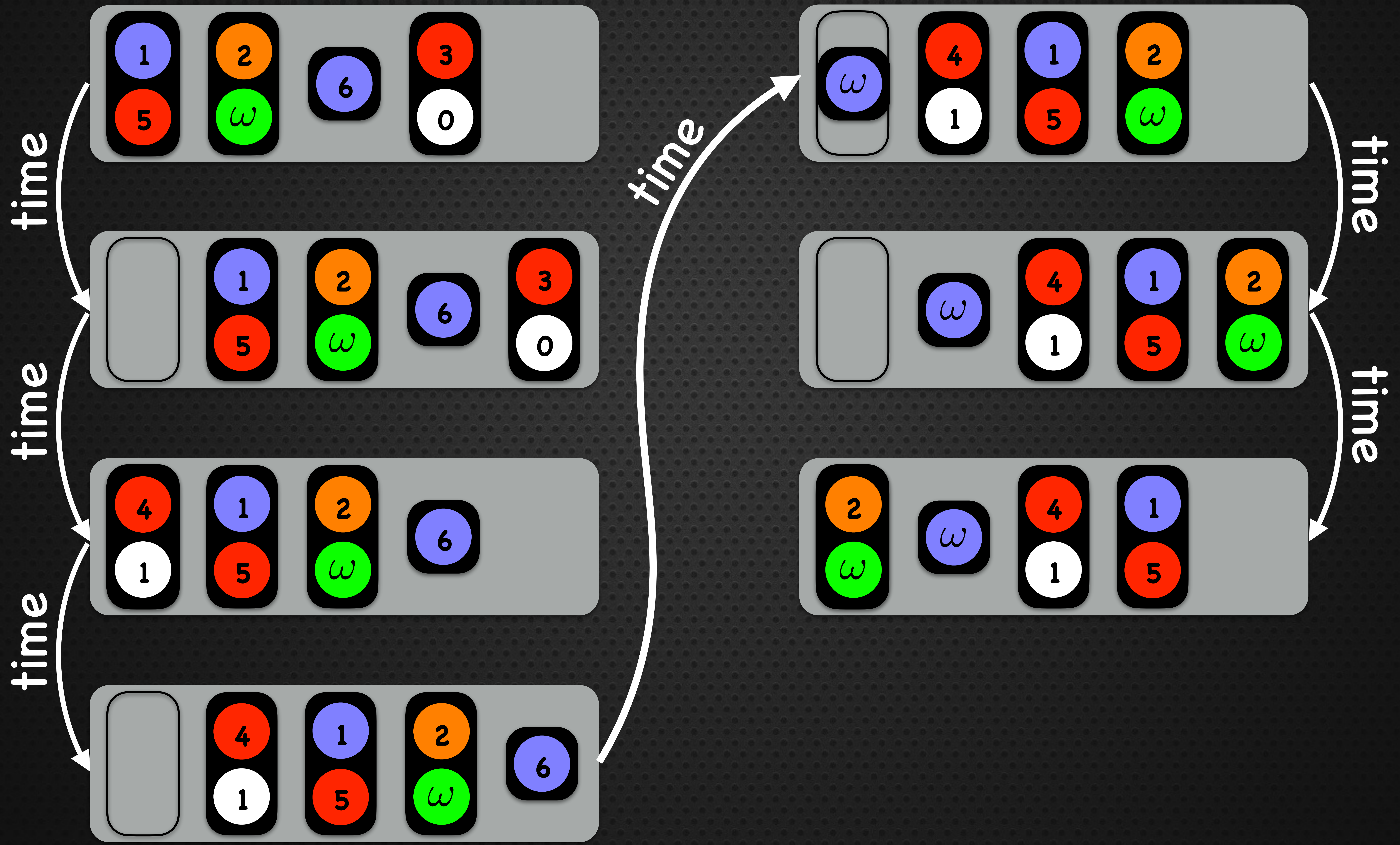
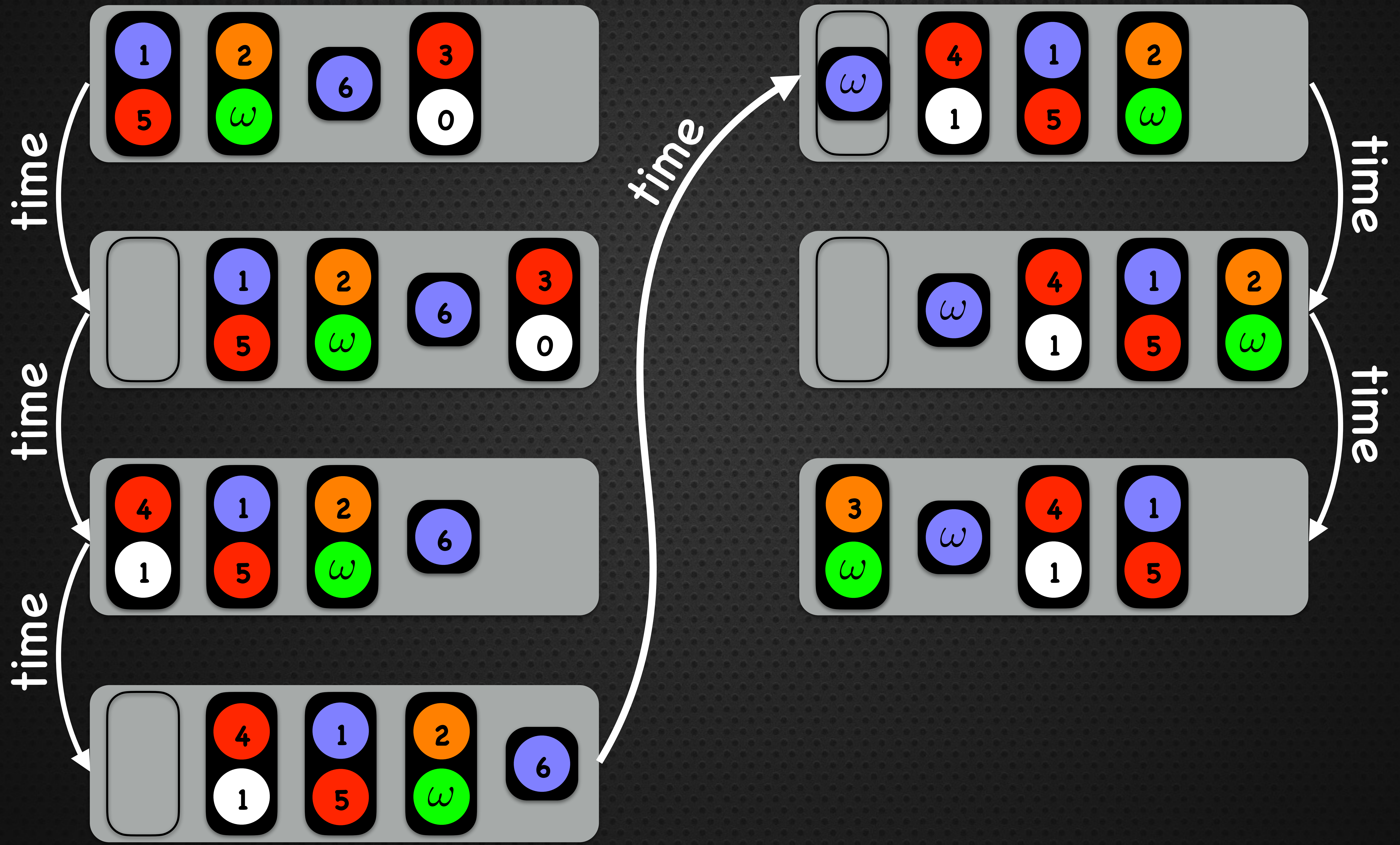


Timed Pe

Signatures



Timed Petri Nets

Model

Configurations

Transitions

signatures

Ordering

Monotoncity

Upward Closed Sets

Computing Predecessors

Backward Reachability

Timed Pe...

Equivalence

$c_1 \equiv c_2$:

$sig(c_1) = sig(c_2)$

Timed Pe

Equivalence

$c_1 \equiv c_2$:

$sig(c_1) = sig(c_2)$

c_1

5.0 1.7 8.2 4.7 3.2 6.5 1.0

$\equiv$

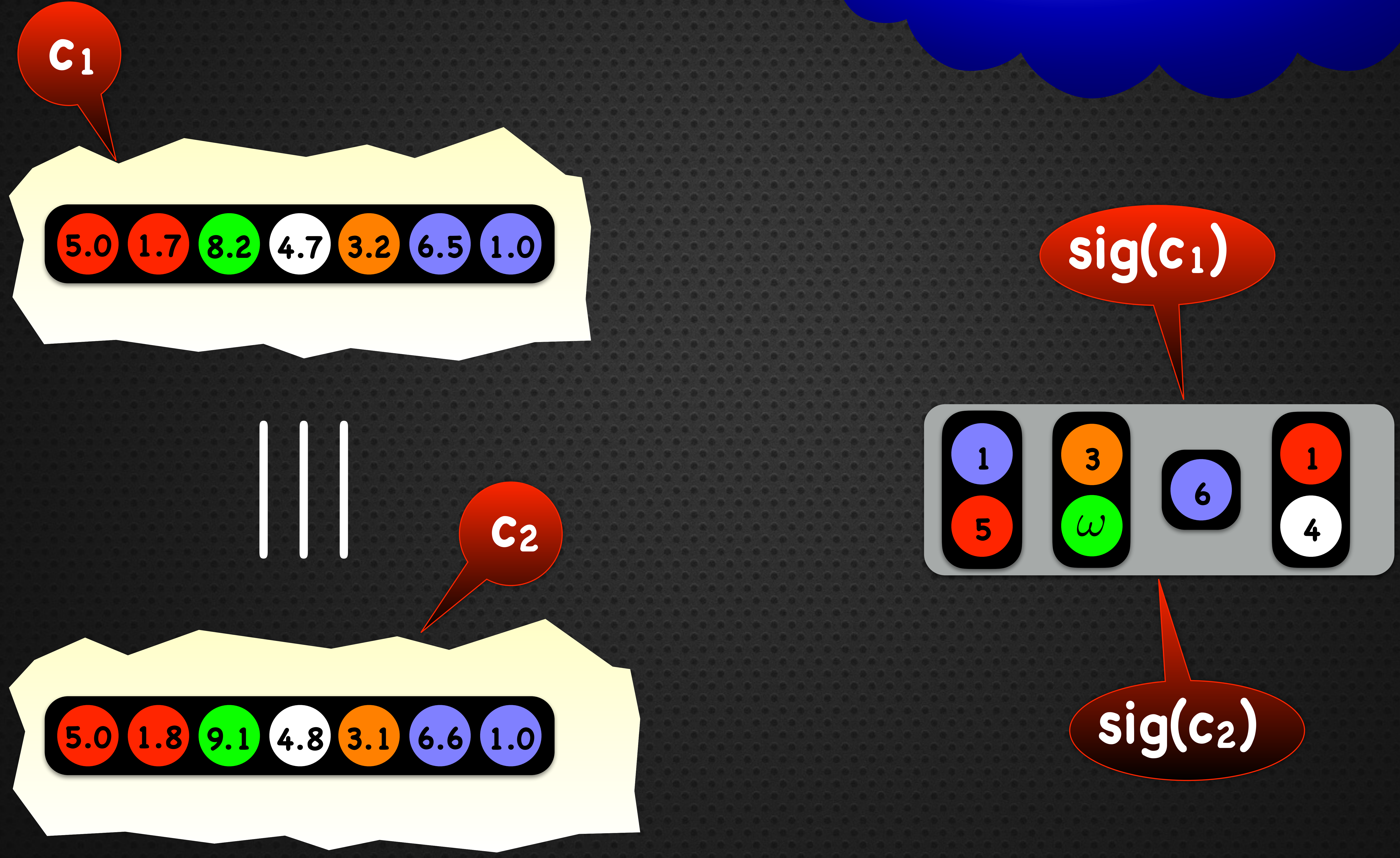
c_2

5.0 1.8 9.1 4.8 3.1 6.6 1.0

Timed Pe… Equivalence

$c_1 \equiv c_2$:

$sig(c_1) = sig(c_2)$



Timed Pe

Ordering

$c_1 \sqsubseteq c_2$:

$\exists c_3 .\, (c_1 \equiv c_3) \wedge (c_3 \subseteq c_2)$

Timed Pe… Ordering

$c_1 \sqsubseteq c_2$:

$\exists c_3.\ (c_1 \equiv c_3) \land (c_3 \subseteq c_2)$

c_1

5.0	1.7	8.2	4.7	3.2	6.5	1.0

$\sqsubseteq$

c_2

5.0	3.2	2.5	4.8	3.1	6.6	1.0
1.8	9.1	9.1	1.1	9.9	6.6	

Timed Pe… Ordering

$c_1 \sqsubseteq c_2$:

$$\exists c_3.\ (c_1 \equiv c_3) \wedge (c_3 \subseteq c_2)$$

c_1

5.0 1.7 8.2 4.7 3.2 6.5 1.0

c_3

5.0 3.2 2.5 4.8 3.1 6.6 1.0
1.8 9.1 9.1 1.1 9.9 6.6

$\sqsubseteq$

c_2

5.0 3.2 2.5 4.8 3.1 6.6 1.0
1.8 9.1 9.1 1.1 9.9 6.6

Timed Pe… Ordering

$c_1 \sqsubseteq c_2$:

$$\exists c_3.\ (c_1 \equiv c_3) \wedge (c_3 \subseteq c_2)$$

c_1

5.0 1.7 8.2 4.7 3.2 6.5 1.0

$\sqsubseteq$

c_2

5.0 3.2 2.5 4.8 3.1 6.6 1.0
1.8 9.1 9.1 1.1 9.9 6.6

c_3

5.0 2.5 4.8 3.1 6.6 1.0
1.8 9.1 9.1 1.1 9.9 6.6

Timed Pe… Ordering

$c_1 \sqsubseteq c_2$:

$$\exists c_3.\ (c_1 \equiv c_3) \wedge (c_3 \subseteq c_2)$$

c_1

5.0 1.7 8.2 4.7 3.2 6.5 1.0

c_3

5.0 4.8 3.1 6.6 1.0
1.8 9.1 9.1 1.1 9.9 6.6

$\sqsubseteq$

c_2

5.0 3.2 2.5 4.8 3.1 6.6 1.0
1.8 9.1 9.1 1.1 9.9 6.6

Timed Pe… Ordering

$c_1 \sqsubseteq c_2$:

$$\exists c_3 . (c_1 \equiv c_3) \land (c_3 \subseteq c_2)$$

c_1

5.0 1.7 8.2 4.7 3.2 6.5 1.0

c_3

5.0 4.8 3.1 1.0
1.8 9.1 6.6

c_2

5.0 3.2 2.5 4.8 3.1 6.6 1.0
1.8 9.1 9.1 1.1 9.9 6.6

Timed Pe

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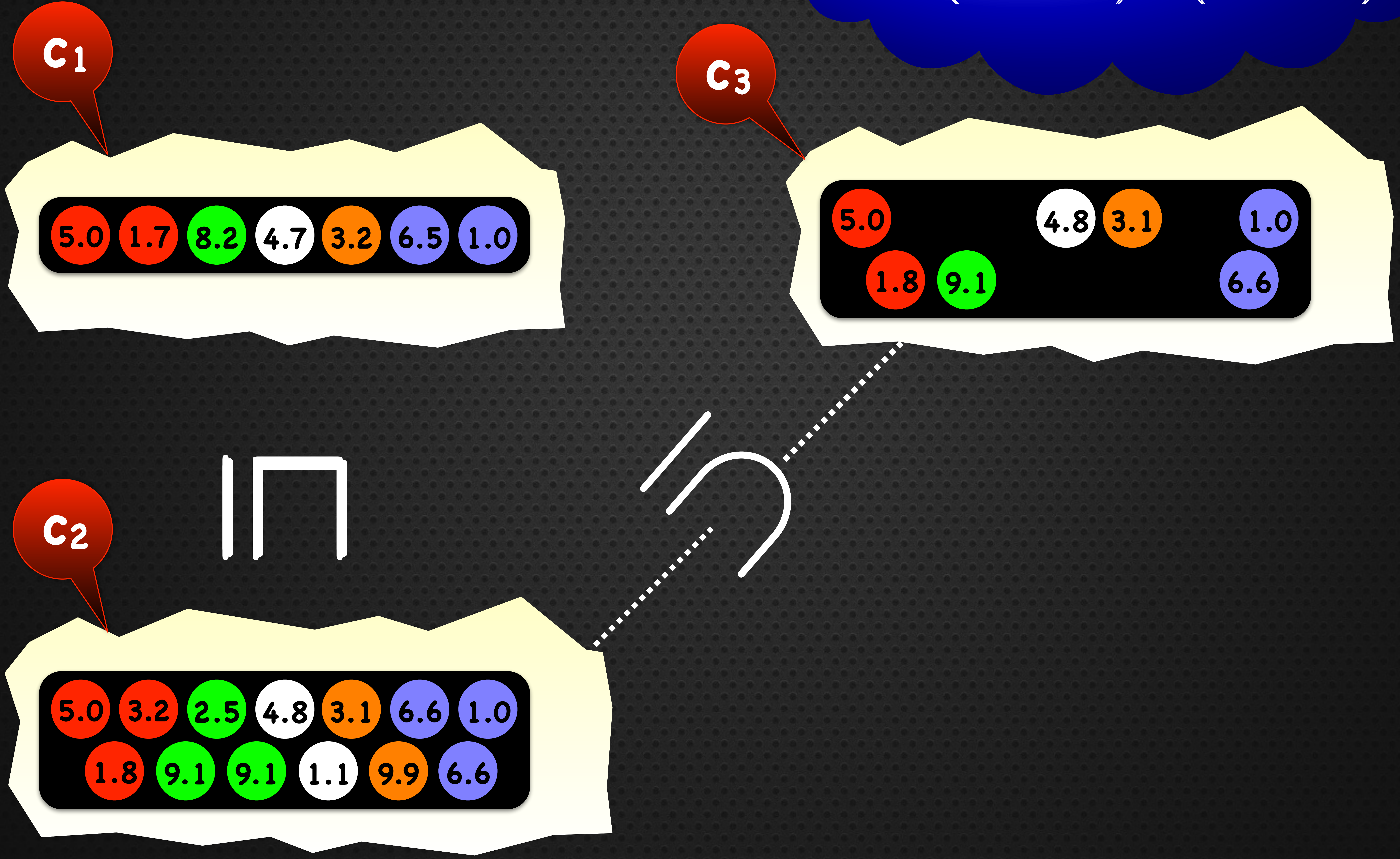

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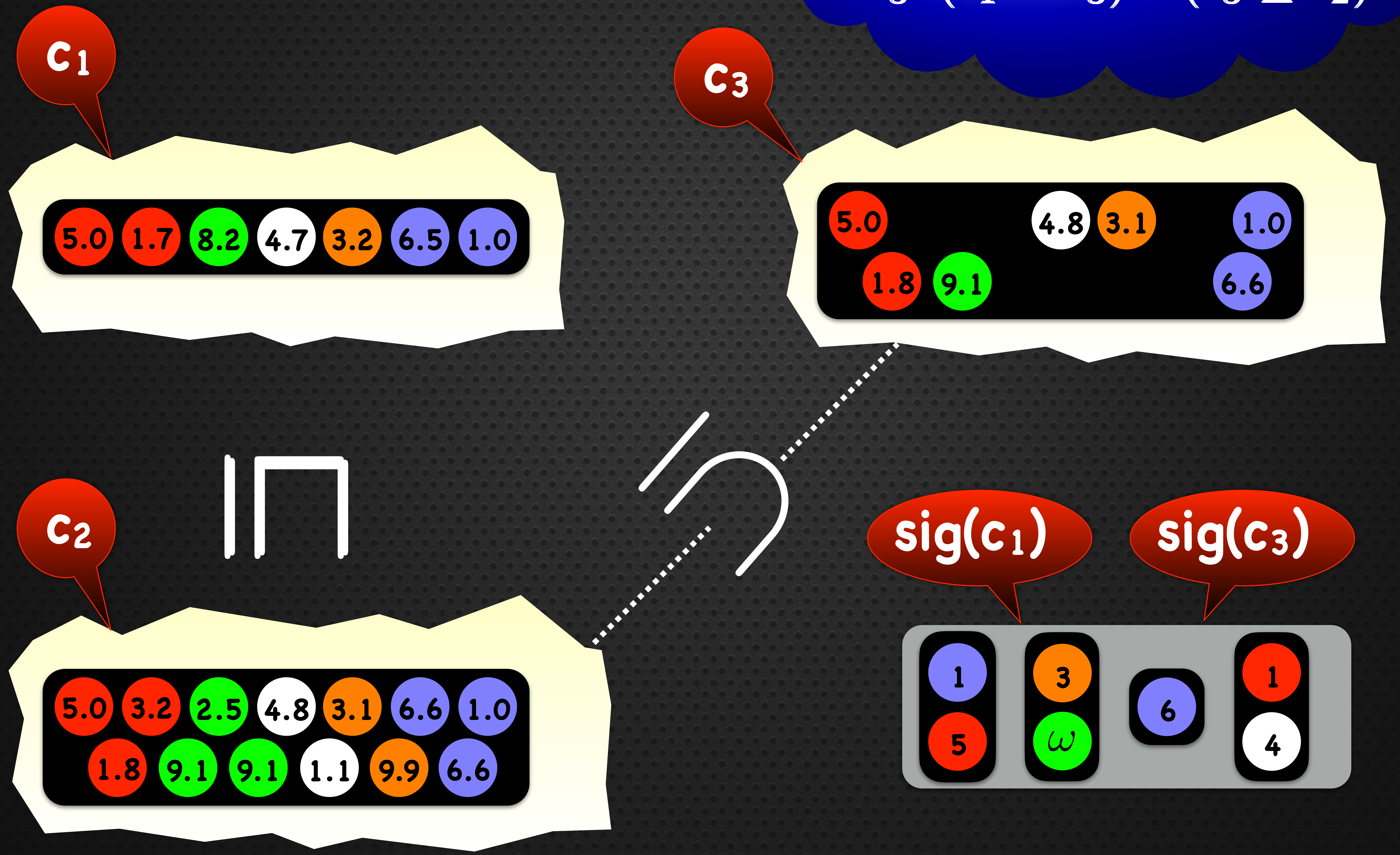
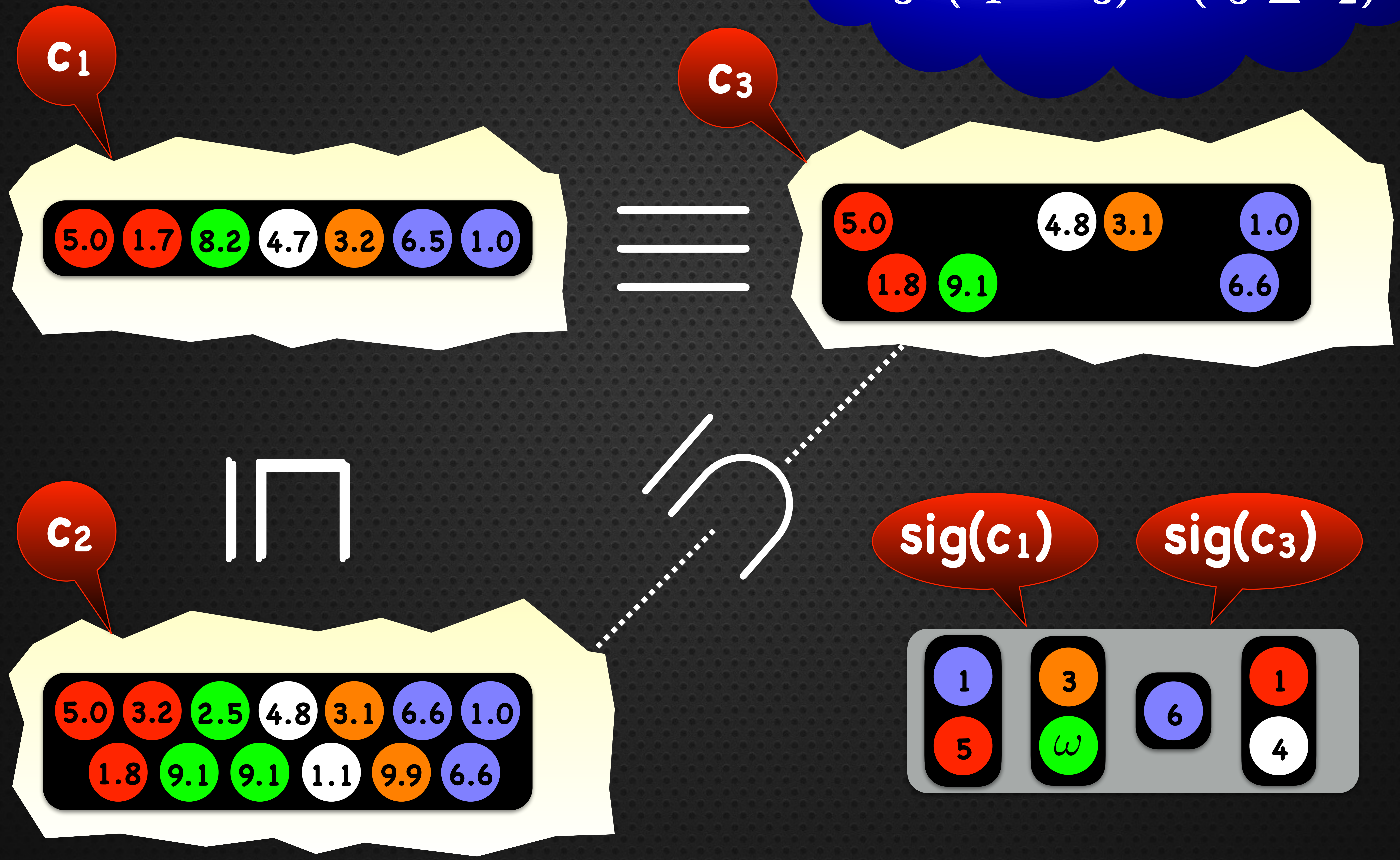


Timed Pe… Ordering

$c_1 \sqsubseteq c_2$:

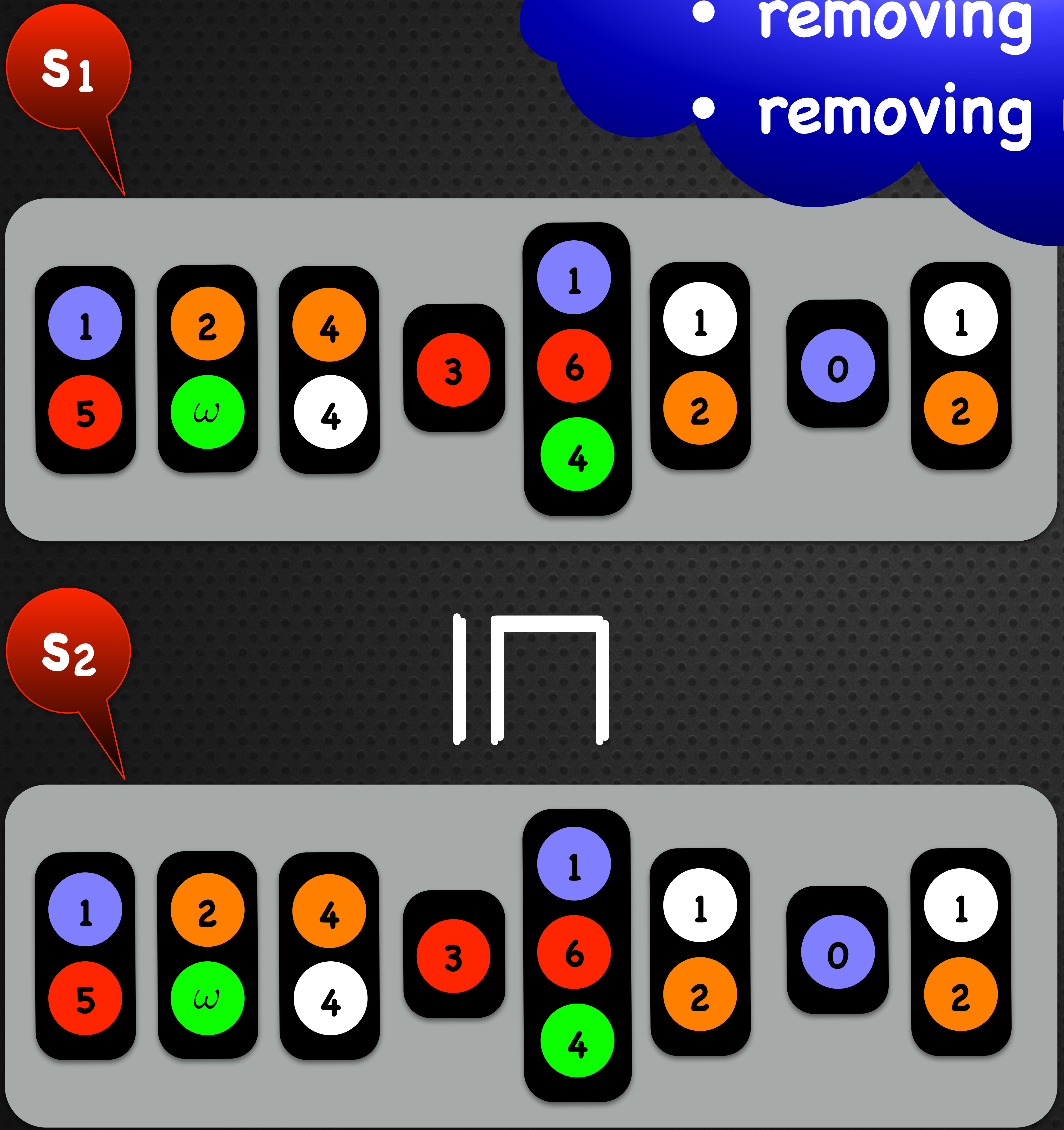
$$\exists c_3.\ (c_1 \equiv c_3) \land (c_3 \subseteq c_2)$$



Timed Pe Ordering

$s_1 \sqsubseteq s_2$: Derive s_1 from s_2 by:

- removing elements from multisets
- removing multisets



Timed Pe

Ordering

$s_1 \sqsubseteq s_2$: Derive s_1 from s_2 by:

- removing elements from multisets
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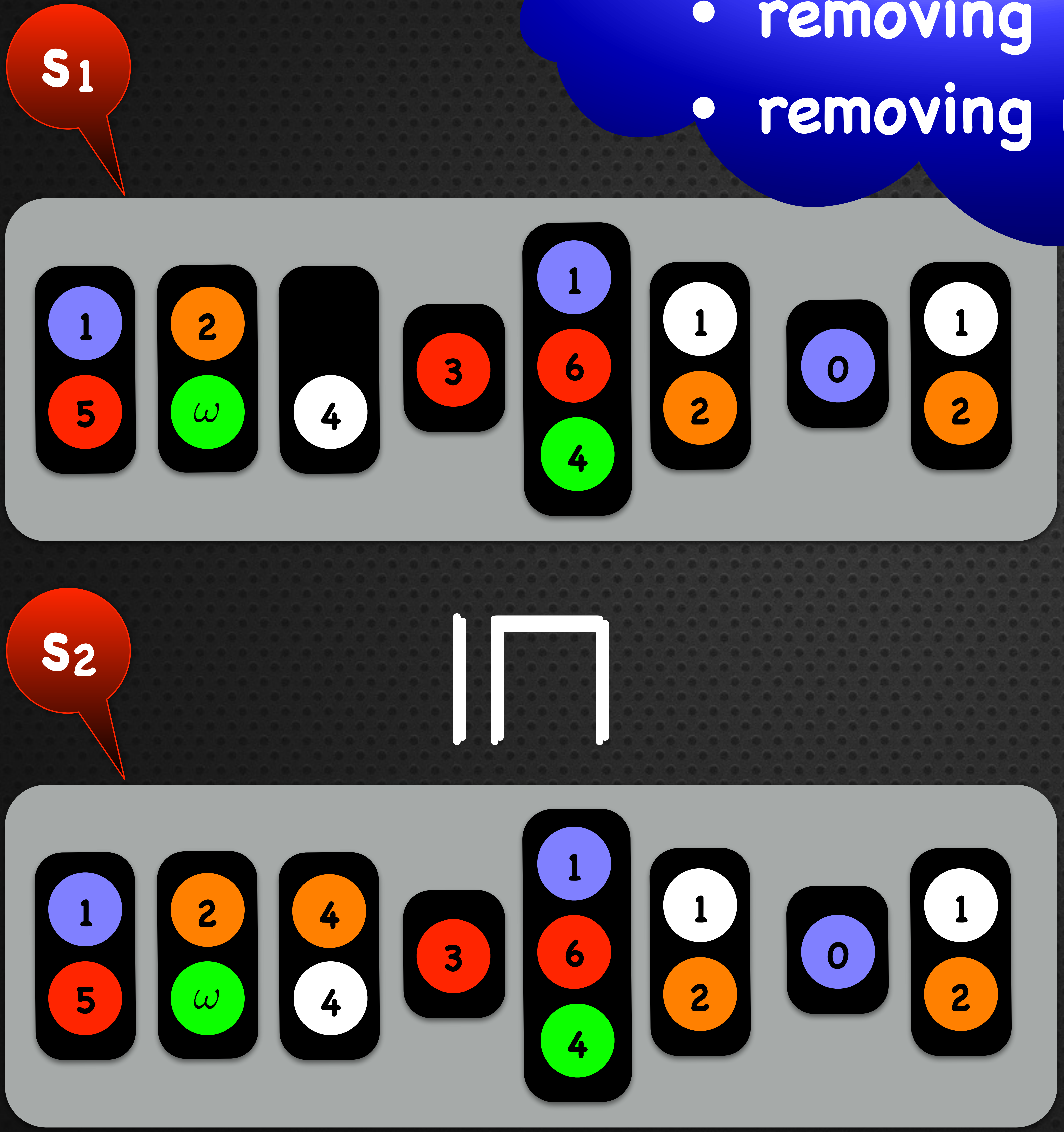

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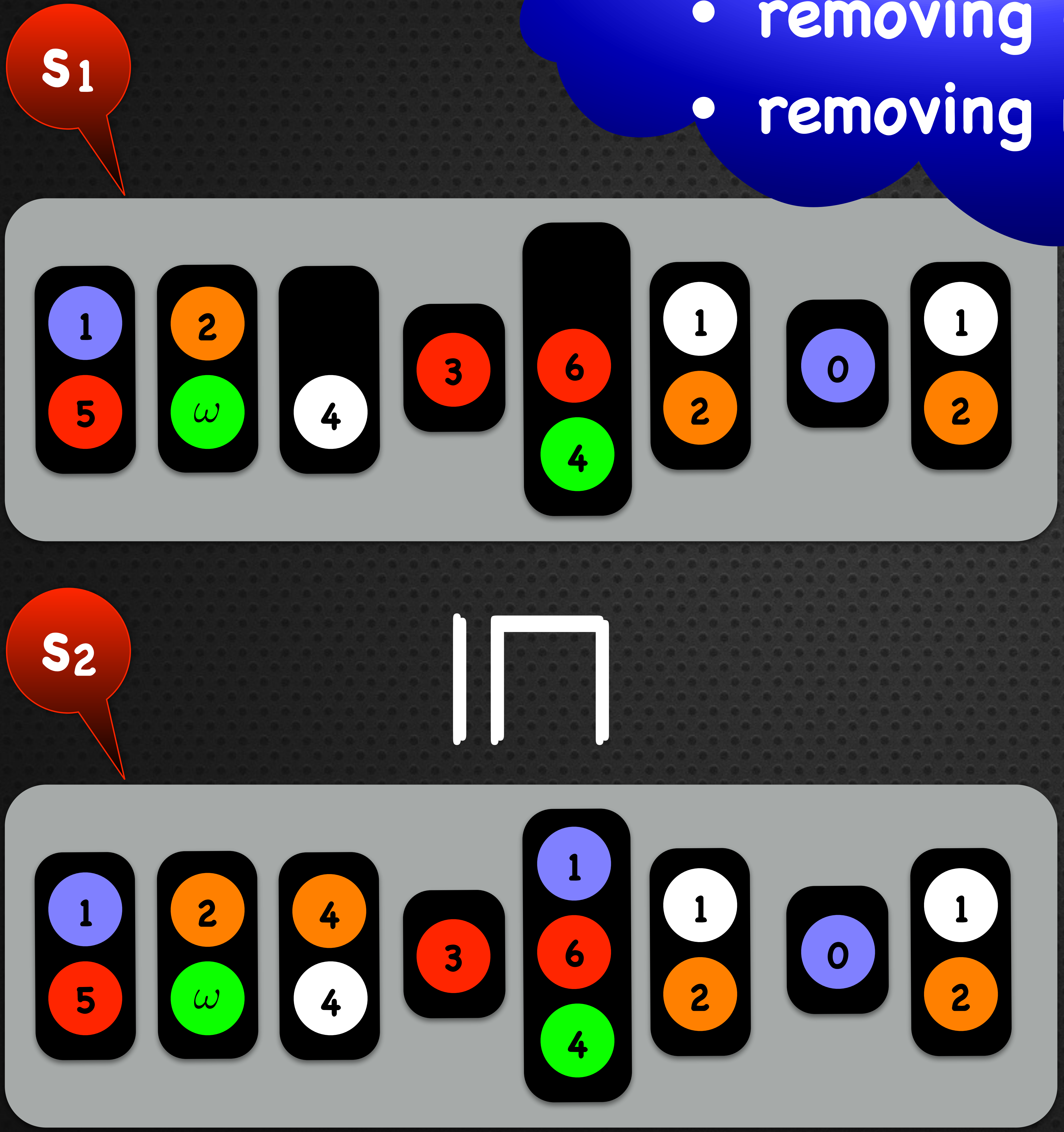

Timed Pe

Ordering

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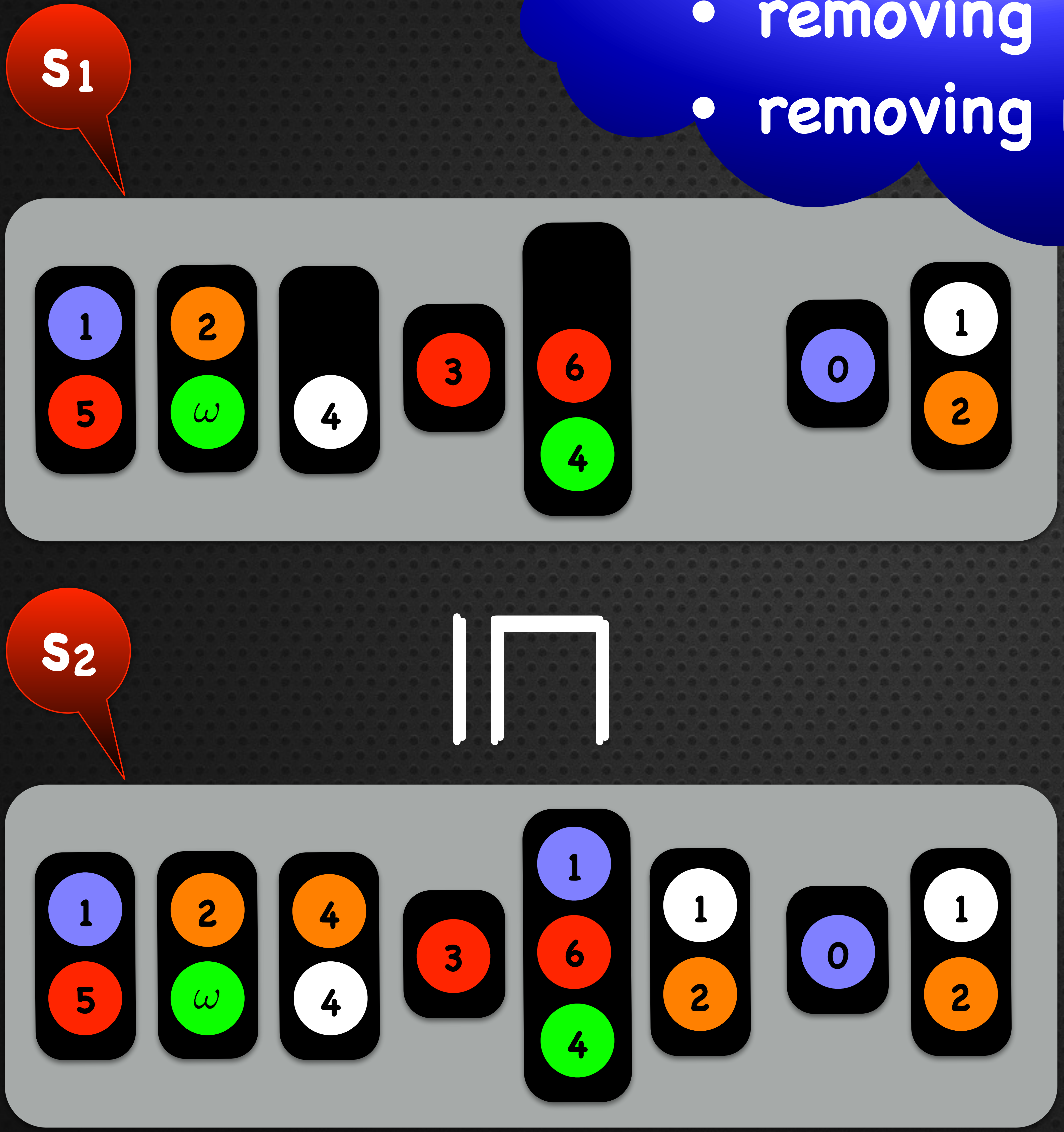

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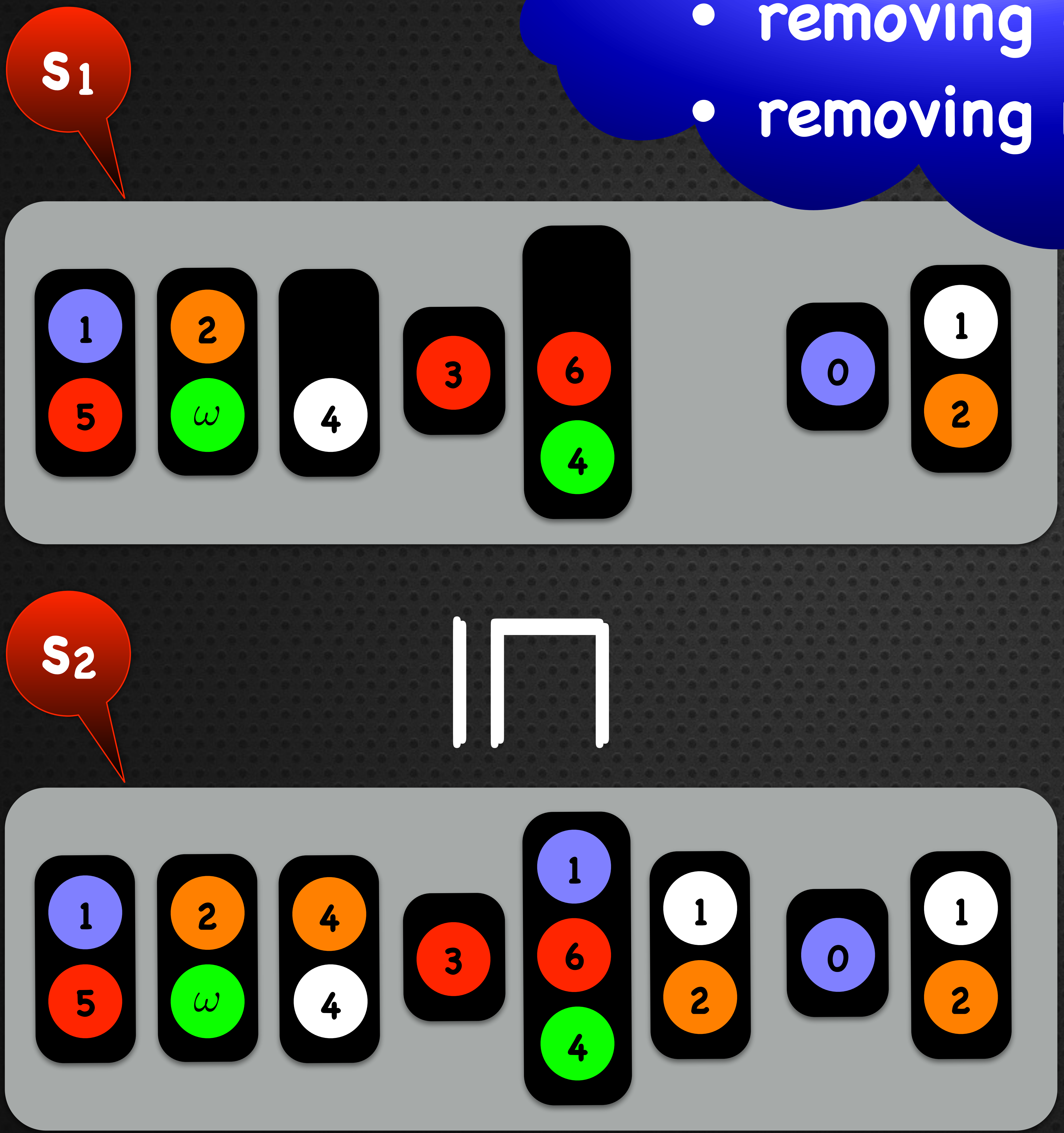

Timed Pe

Ordering

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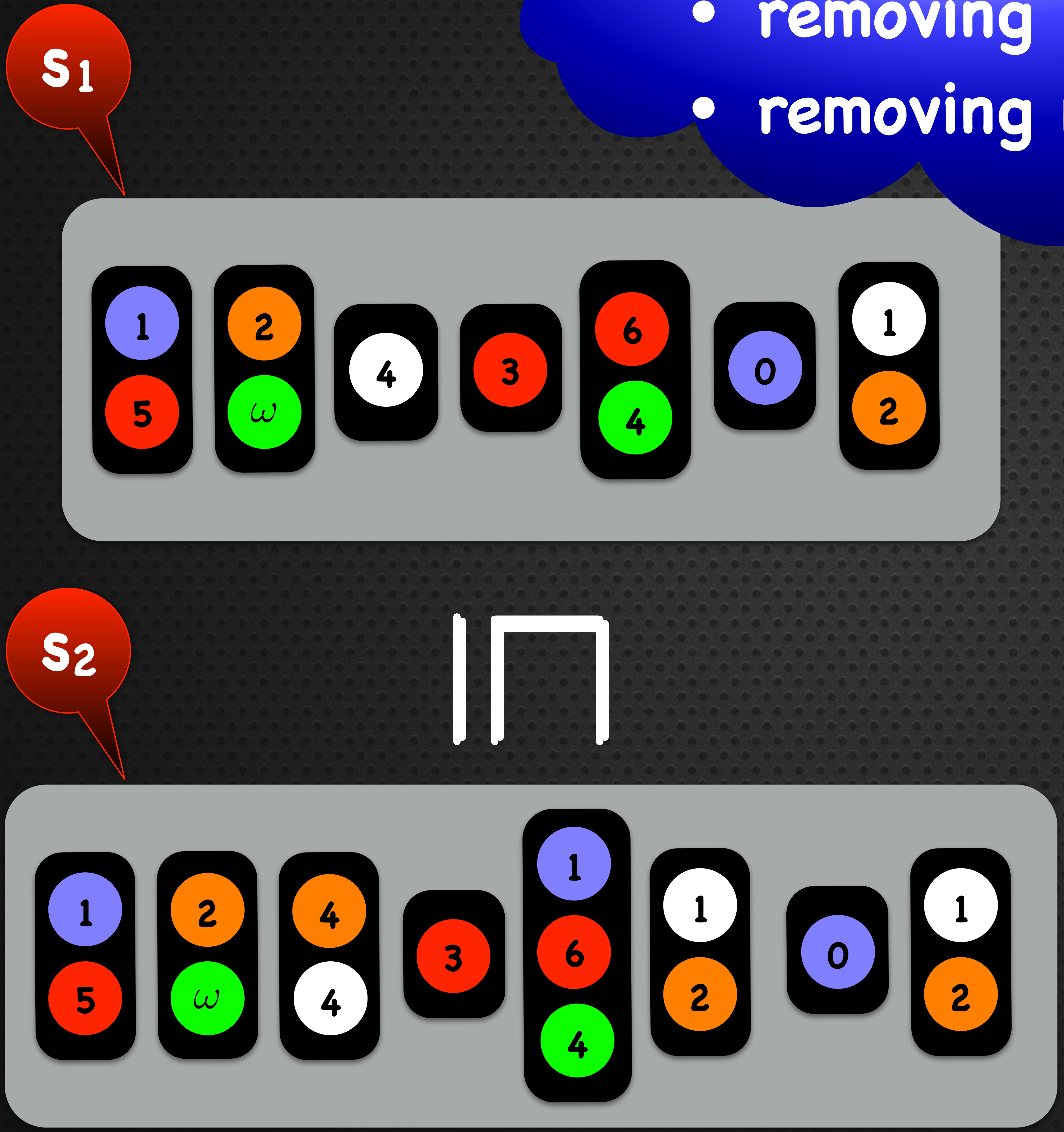


Timed Pe

Ordering

$c \models s$:

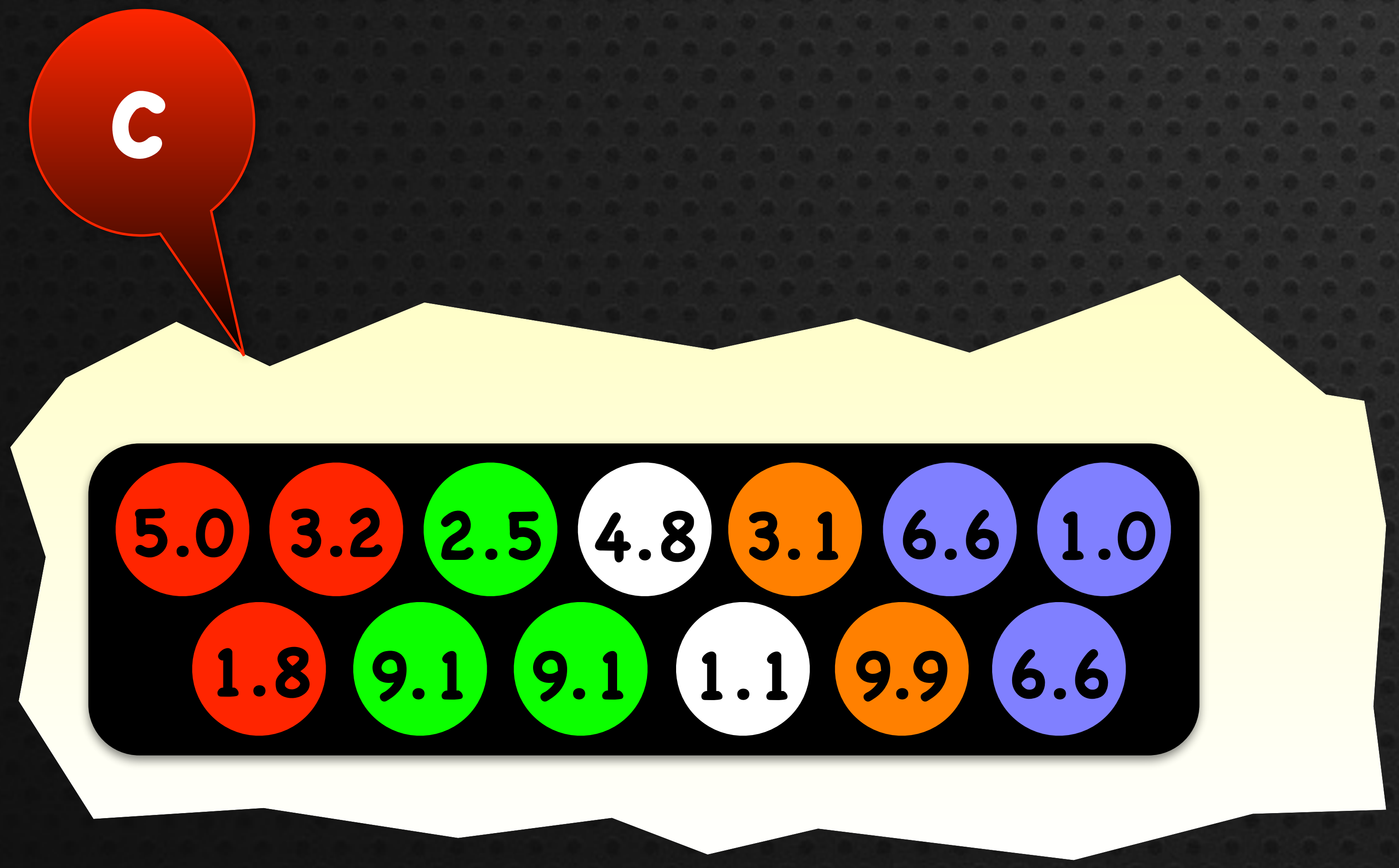
$\exists c'. \, (c' \sqsubseteq c) \wedge (sig(c') = s)$

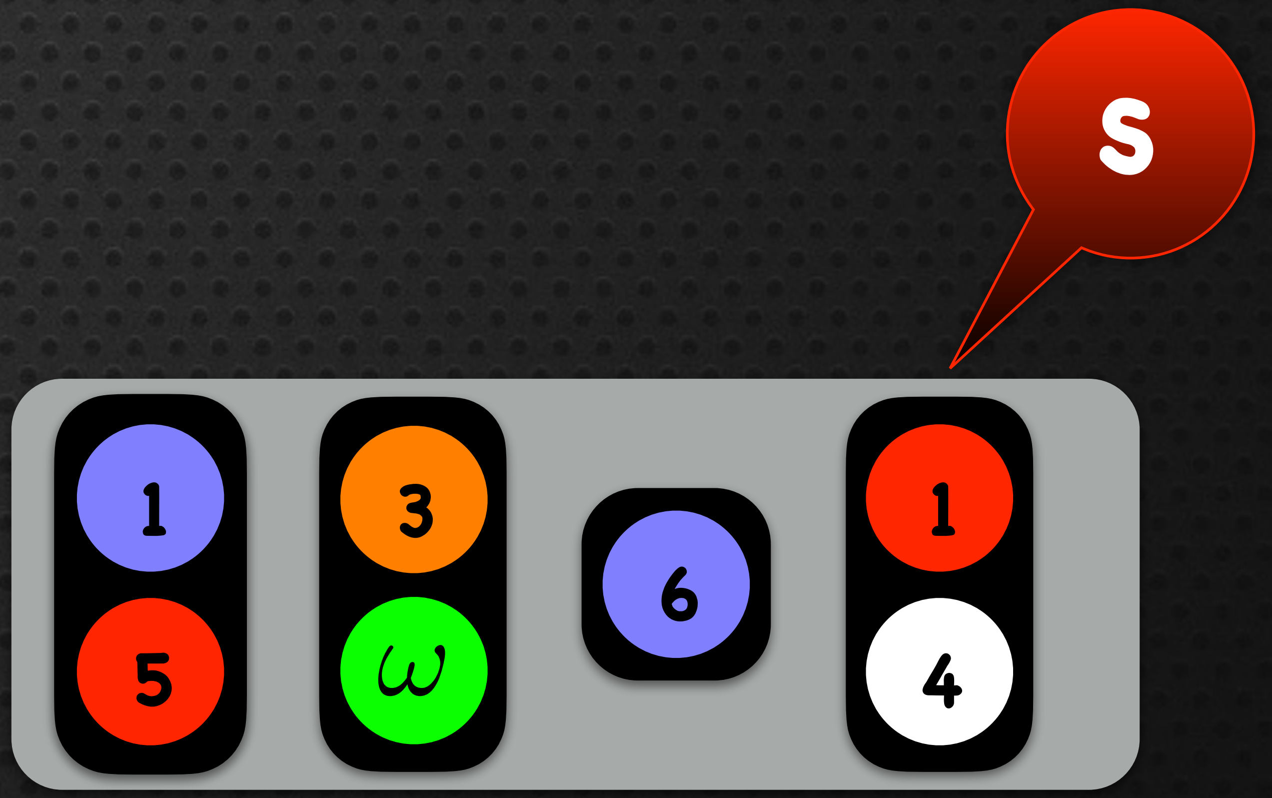
Timed Pe

Ordering

$$c \models s \quad :$$

$$\exists c'.\ (c' \sqsubseteq c) \wedge (sig(c') = s)$$



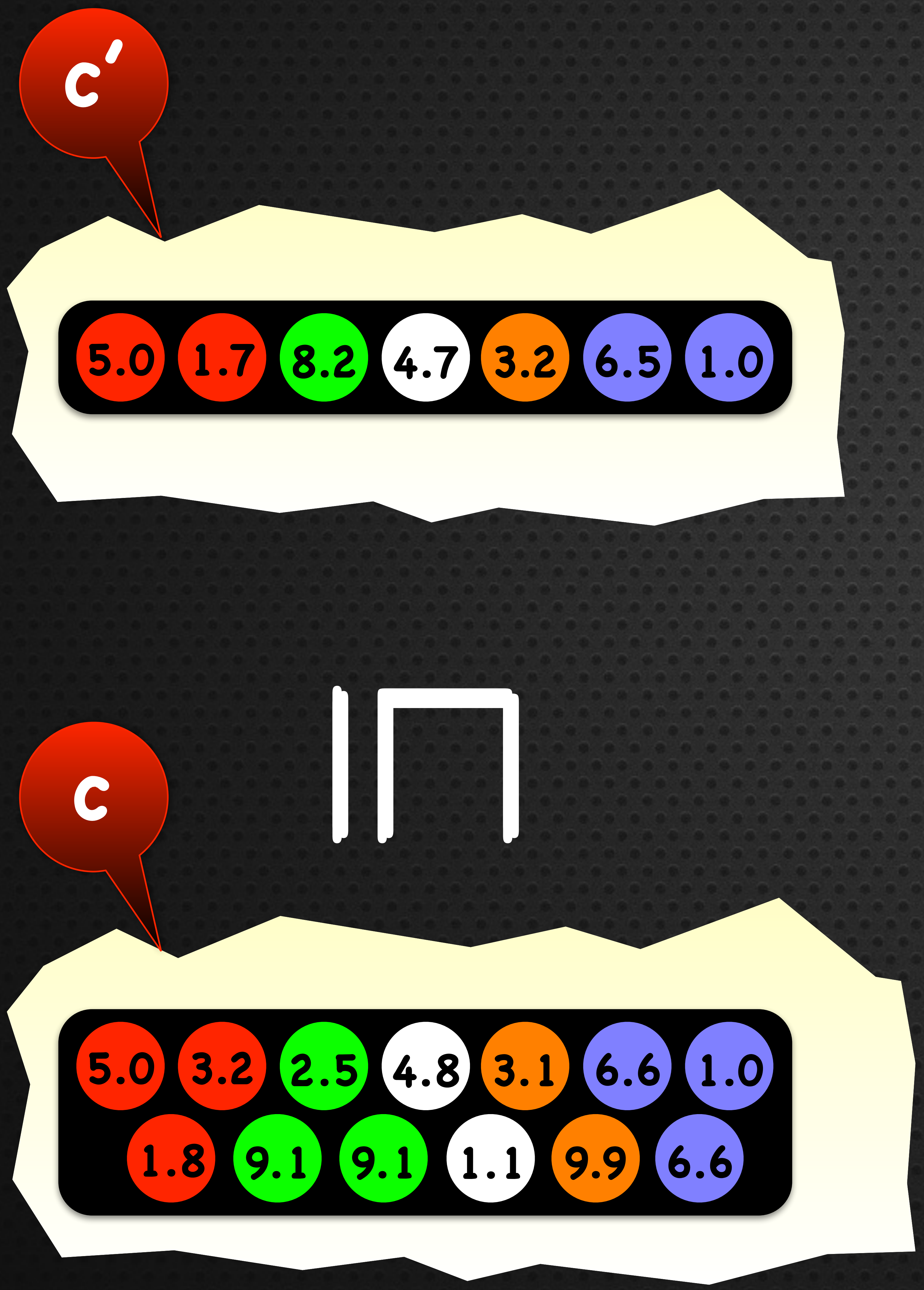


Timed Pe

Ordering

$c \models s$:

$$\exists c'.\,(c' \sqsubseteq c) \wedge (sig(c') = s)$$

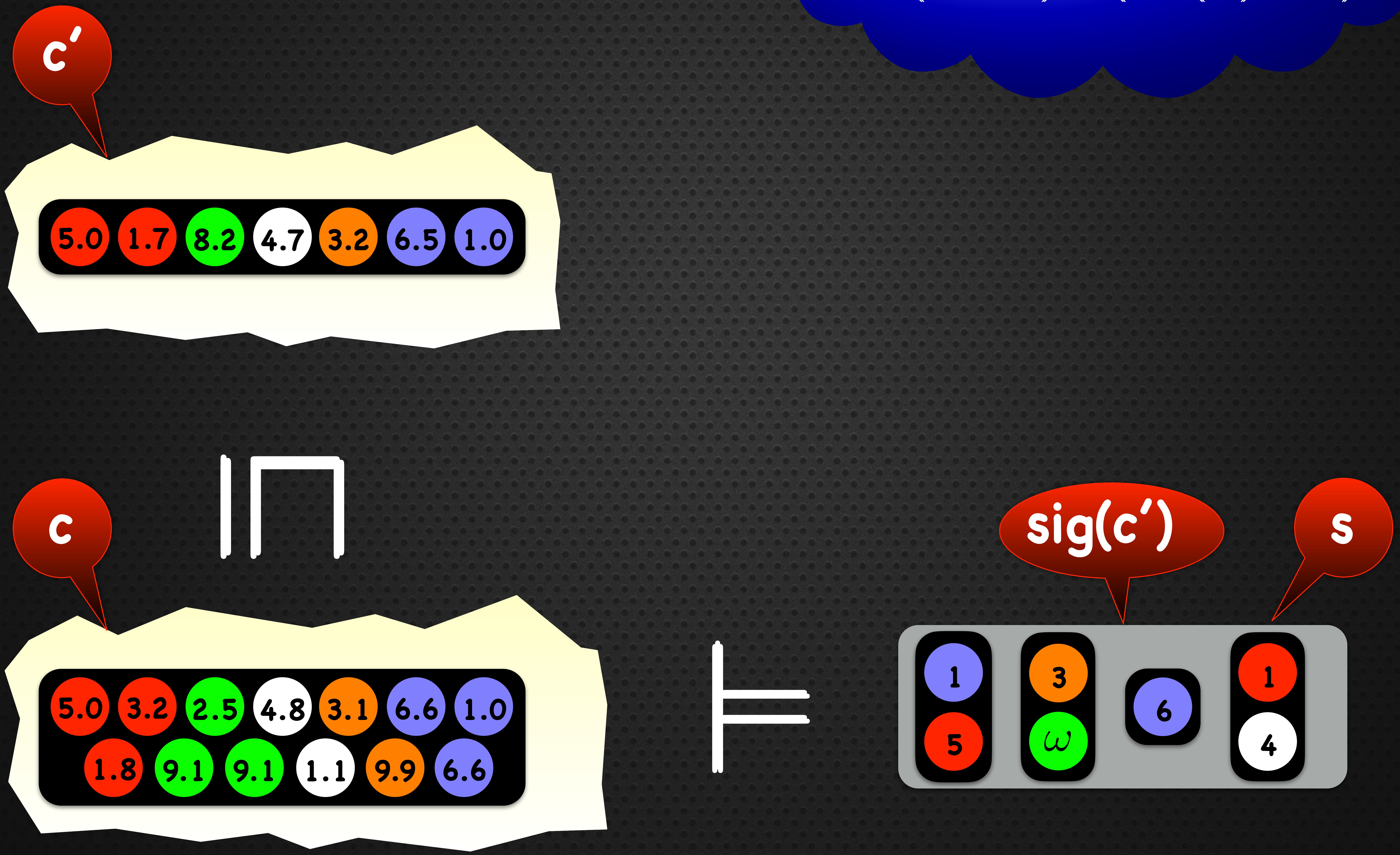


Timed Pe

Ordering

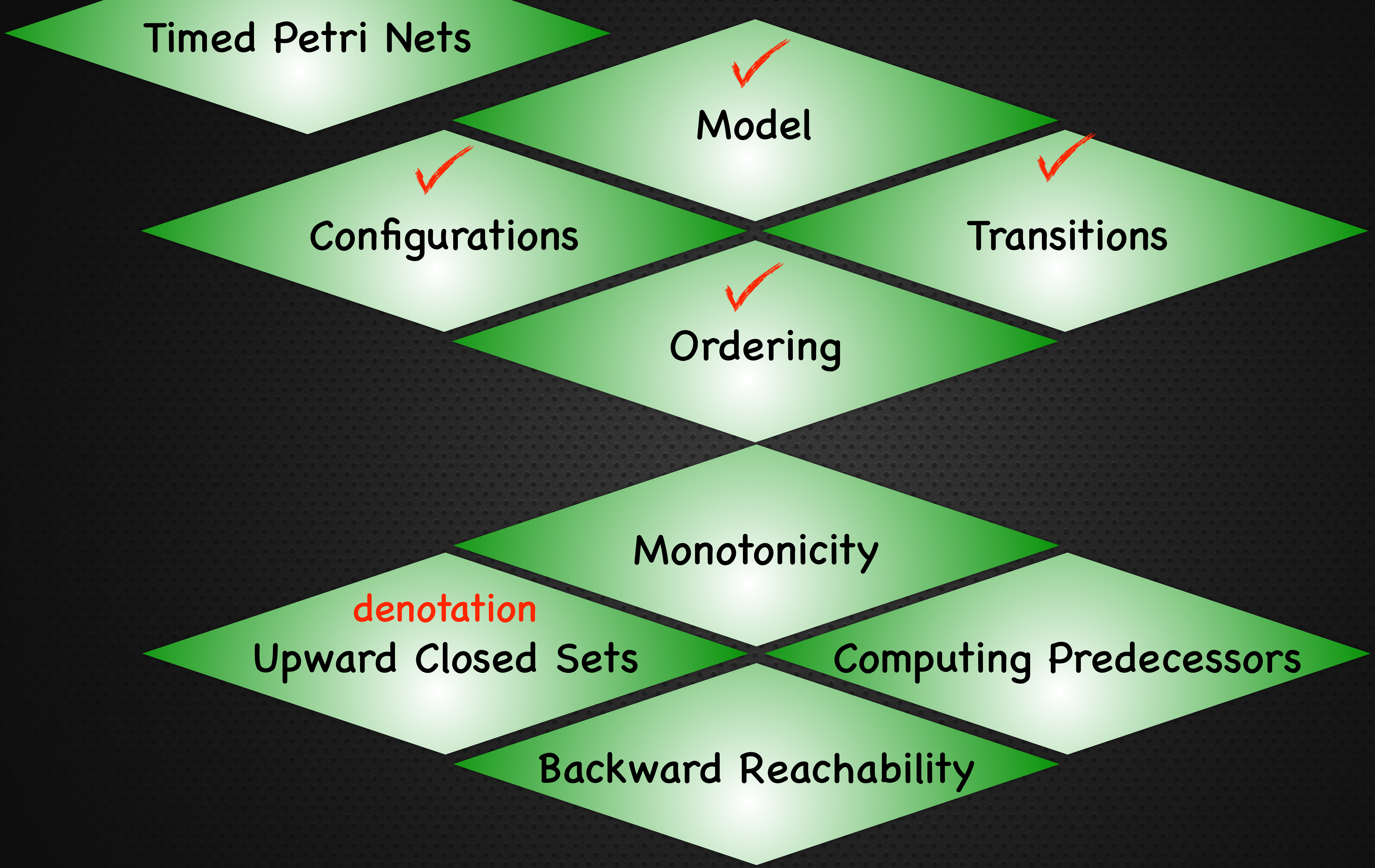
$c \models s$:

$$\exists c'.\ (c' \sqsubseteq c) \wedge (sig(c') = s)$$



Timed Petri Nets

- Model
- Configurations
- Transitions
- Ordering
- Monotonicity
- Upward Closed Sets
- Computing Predecessors
- Backward Reachability


Timed Petri Nets
Model
Configurations
Transitions
Ordering
Monotonicity
denotation
Upward Closed Sets
Computing Predecessors
Backward Reachability

Timed Pe

Denotation

$$[\![s]\!] = \{c \mid c \models s\}$$

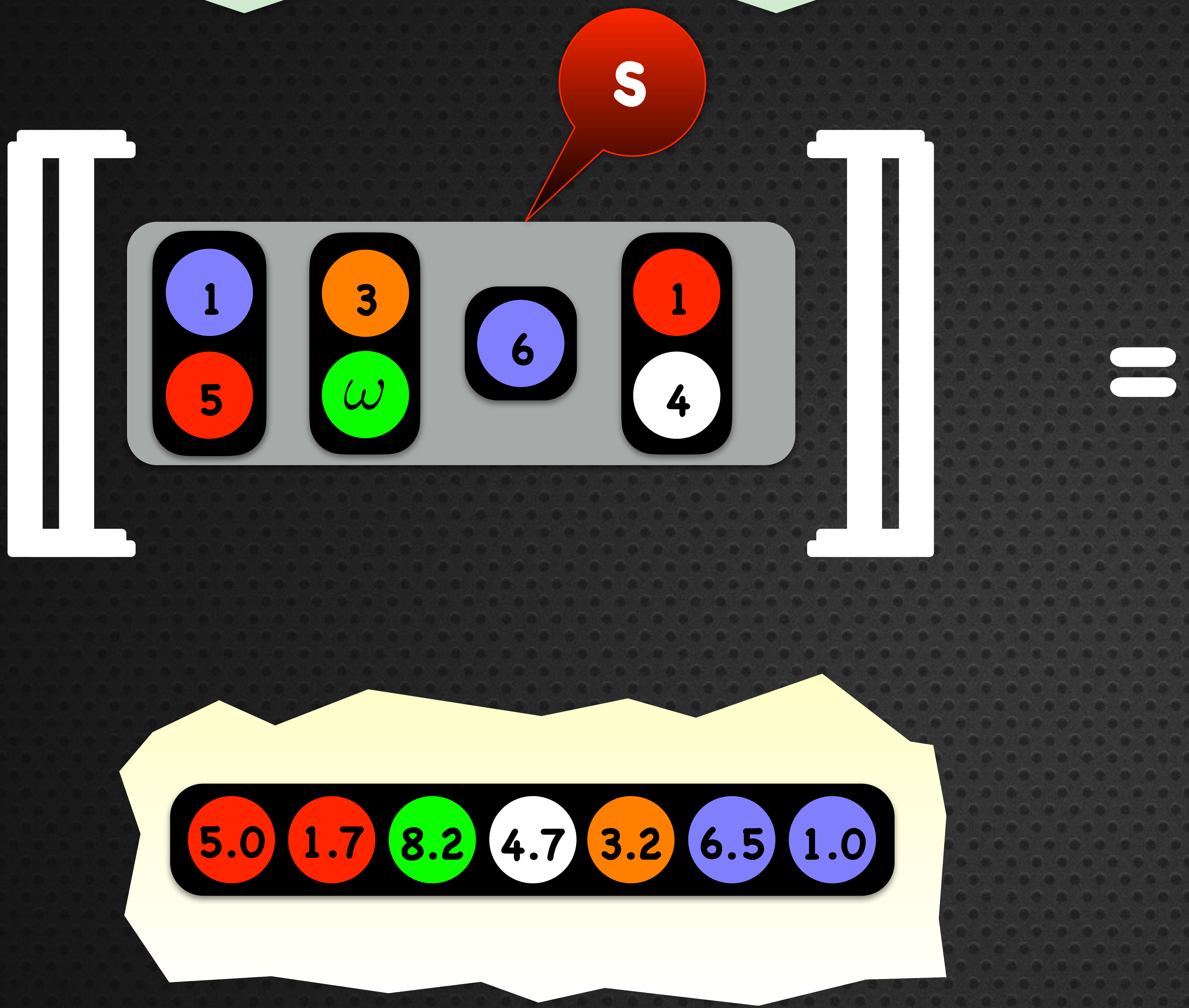
Timed Pe

Denotation

$$[\![s]\!] = \{c \mid c \models s\}$$

Timed Pe… Denotation

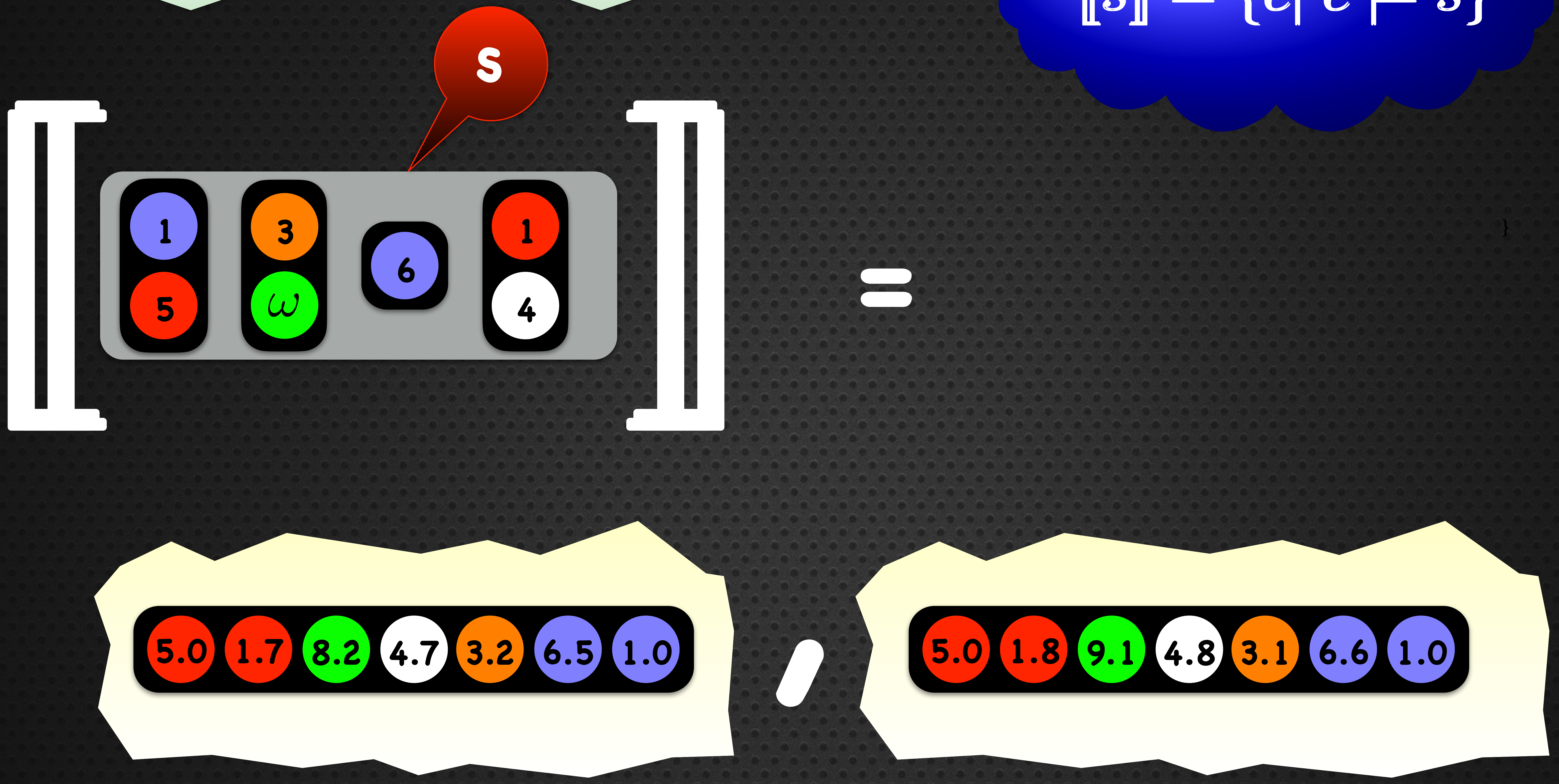
$$[\![s]\!] = \{c \mid c \models s\}$$



Timed Pe

Denotation

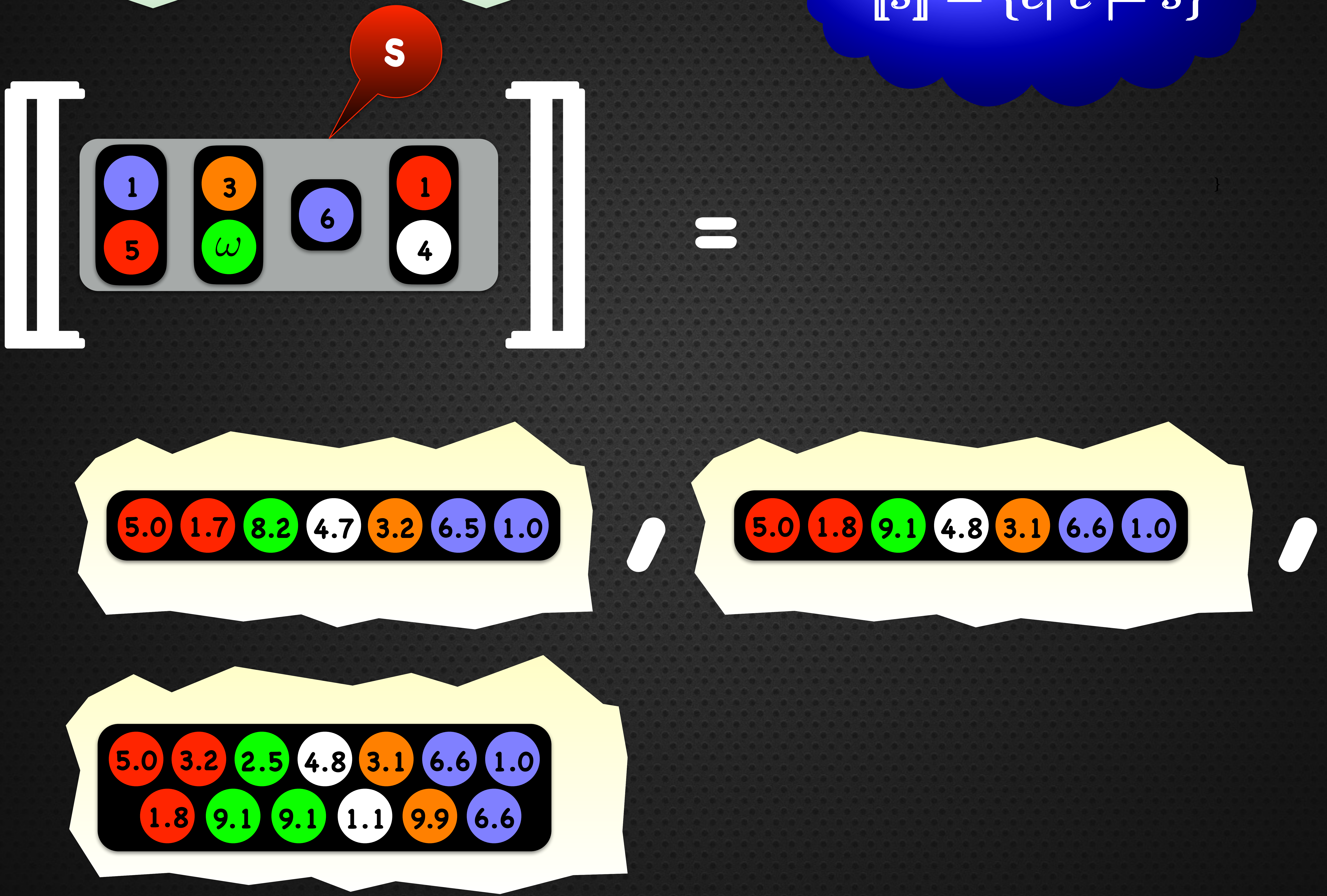
$$[\![s]\!] = \{c \mid c \models s\}$$



Timed Pe

Denotation

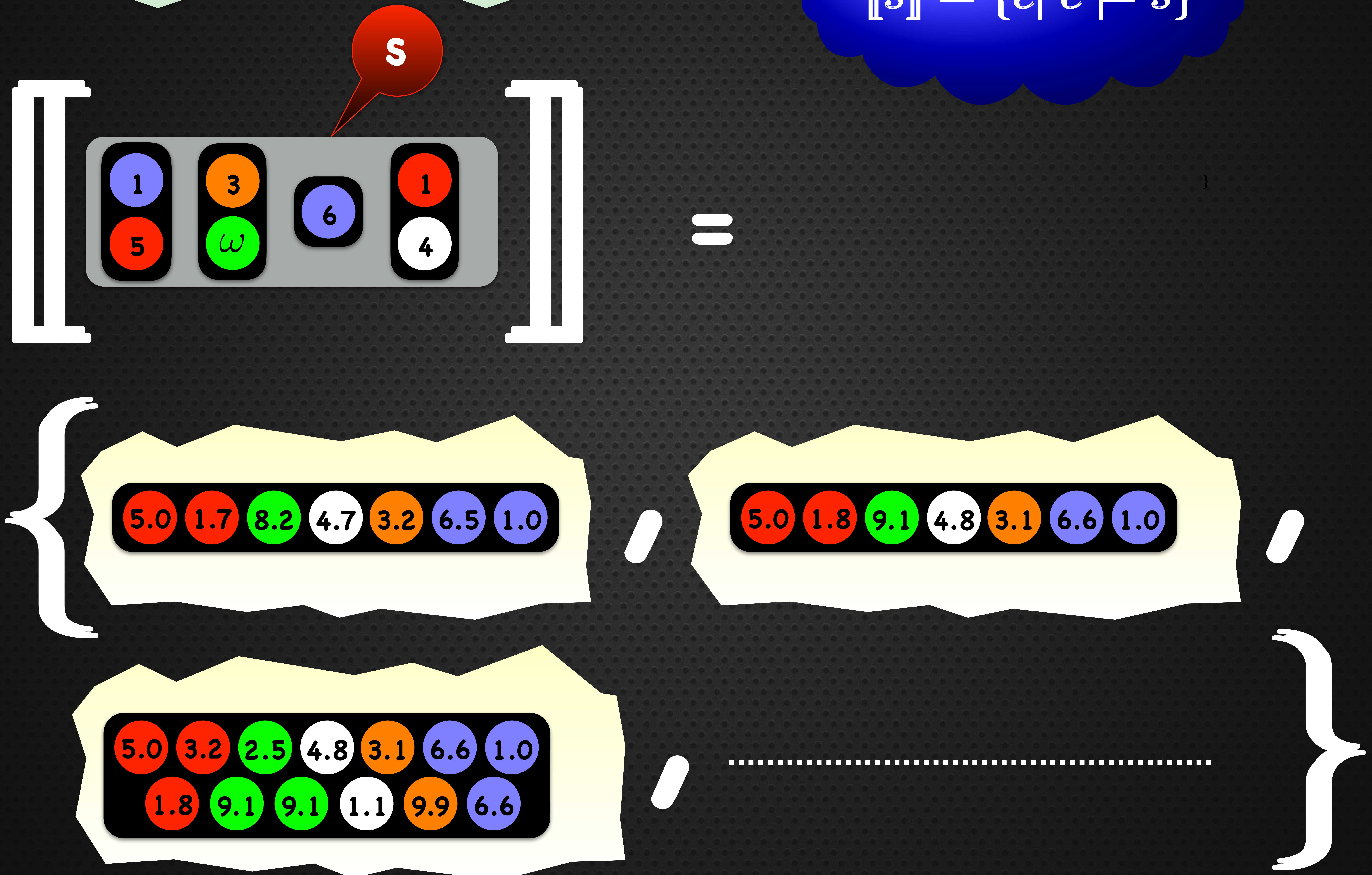
$$[\![s]\!] = \{c \mid c \models s\}$$



Timed Pe

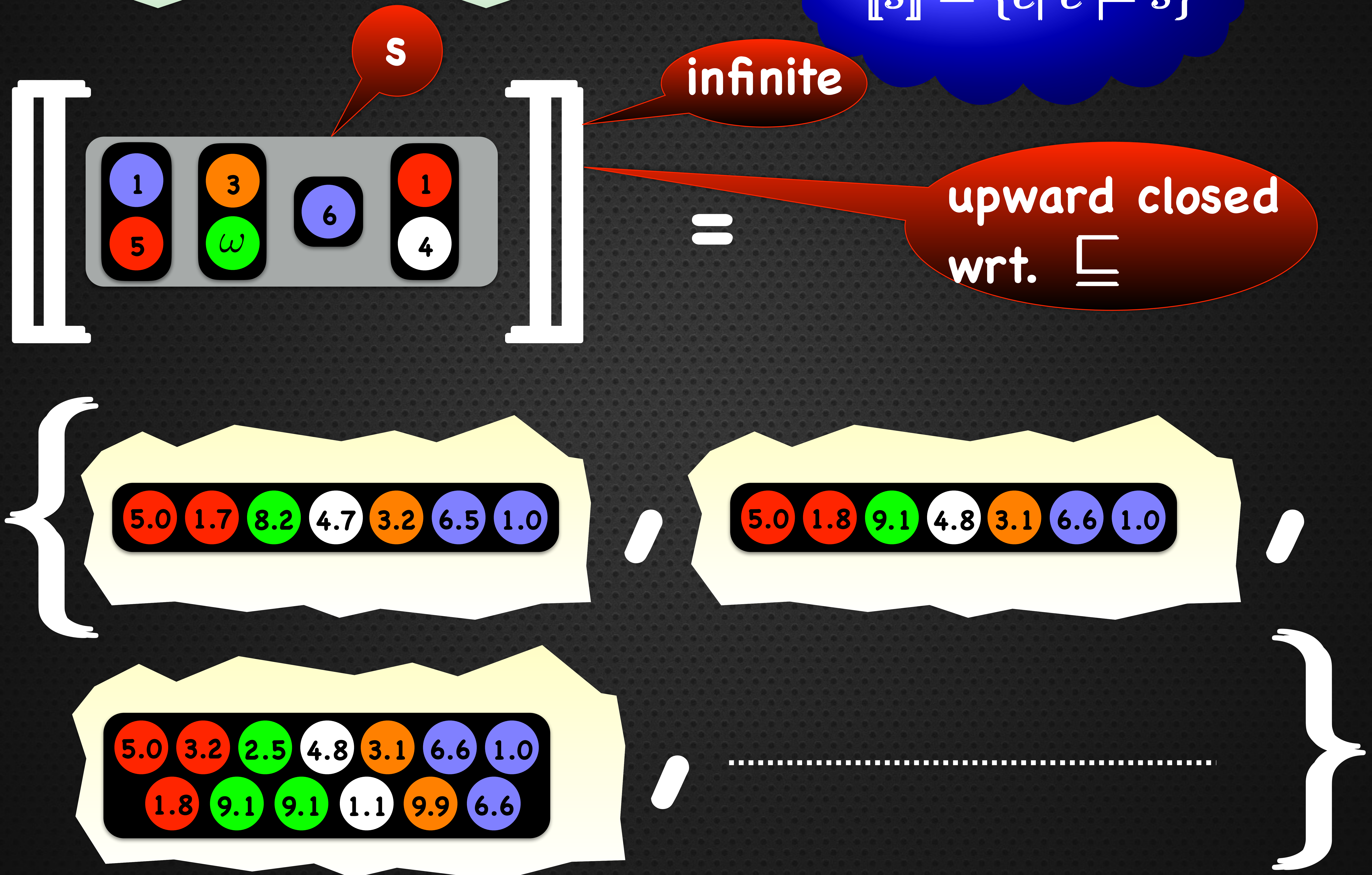
Denotation

$$[\![s]\!] = \{c |\ c \models s\}$$



Timed Pe… Denotation

$$[\![s]\!] = \{c \mid c \models s\}$$



Timed Pe

Denotation

$[\![s]\!] = \{c \mid c \models s\}$

s

1 5 | 3 ω | 6 | 1 4

infinite

upward closed wrt. $\sqsubseteq$

=

$s_1 \sqsubseteq s_2$

implies

$[\![s_2]\!] \subseteq [\![s_1]\!]$

{ 5.0 1.7 8.2 4.7 … 1.8 9.1 4.8 3.1 6.6 1.0 ,

5.0 3.2 2.5 4.8 3.1 6.6 1.0
1.8 9.1 9.1 1.1 9.9 6.6 , ... }

Timed Petri Nets

Model

Configurations

Transitions

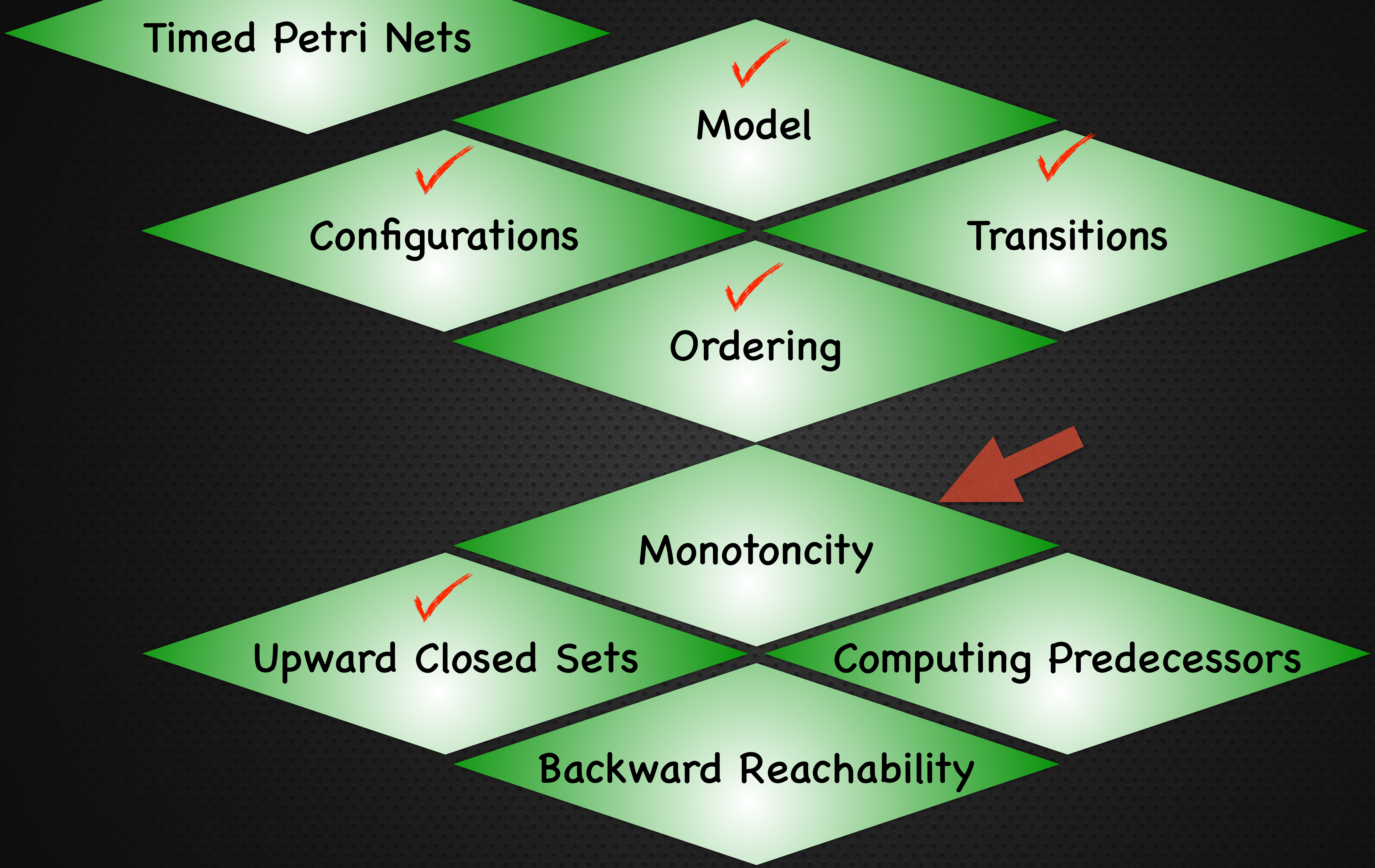
Ordering

Monotoncity

Upward Closed Sets

Computing Predecessors

Backward Reachability


Timed Petri Nets
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Backward Reachability

Timed

Monotonicity

5.0 1.7 8.2 4.7 3.2 6.5 1.0

Timed

Monotonicity

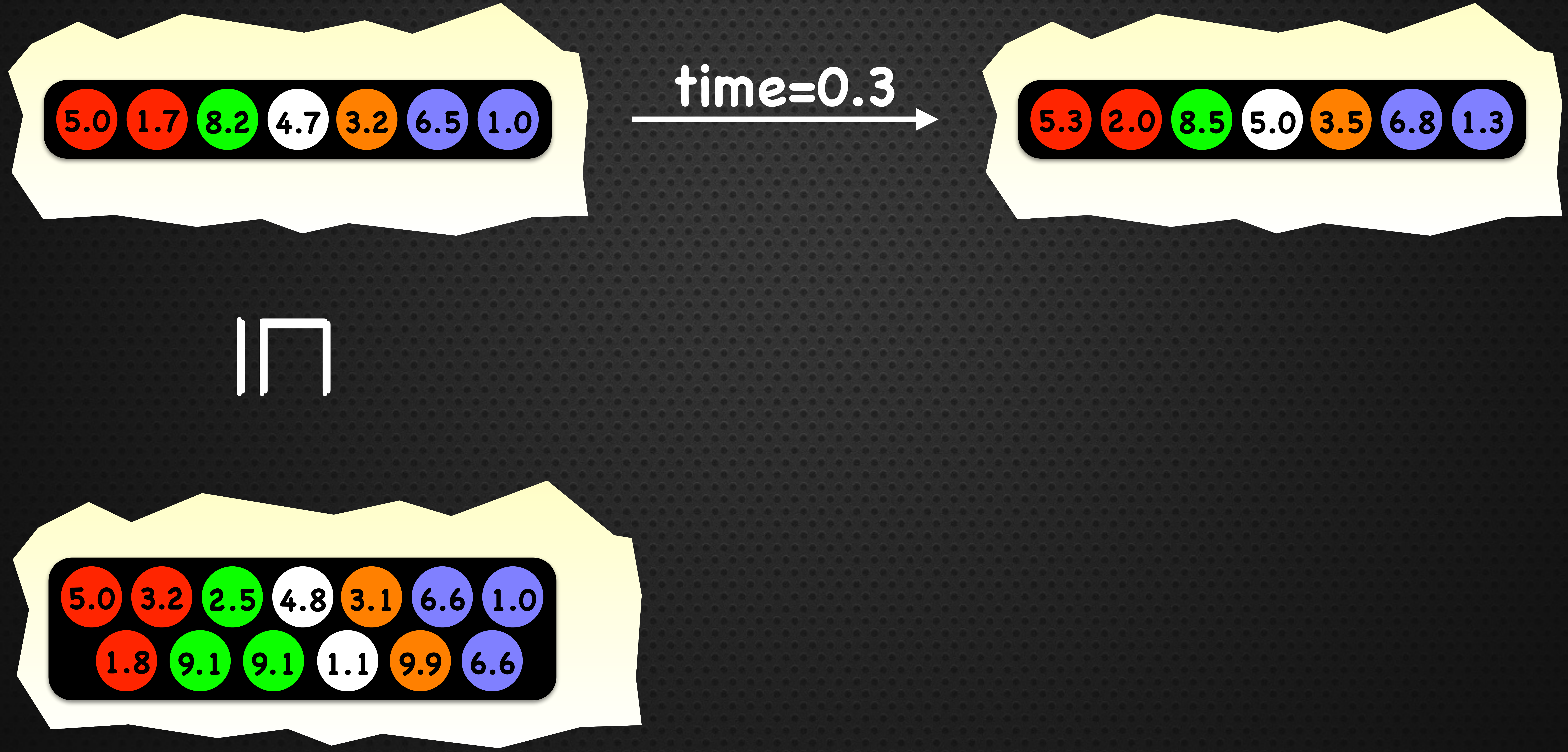
5.0 1.7 8.2 4.7 3.2 6.5 1.0

$\sqcap$

5.0 3.2 2.5 4.8 3.1 6.6 1.0
1.8 9.1 9.1 1.1 9.9 6.6

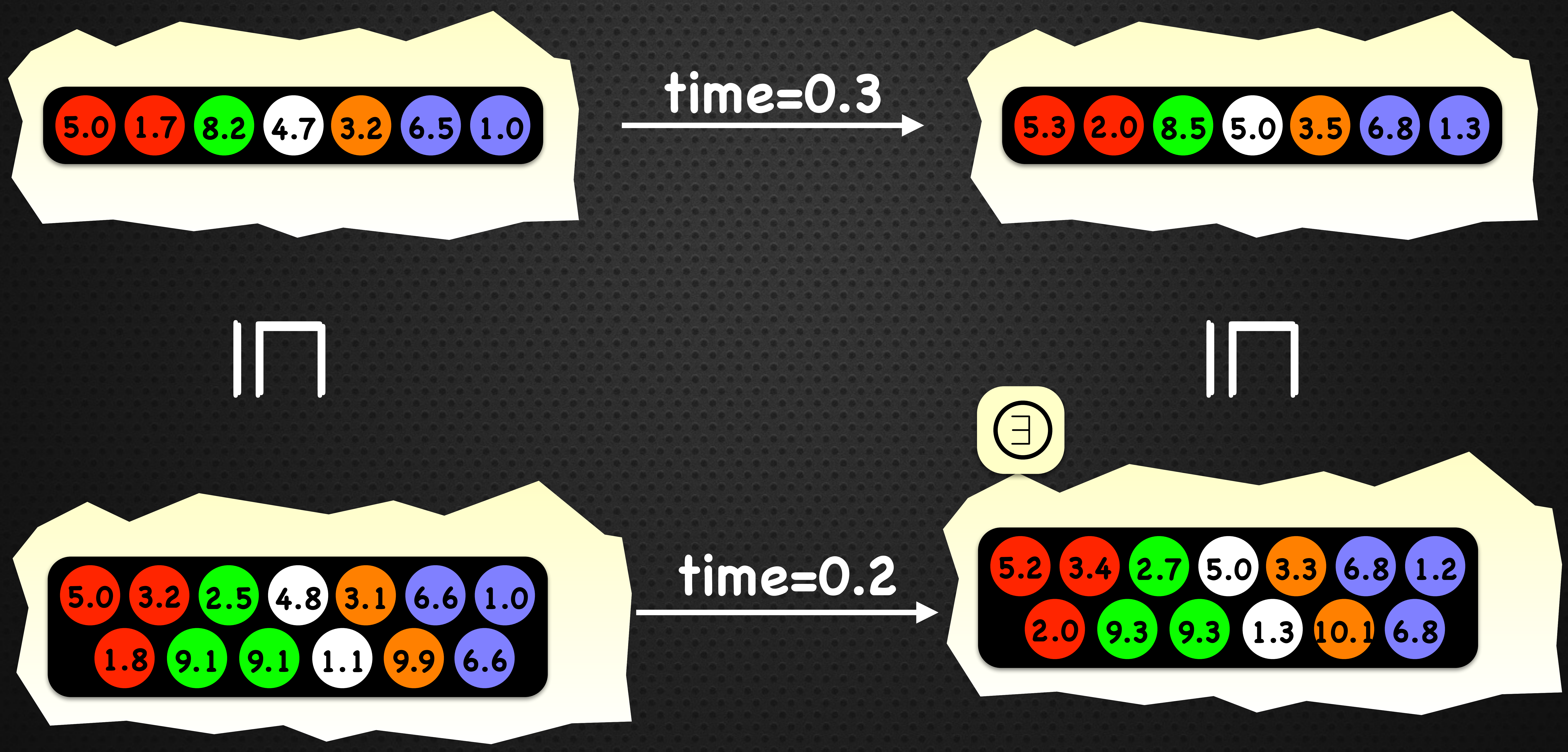
Timed

Monotonicity

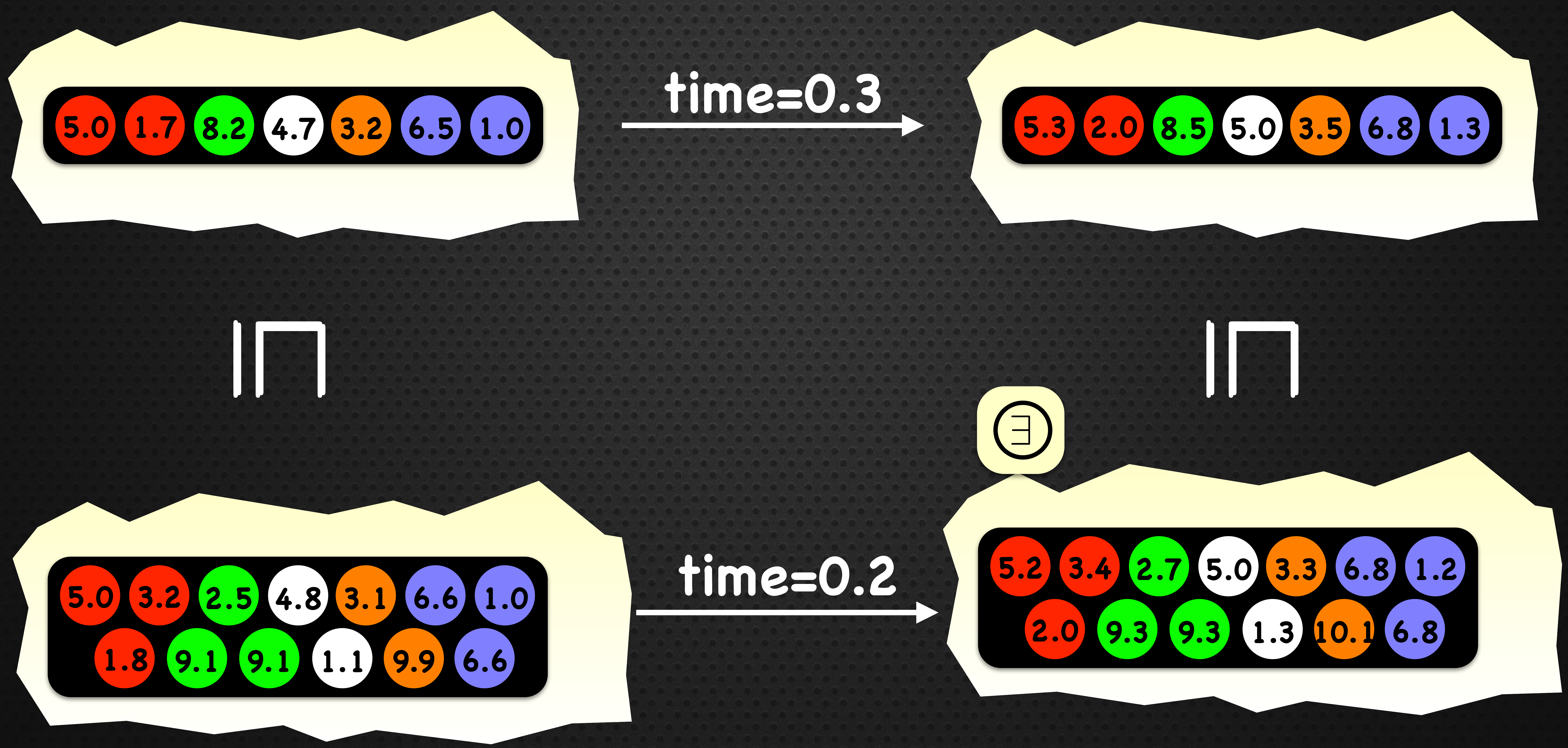


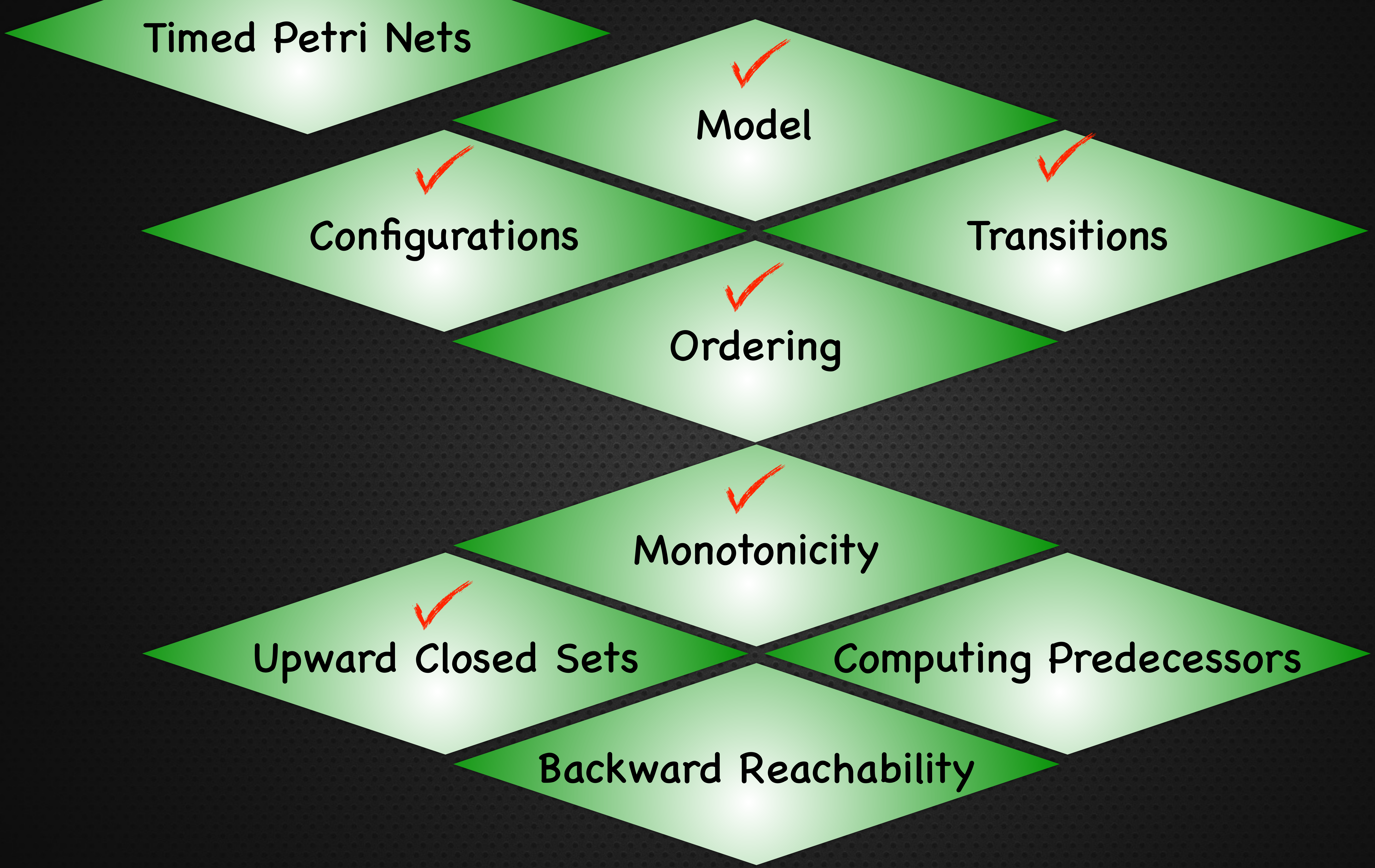
Timed

Monotonicity



Computing Predecessors




Timed Petri Nets
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Timed Petri Nets

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Transitions

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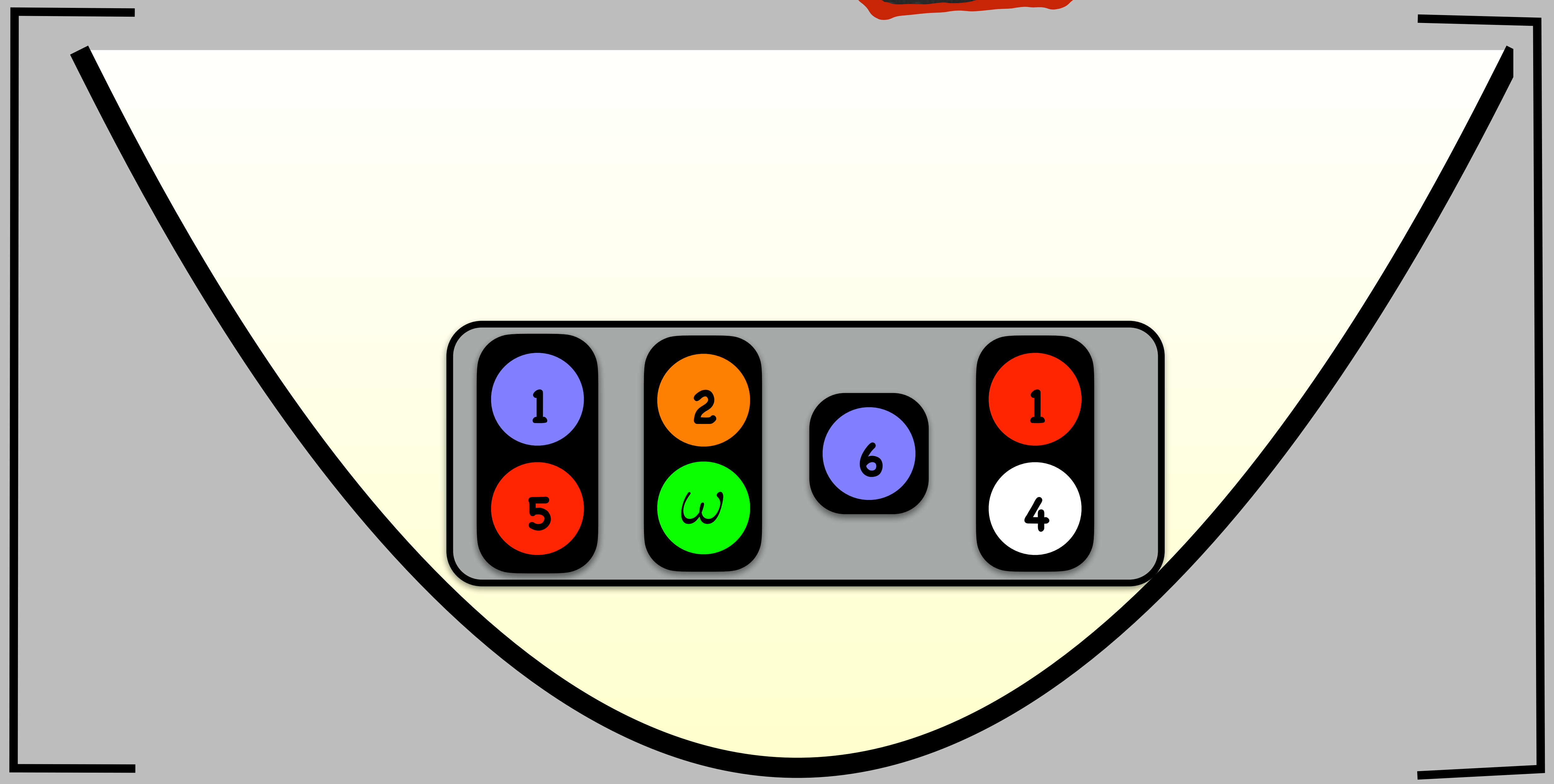
Computing Predecessors

Backward Reachability

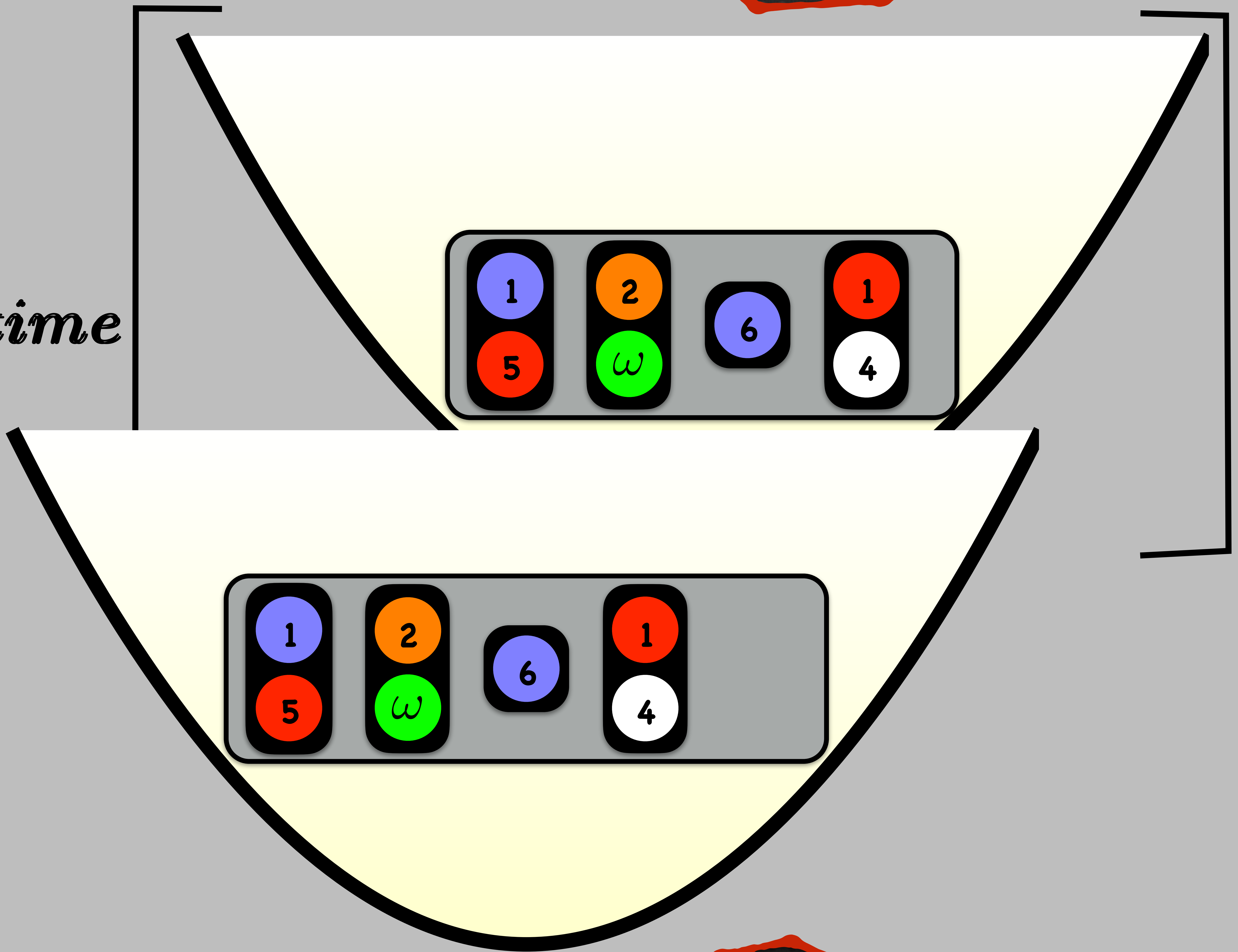
Timed ... Computing Predecessors

Pre_{time}  $=$

Timed

Computing Predecessors

Pre_{time}



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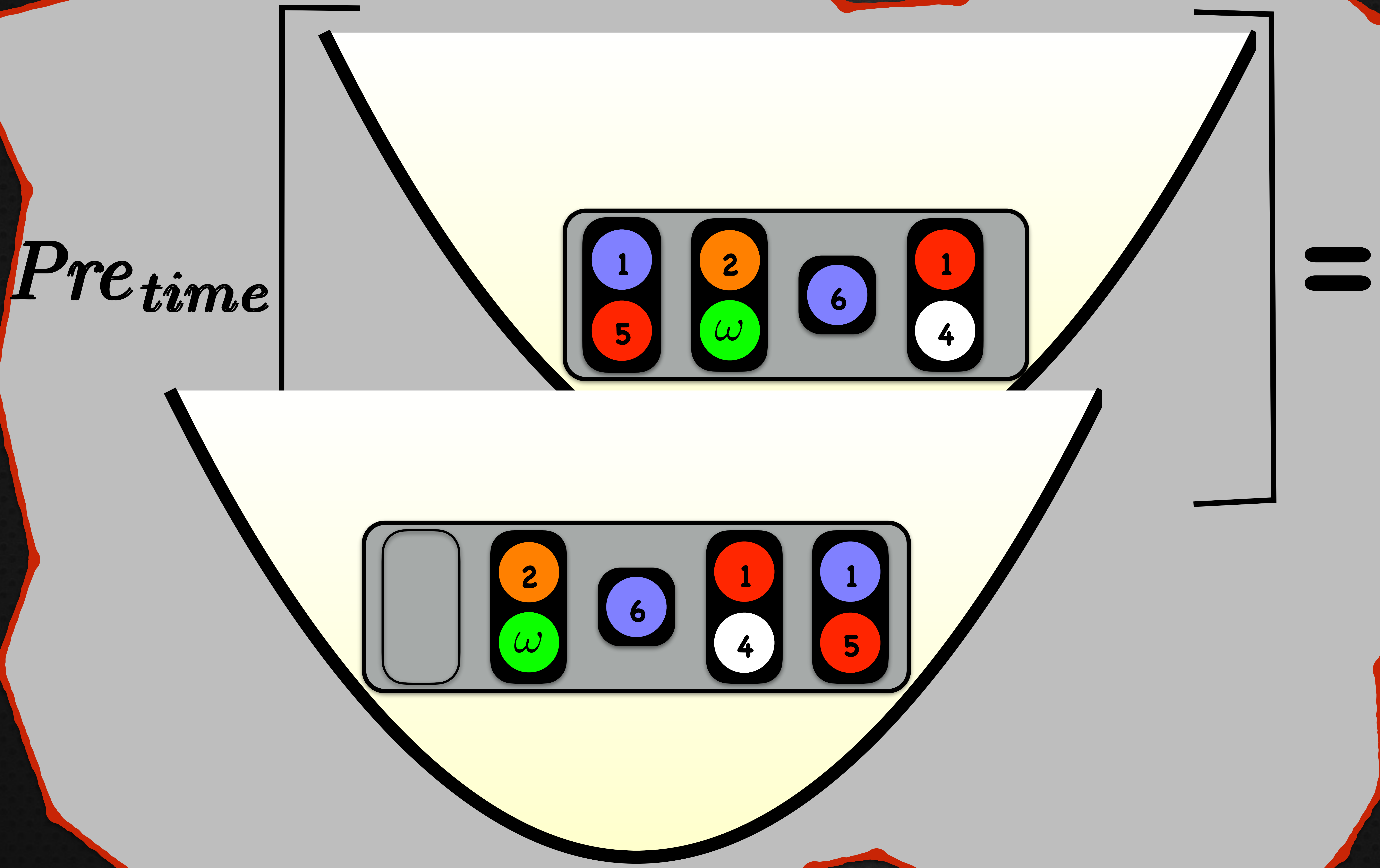
Timed

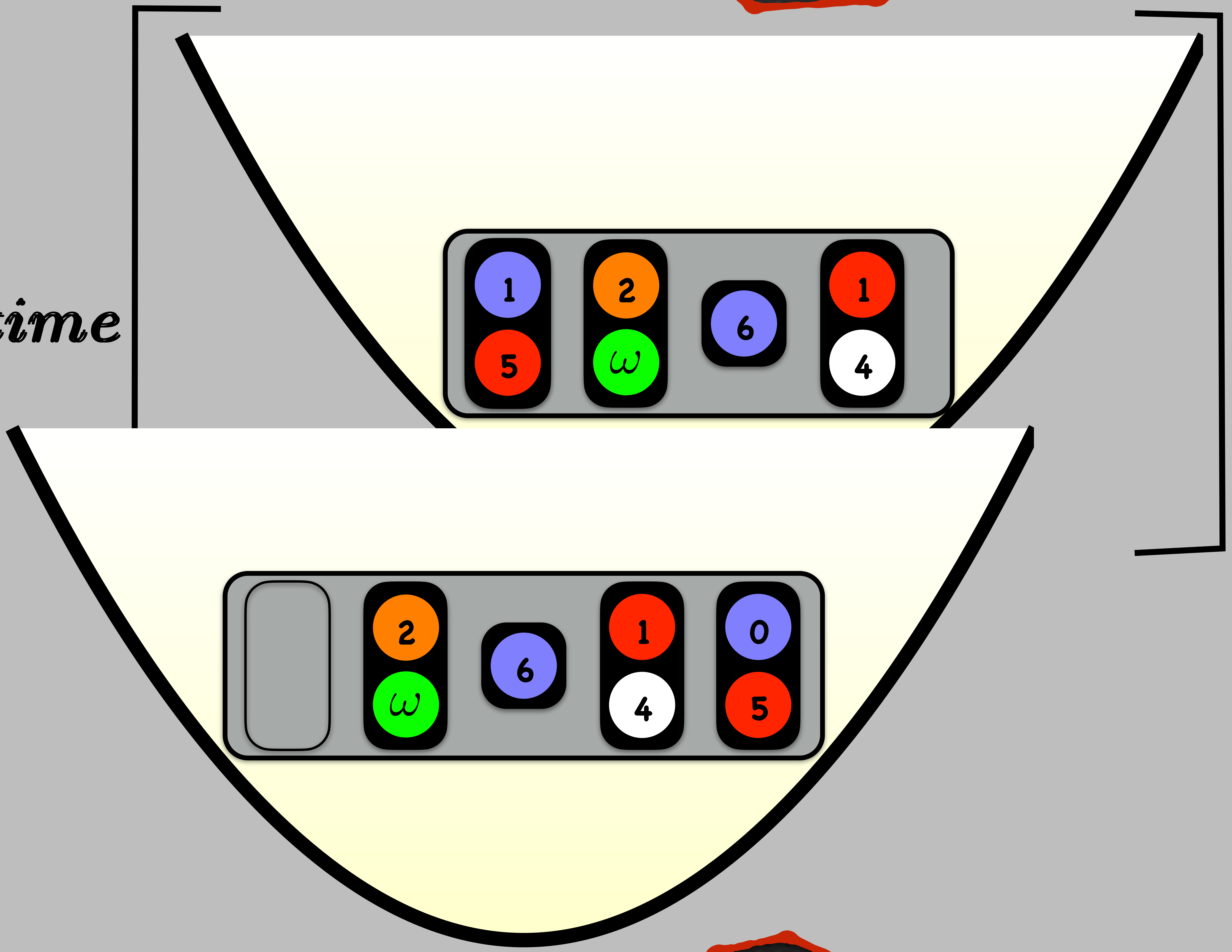
Computing Predecessors



Timed

Computing Predecessors

Pre_{time}



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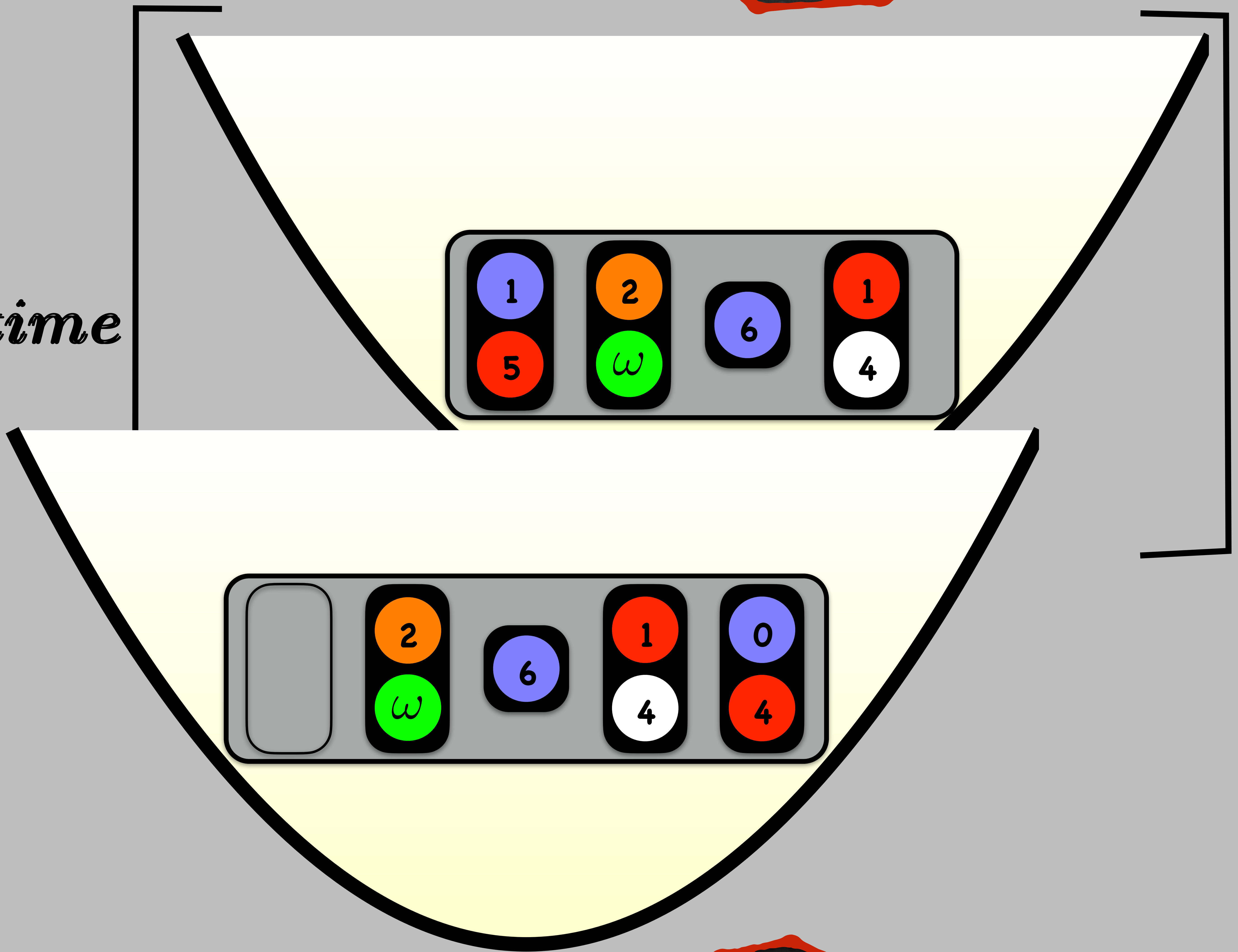
Timed · Computing Predecessors

Pre_{time}



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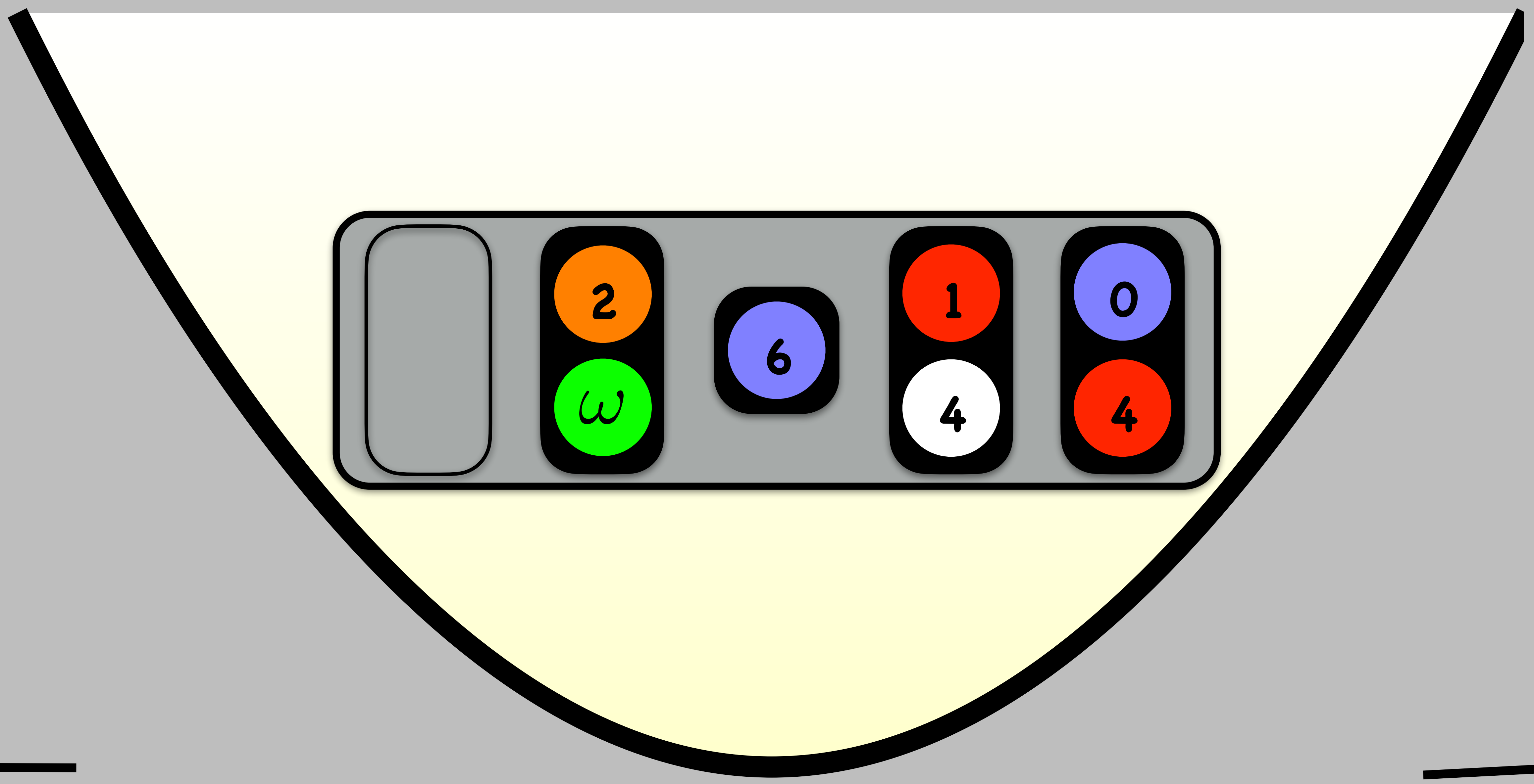
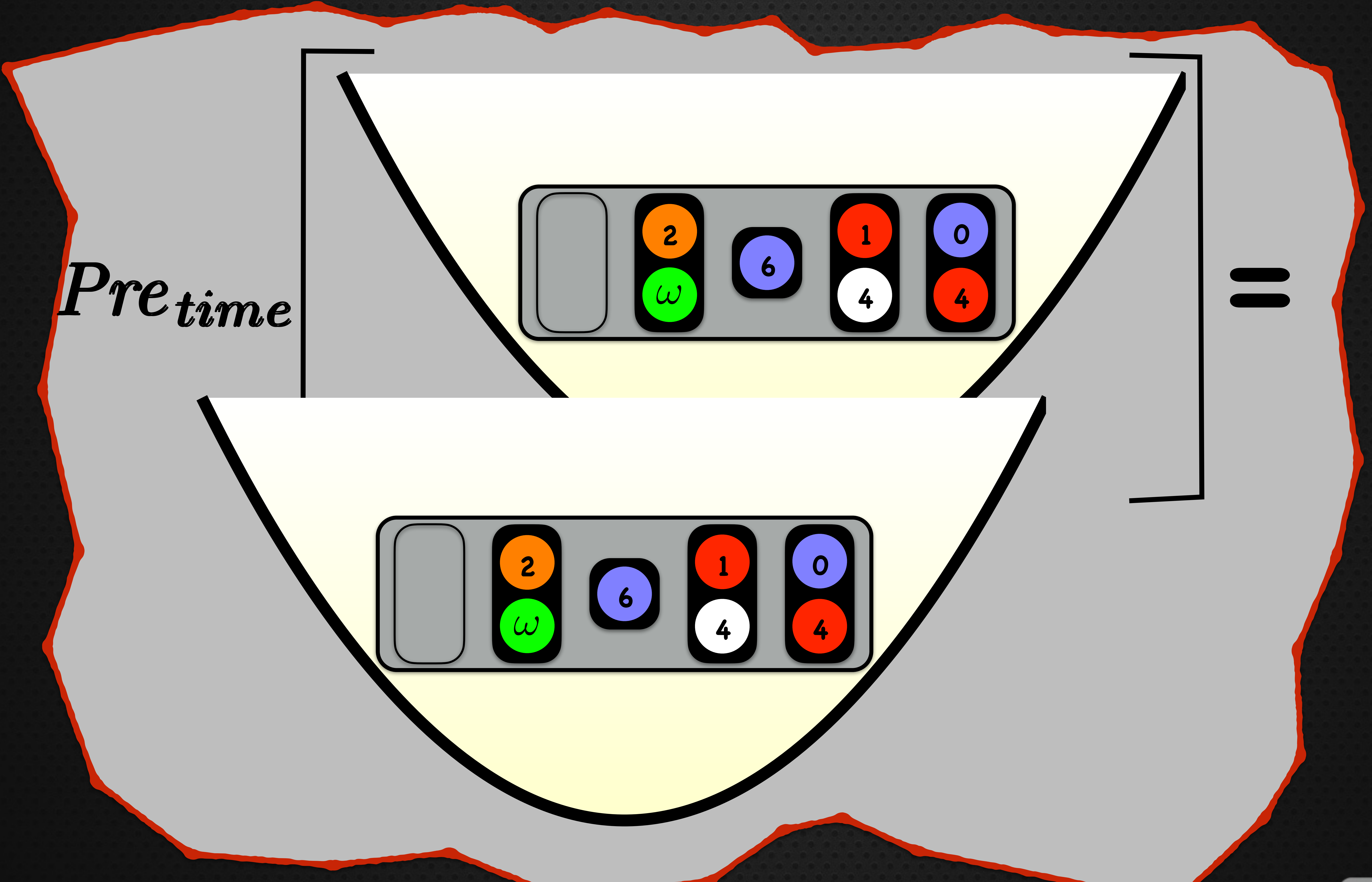
Timed

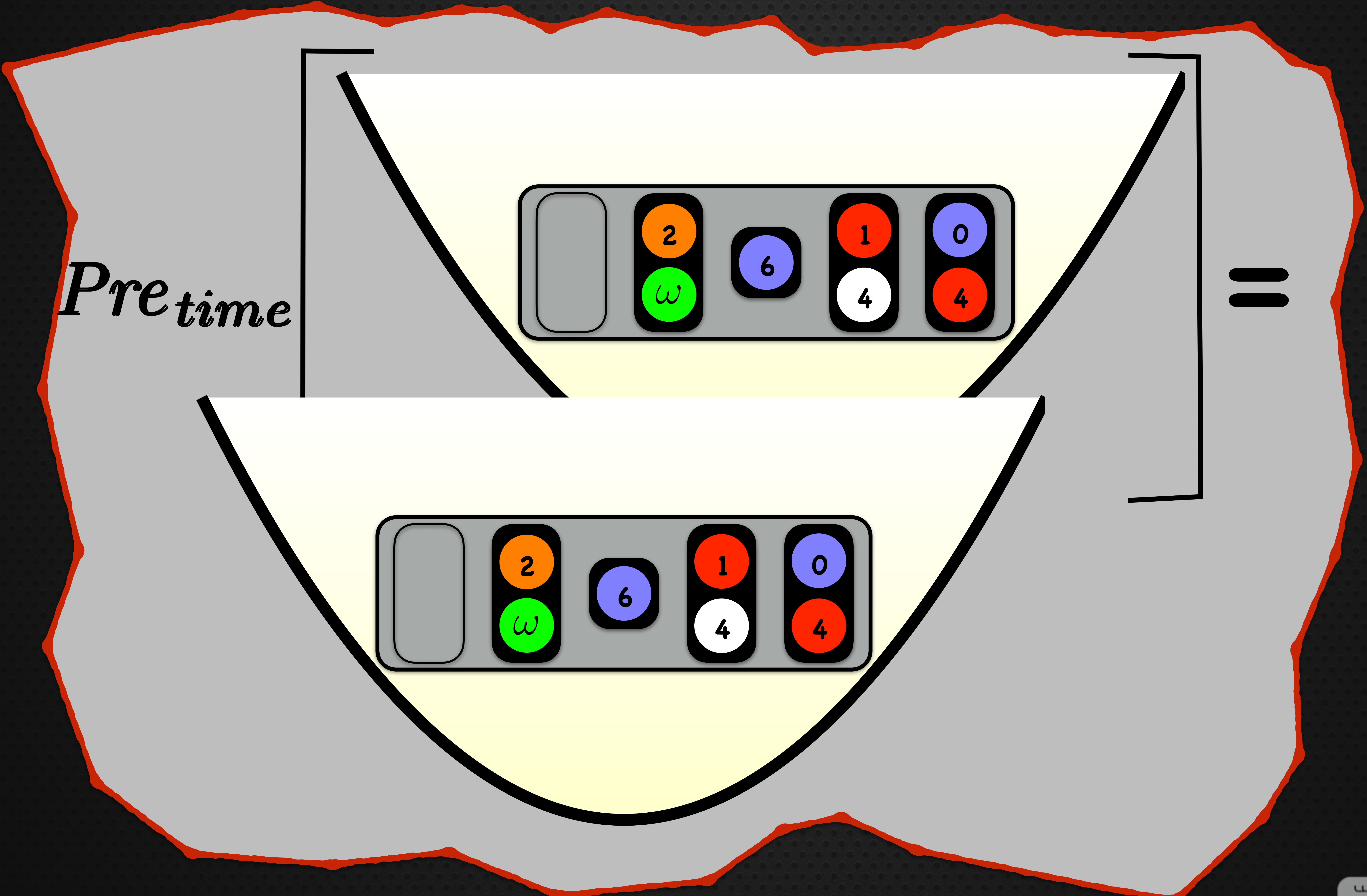
Computing Predecessors

Pre_{time} [] =

Computing Predecessors



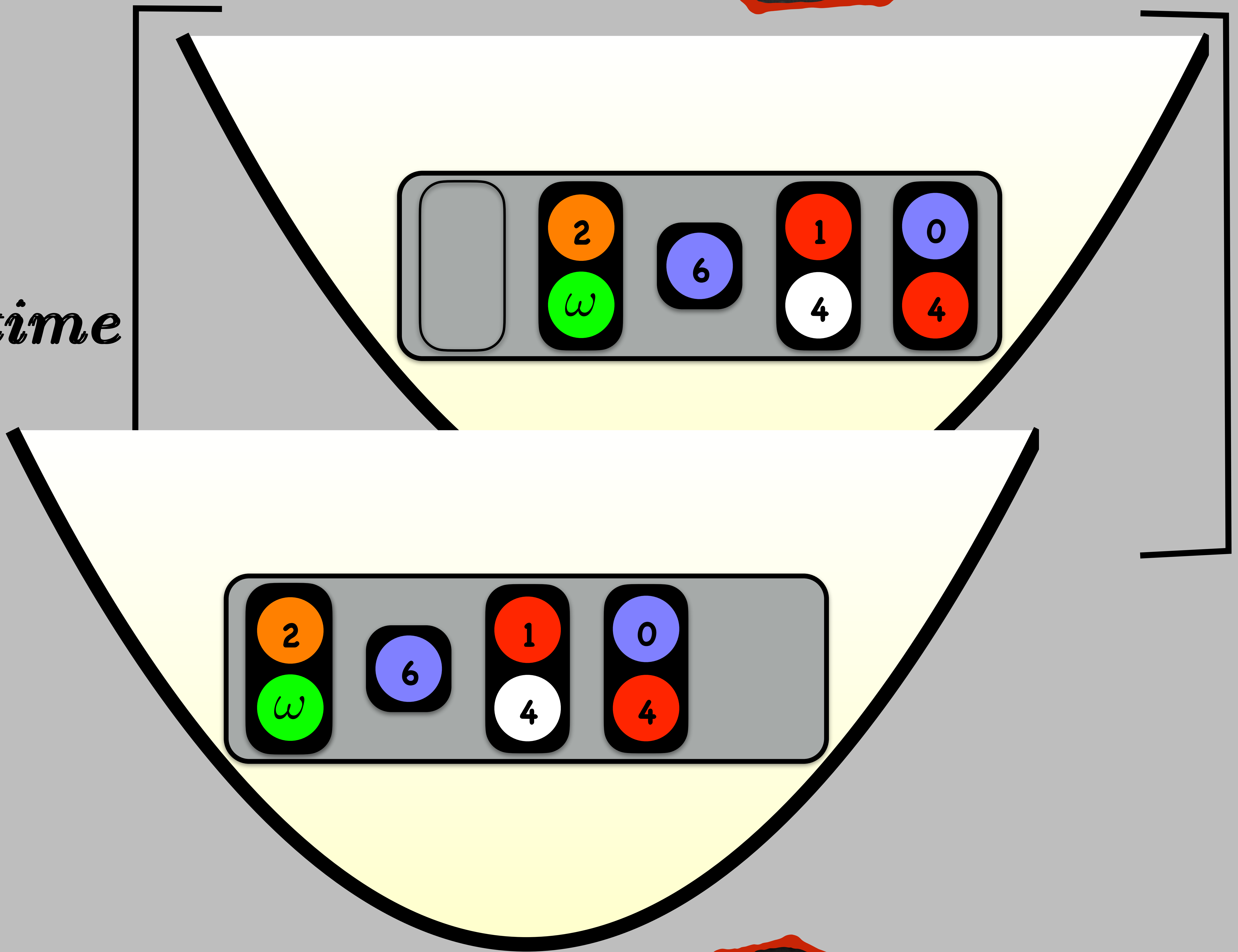
Timed Computing Predecessors



Computing Predecessors

Timed

Pre_{time}



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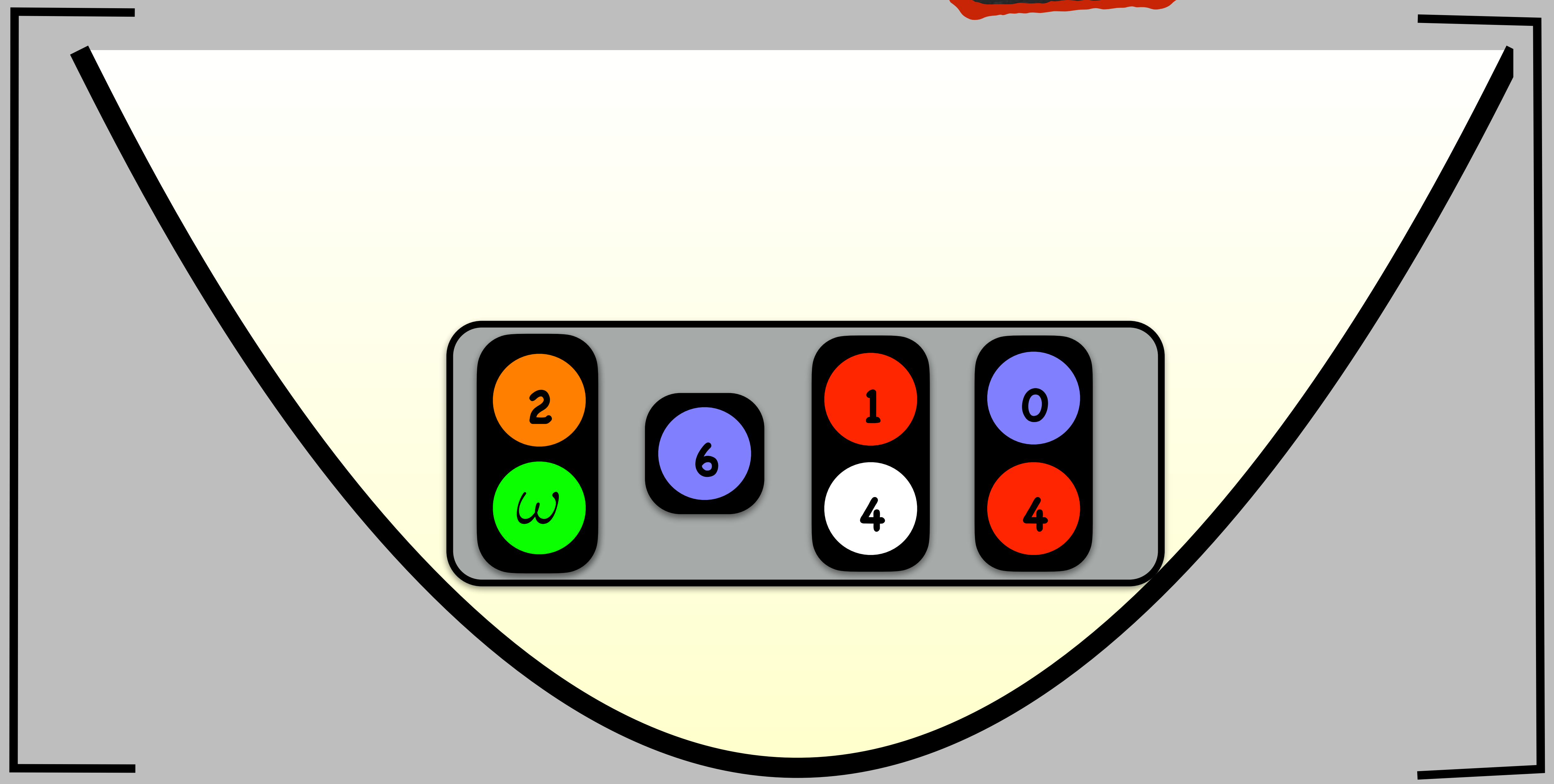
Timed

Computing Predecessors

$$Pre_{time}$$



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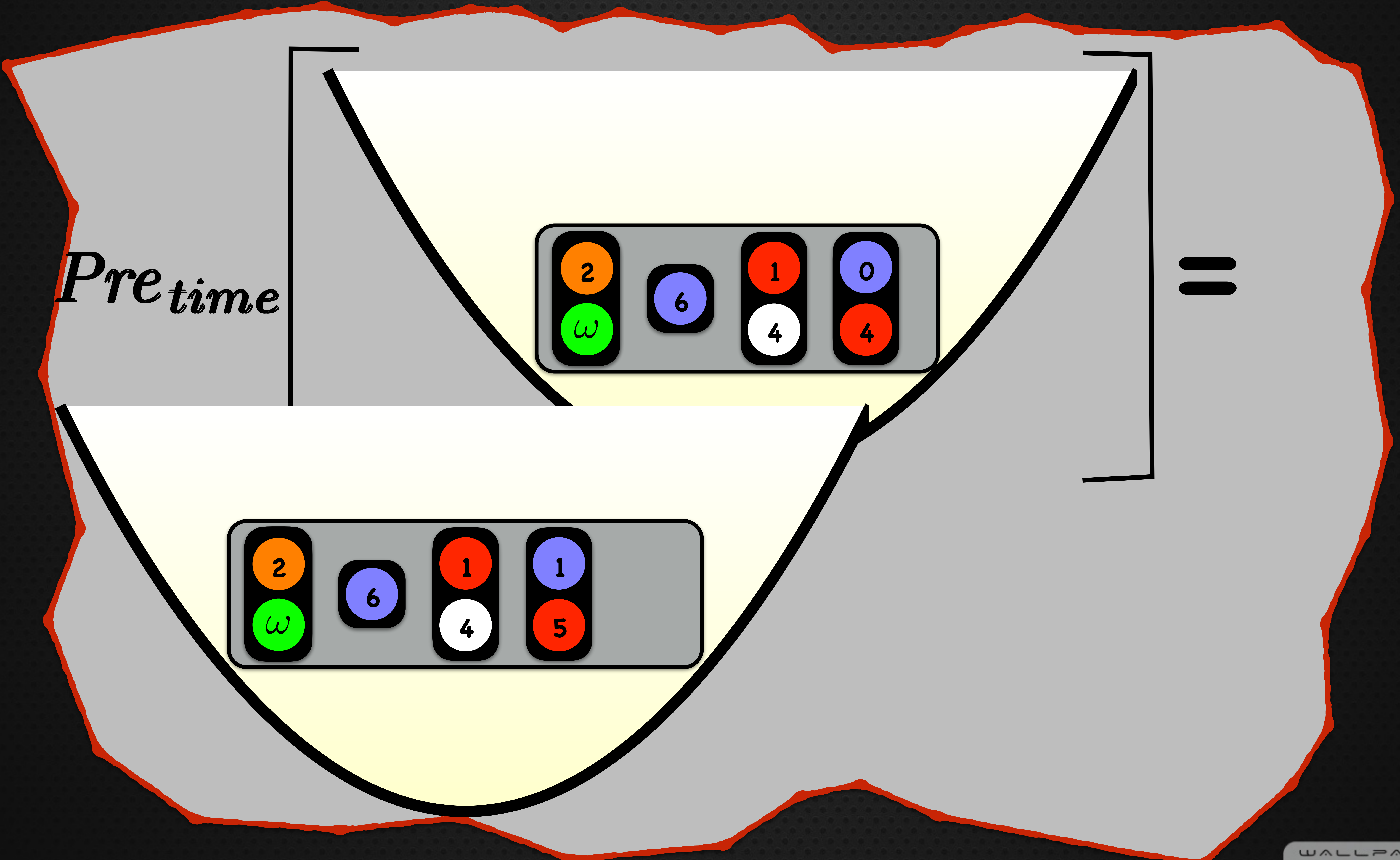
Computing Predecessors

Timed



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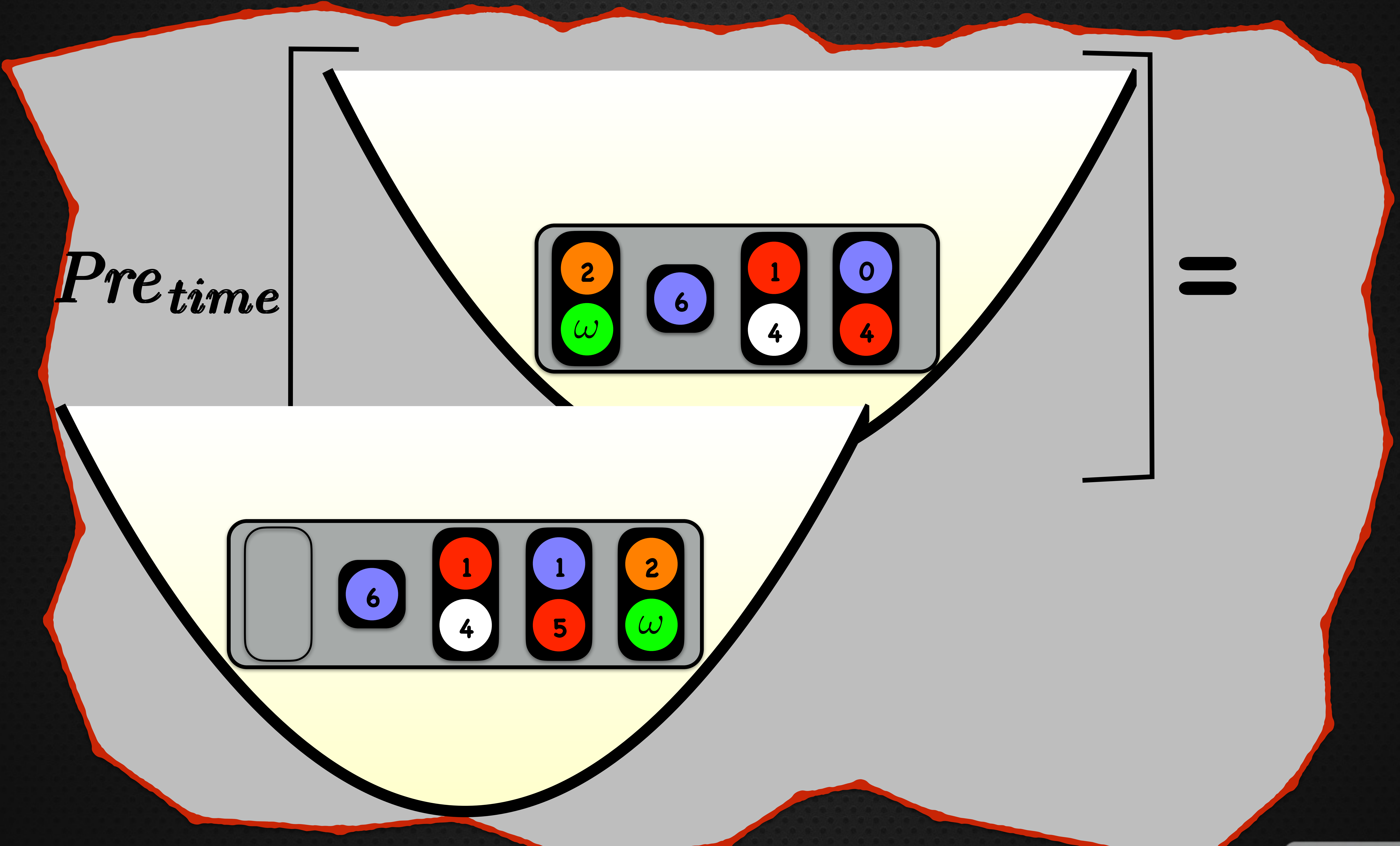

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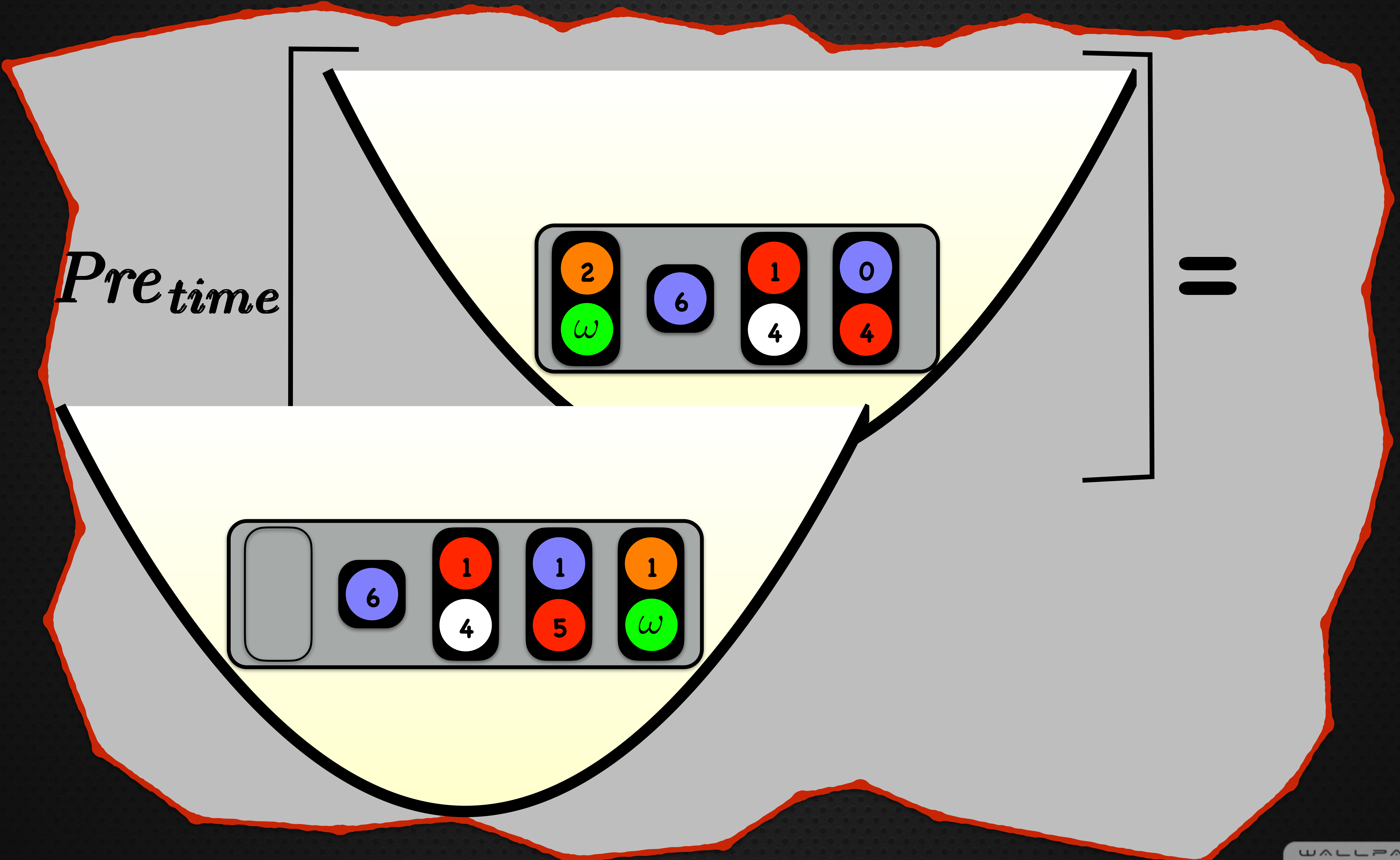
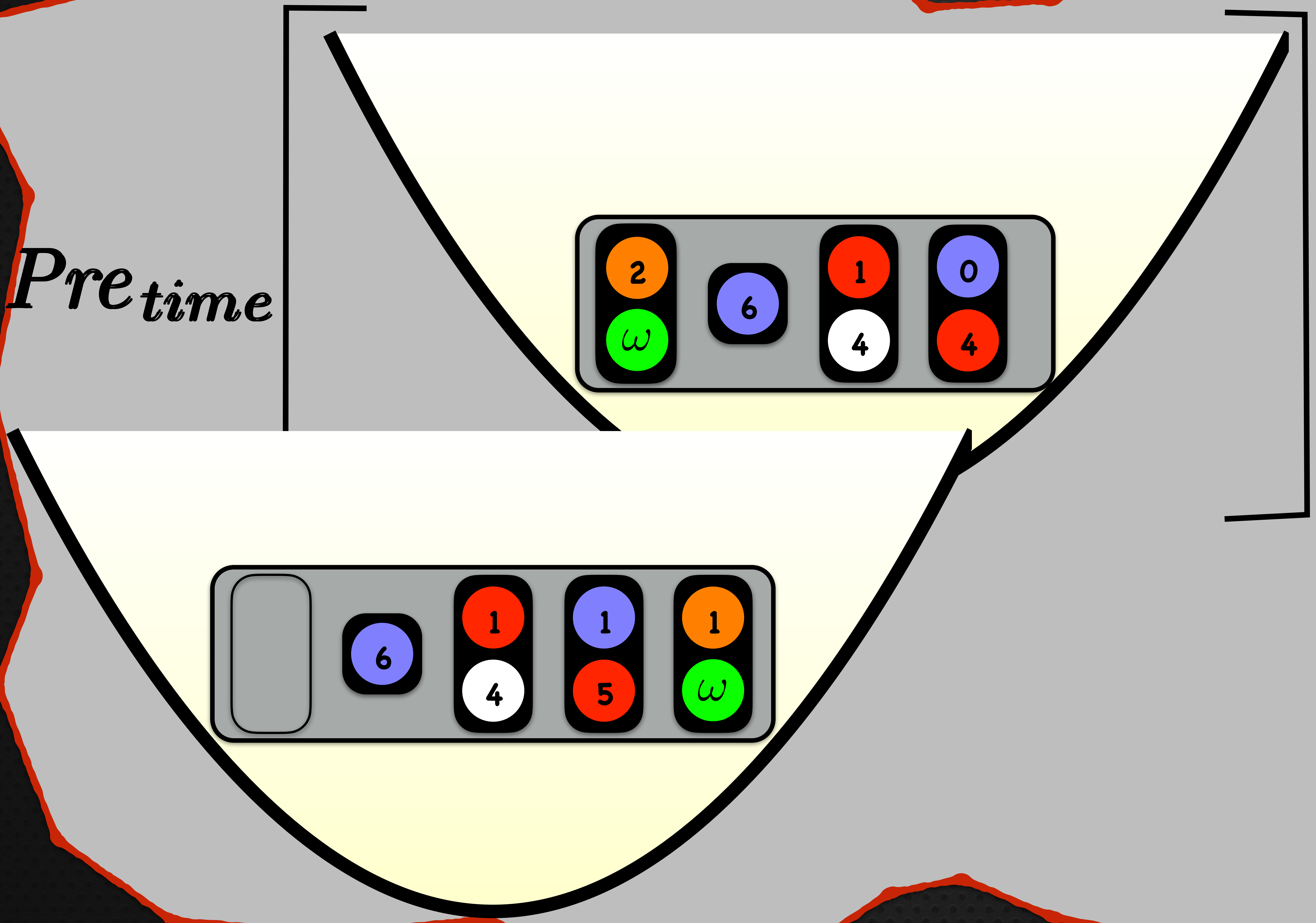
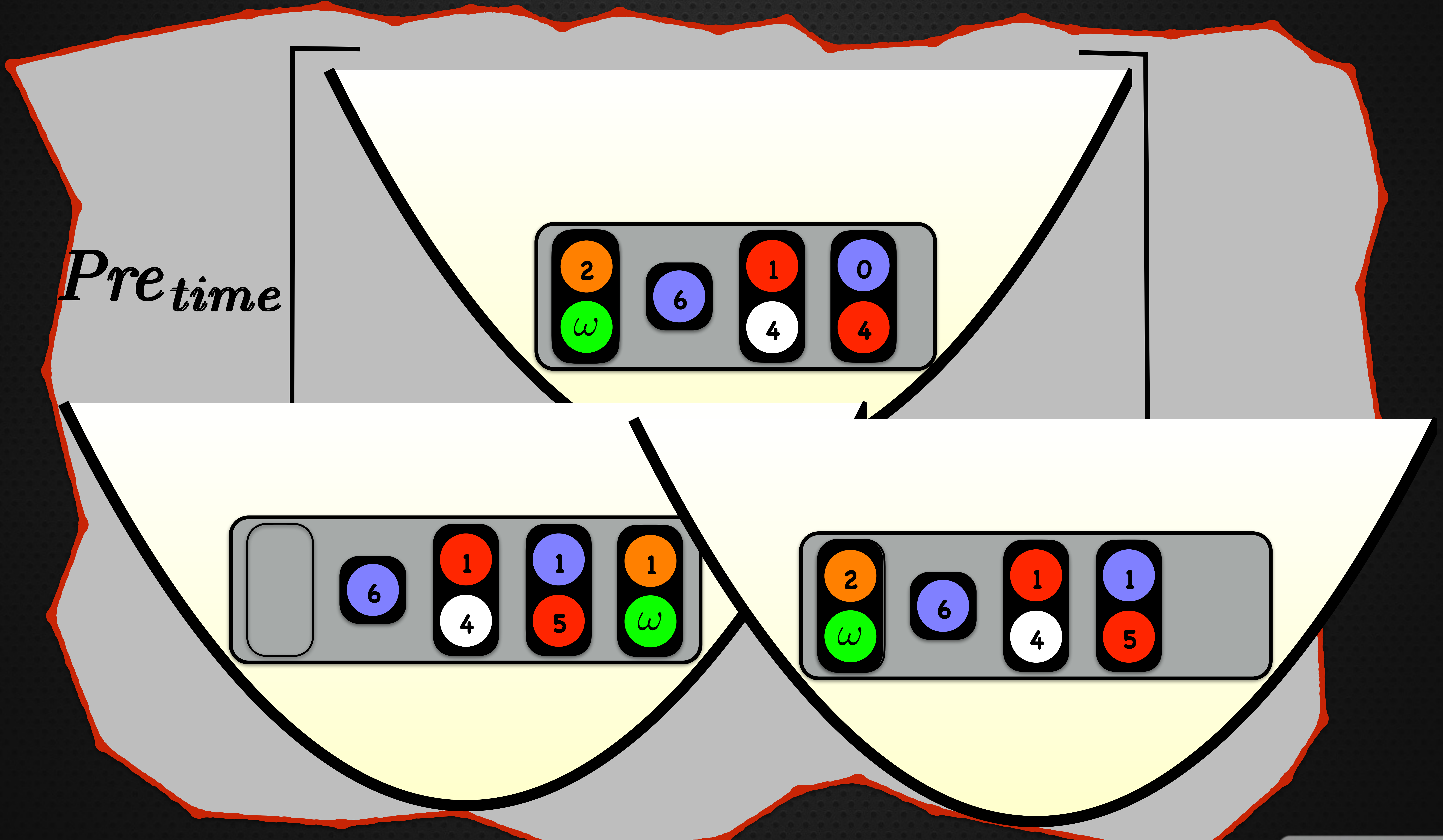
Computing Predecessors



Computing Predecessors

Pre_{time}  $=$

Timed Computing Predecessors



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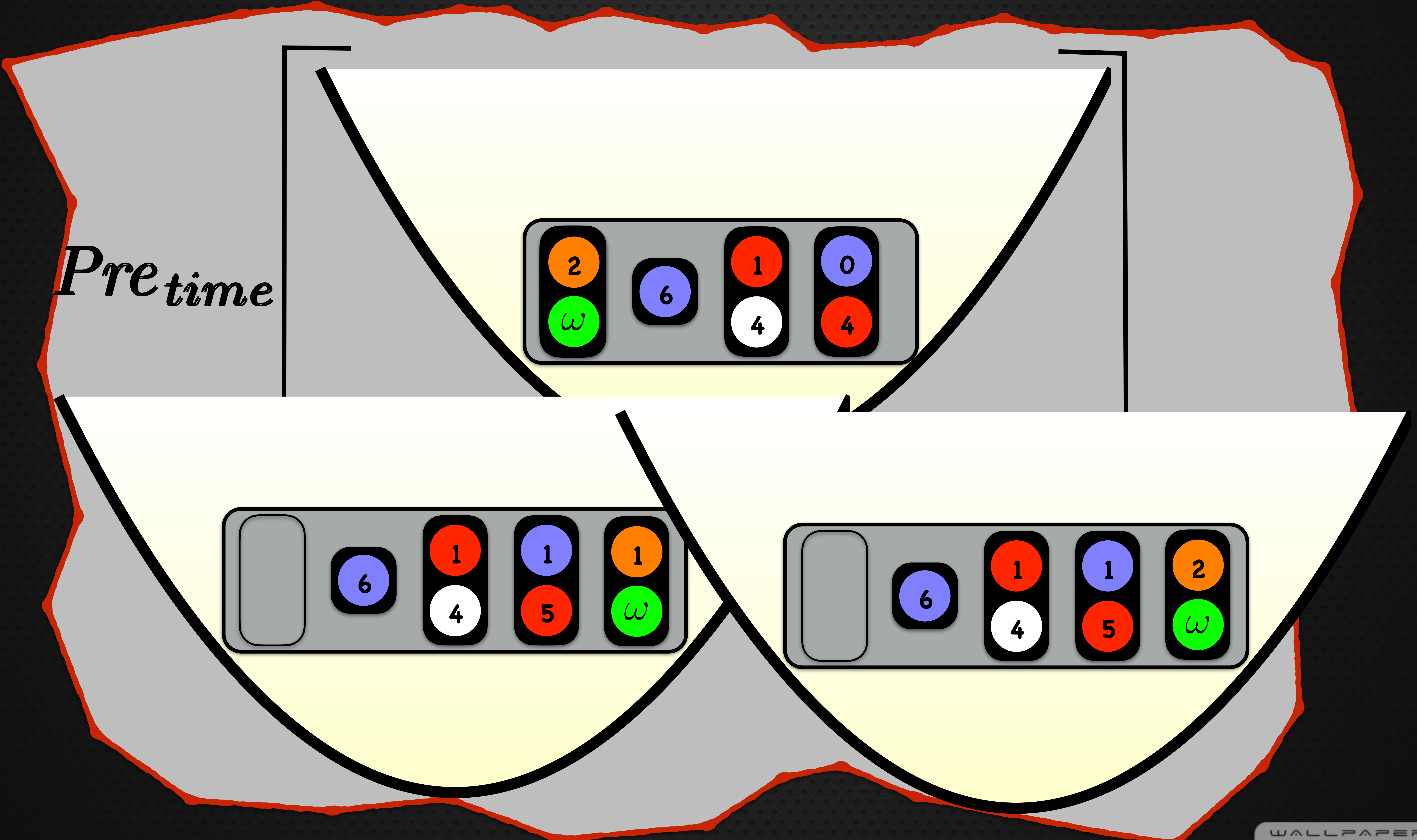
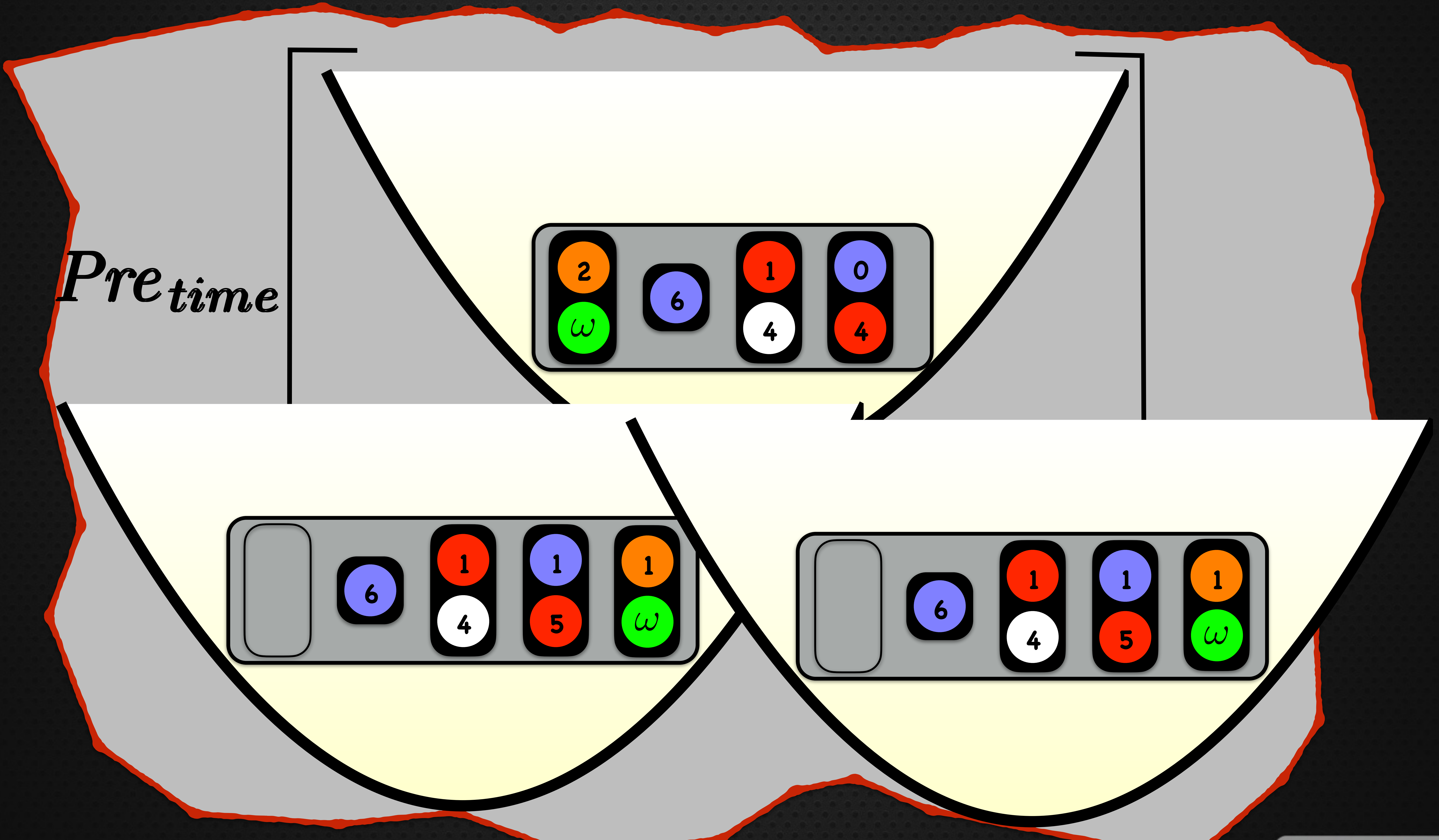
Computing Predecessors



Computing Predecessors



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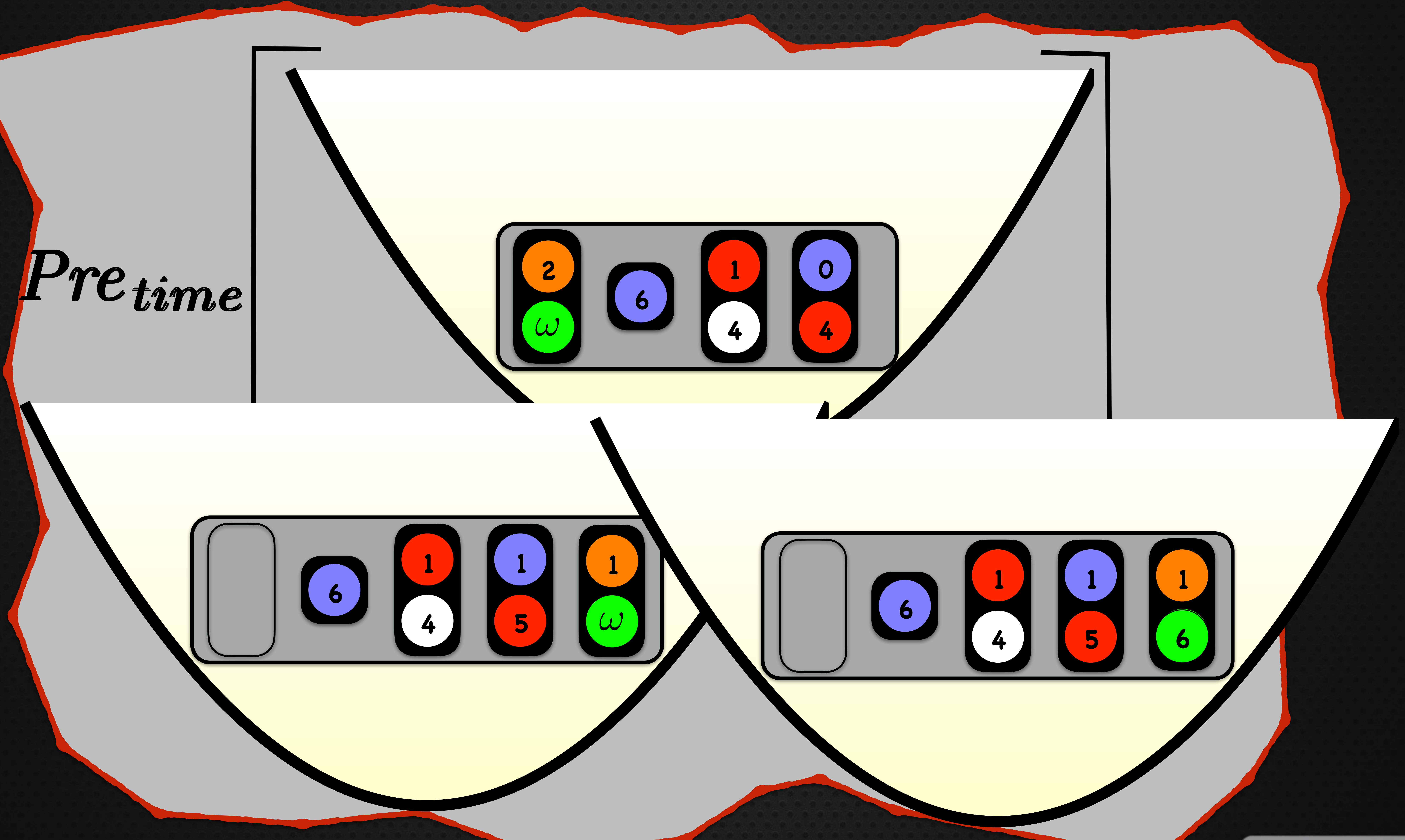

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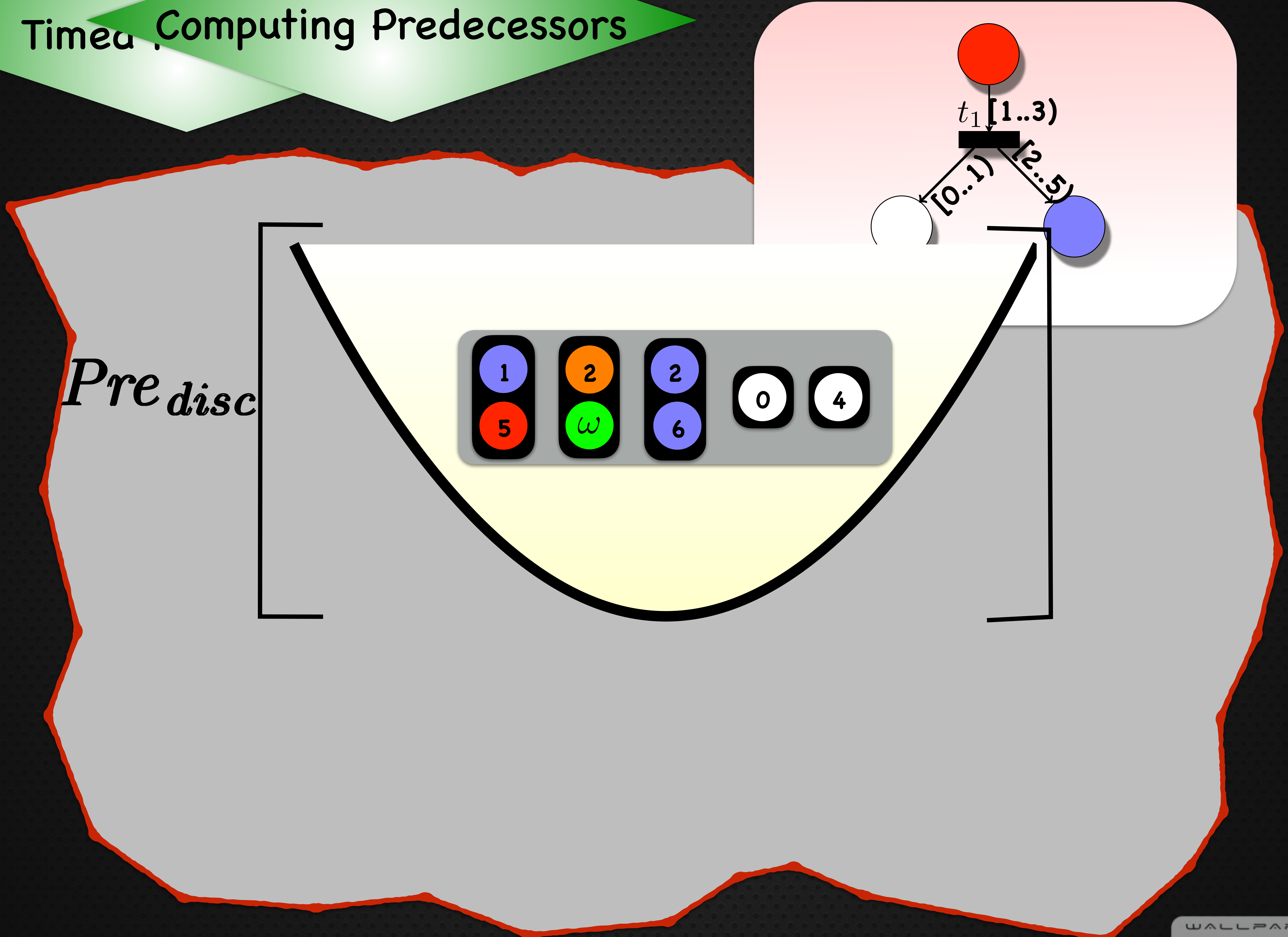

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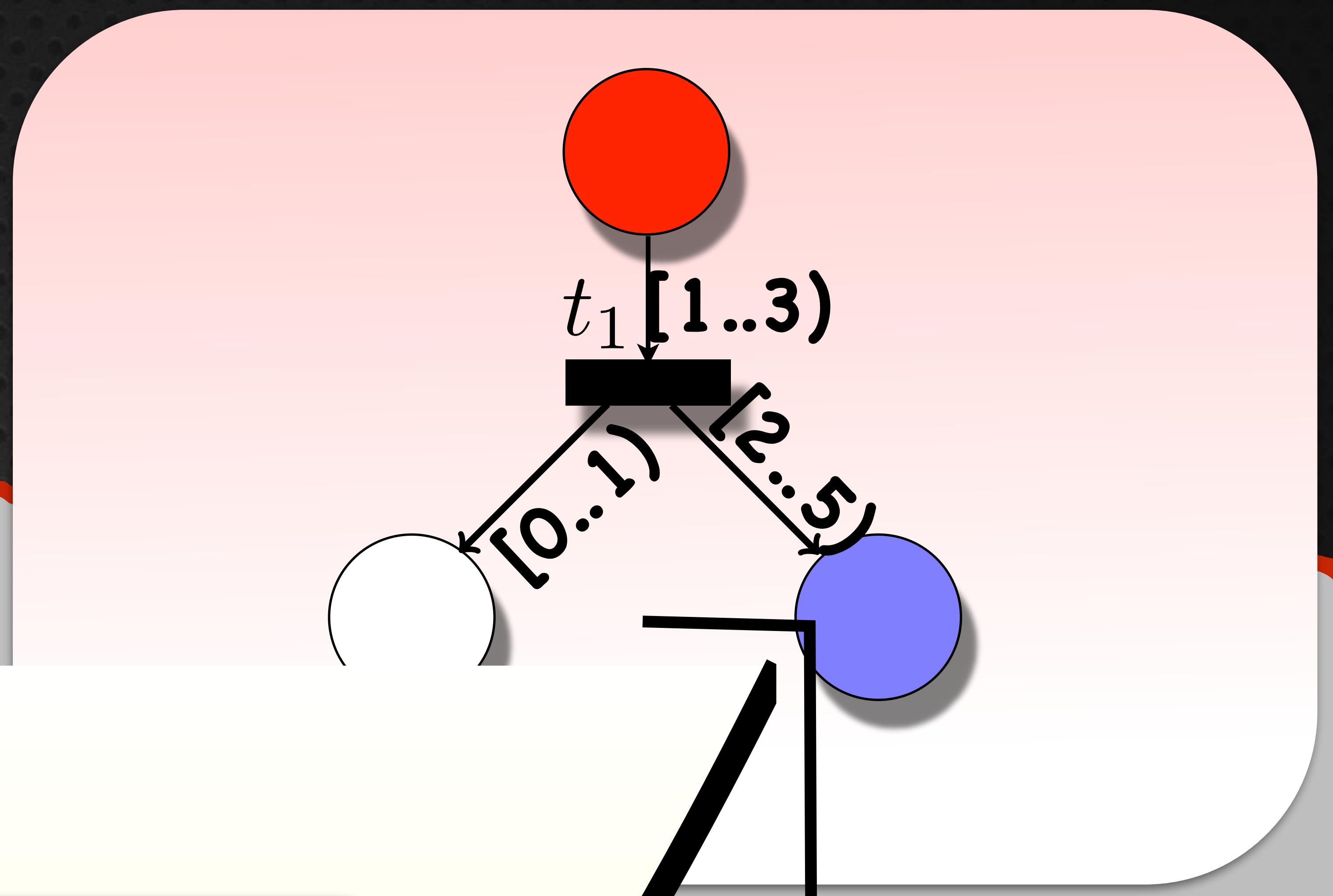
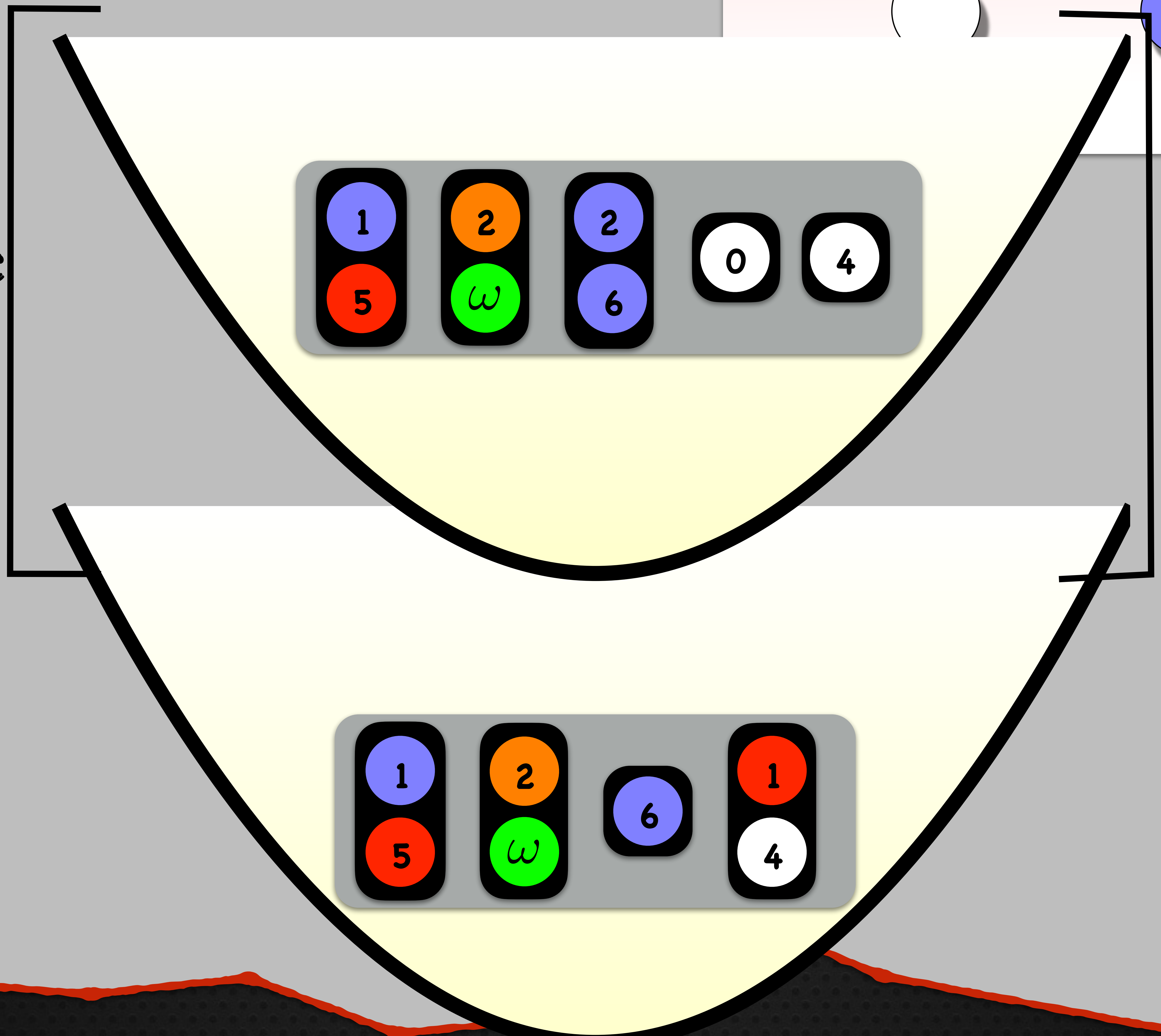


Pre_{disc}



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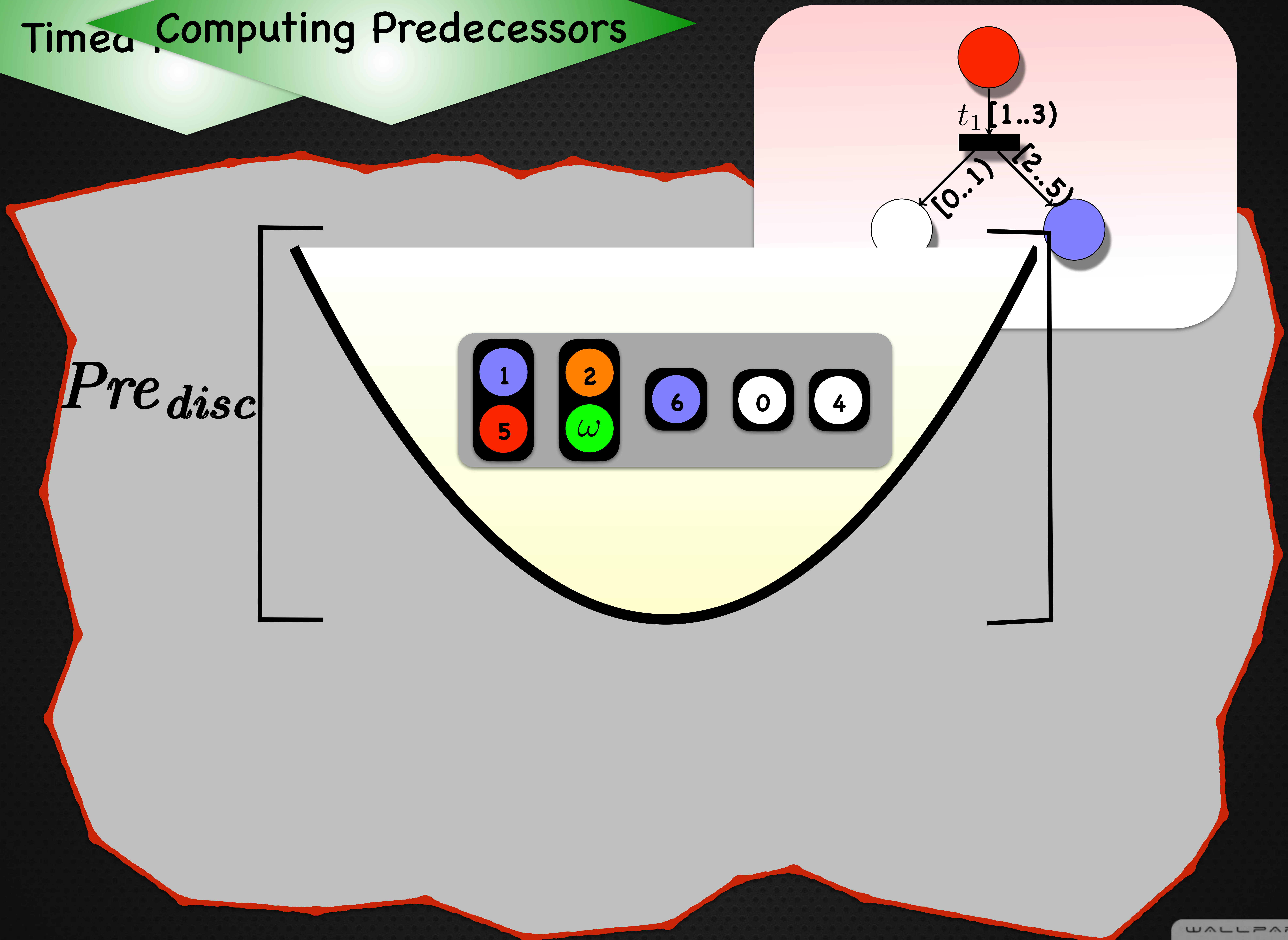
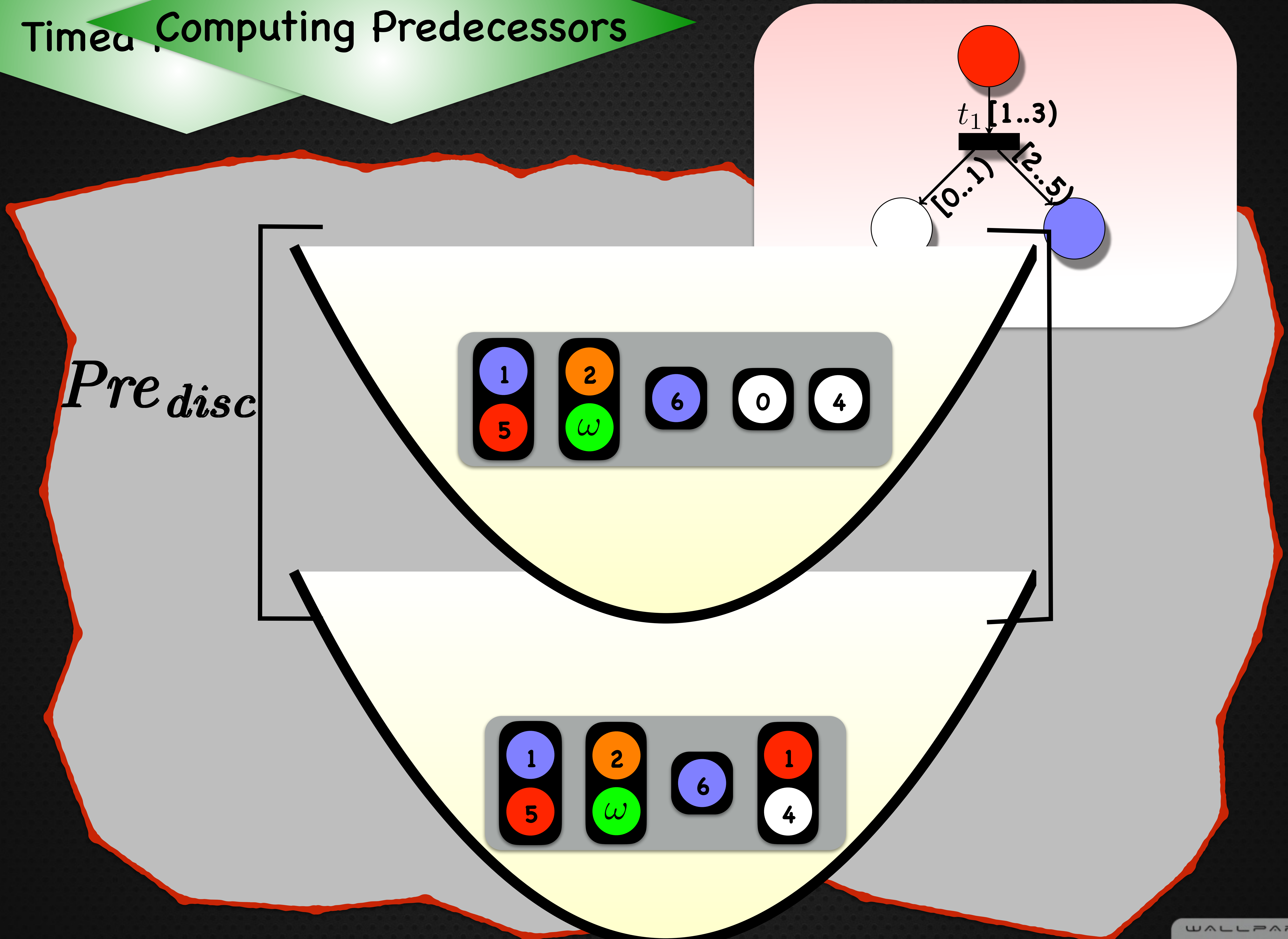


Timed ... Computing Predecessors



Timed Petri Nets

Model

Configurations

Transitions

Ordering

Monotonicity

Upward Closed Sets

Computing Predecessors

Backward Reachability

Timed Petri Nets

Model

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Computing Predecessors

Backward Reachability

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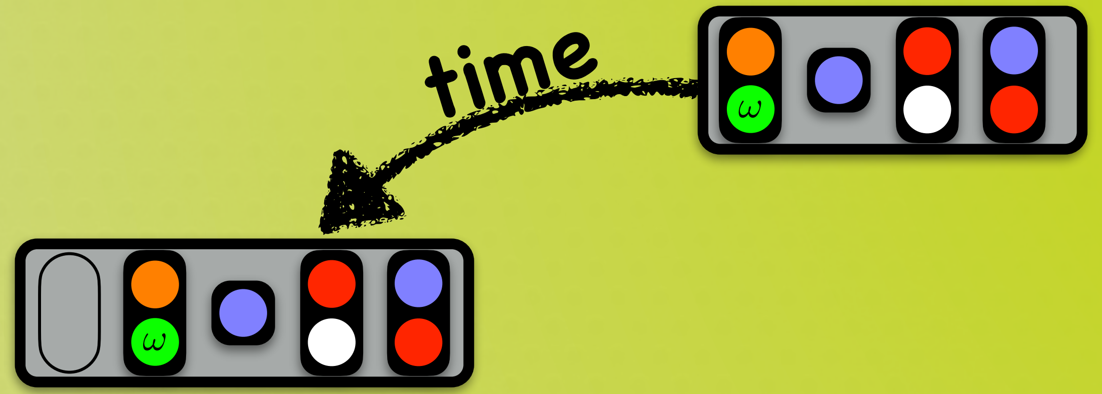
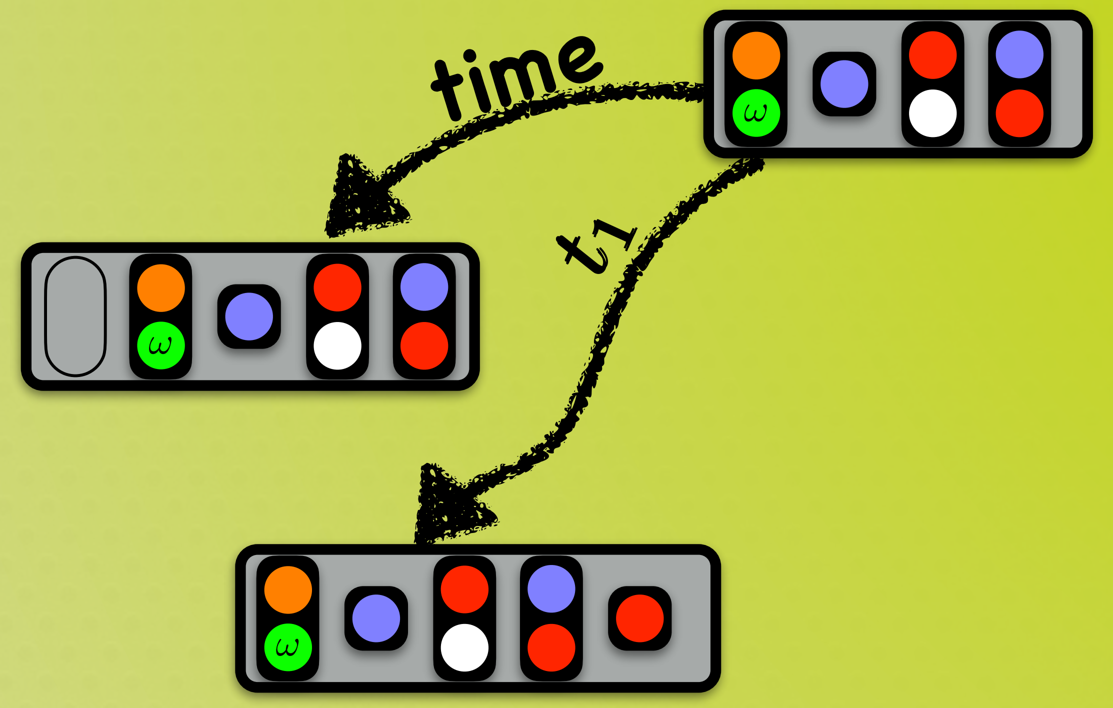
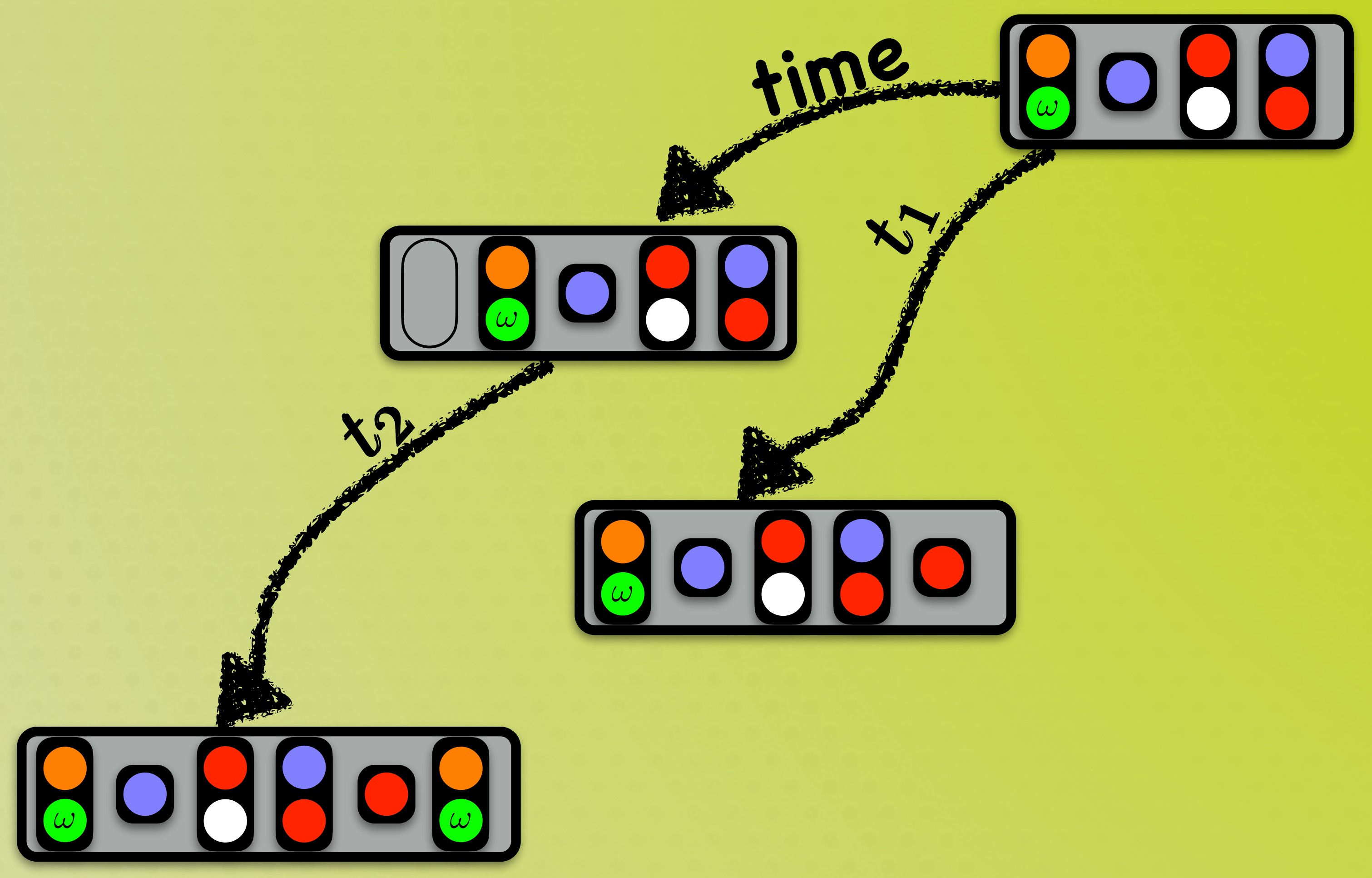


Timed

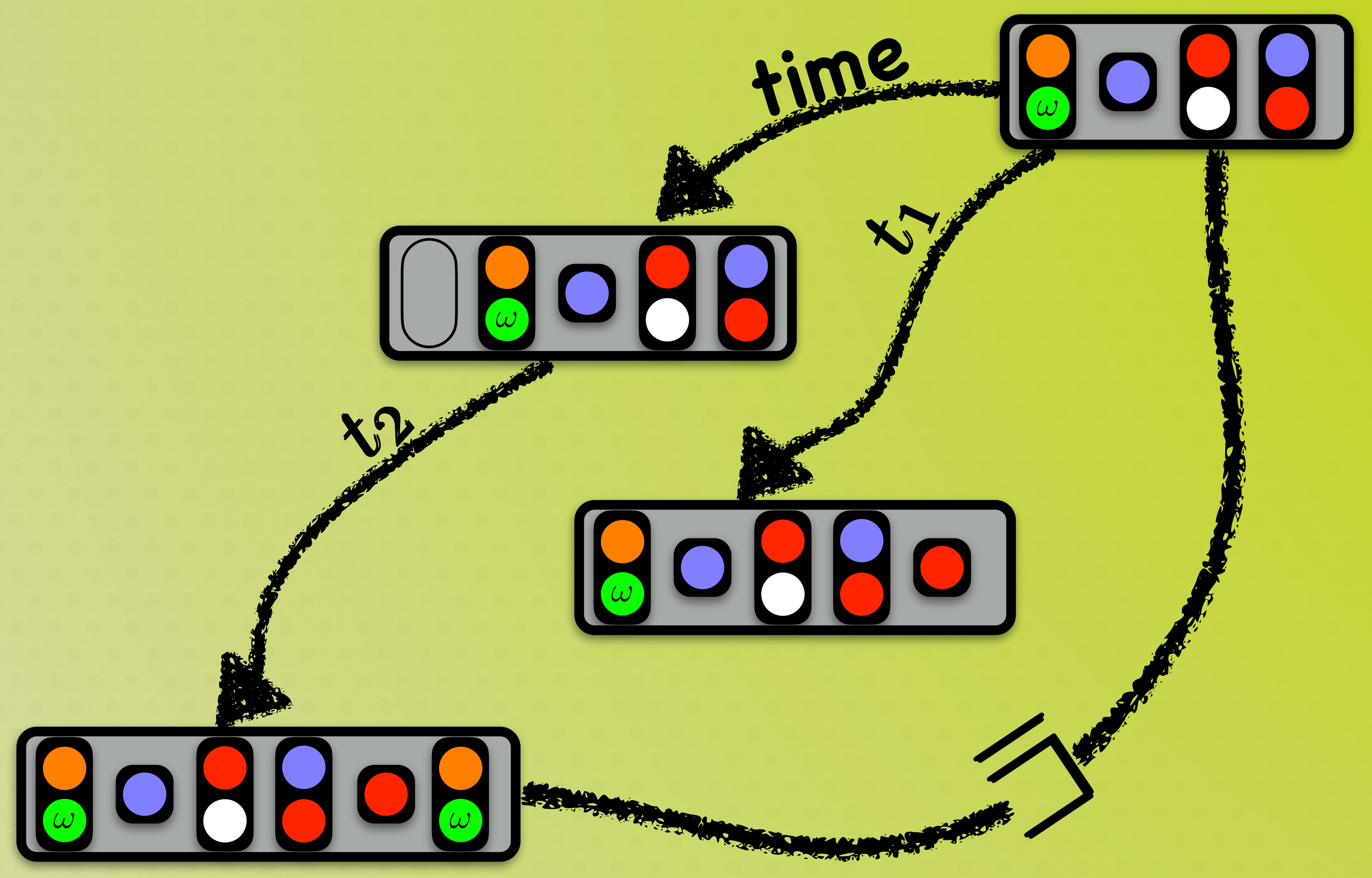
Backward Reachability



Timed … Backward Reachability

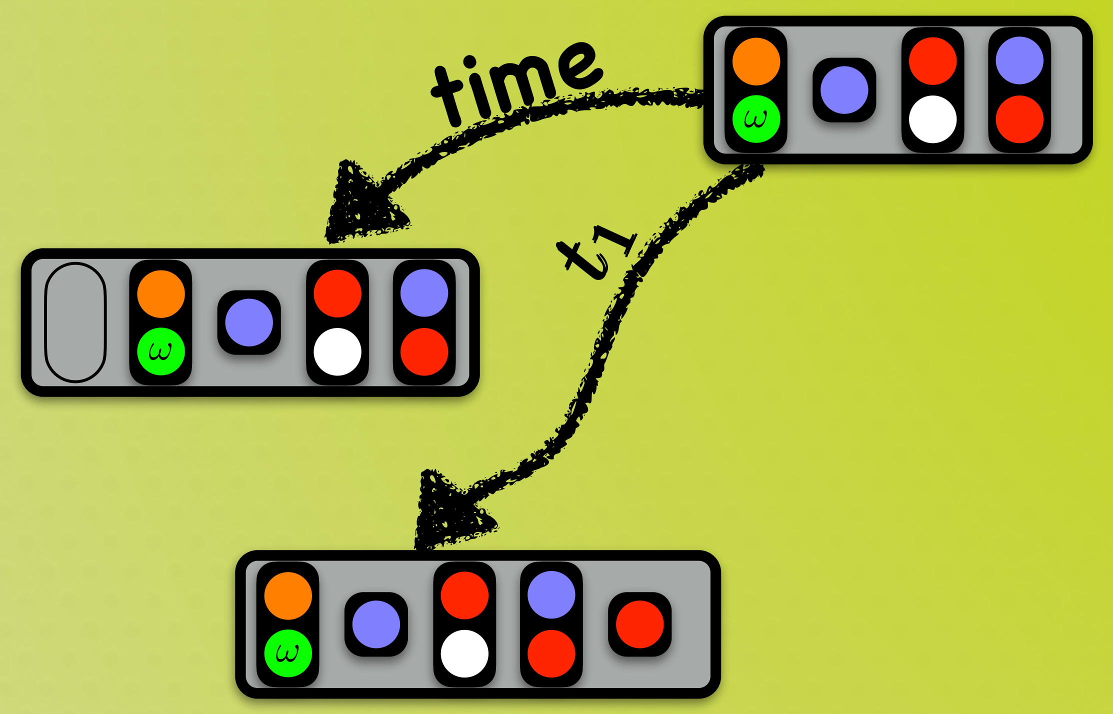


Backward Reachability



Timed

Backward Reachability



Timed

Backward Reachability

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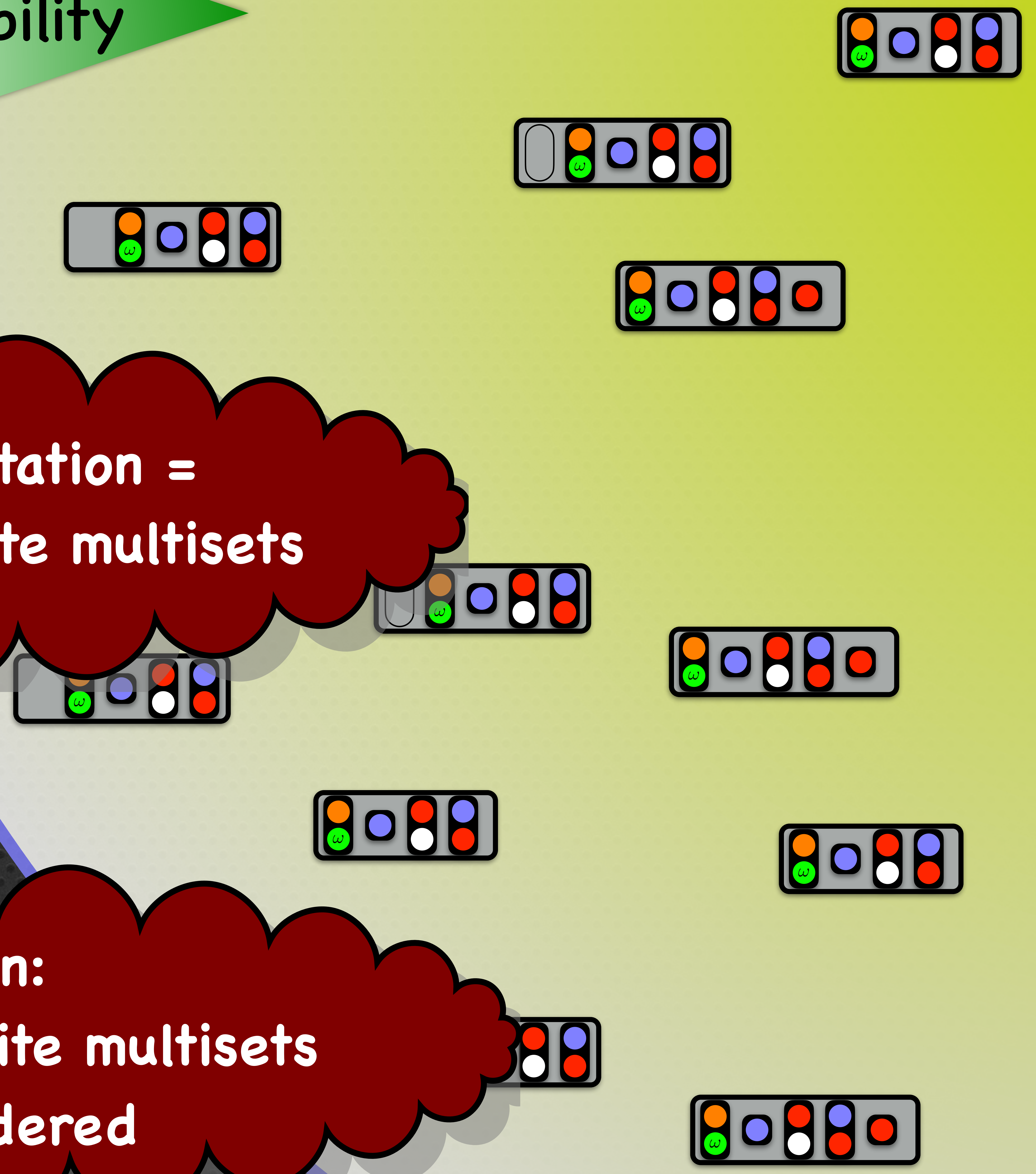
Backward Reachability



symbolic representation =
finite words over finite multisets

Termination:
finite words over finite multisets
well quasi-ordered