

Background

Parameterized Systems

Petri Nets

Lossy Channel Systems

Timed Petri Nets



# Lossy Channel Systems



# Lossy Channel Systems

Model

Configurations

Transitions

Ordering

Monotonicity

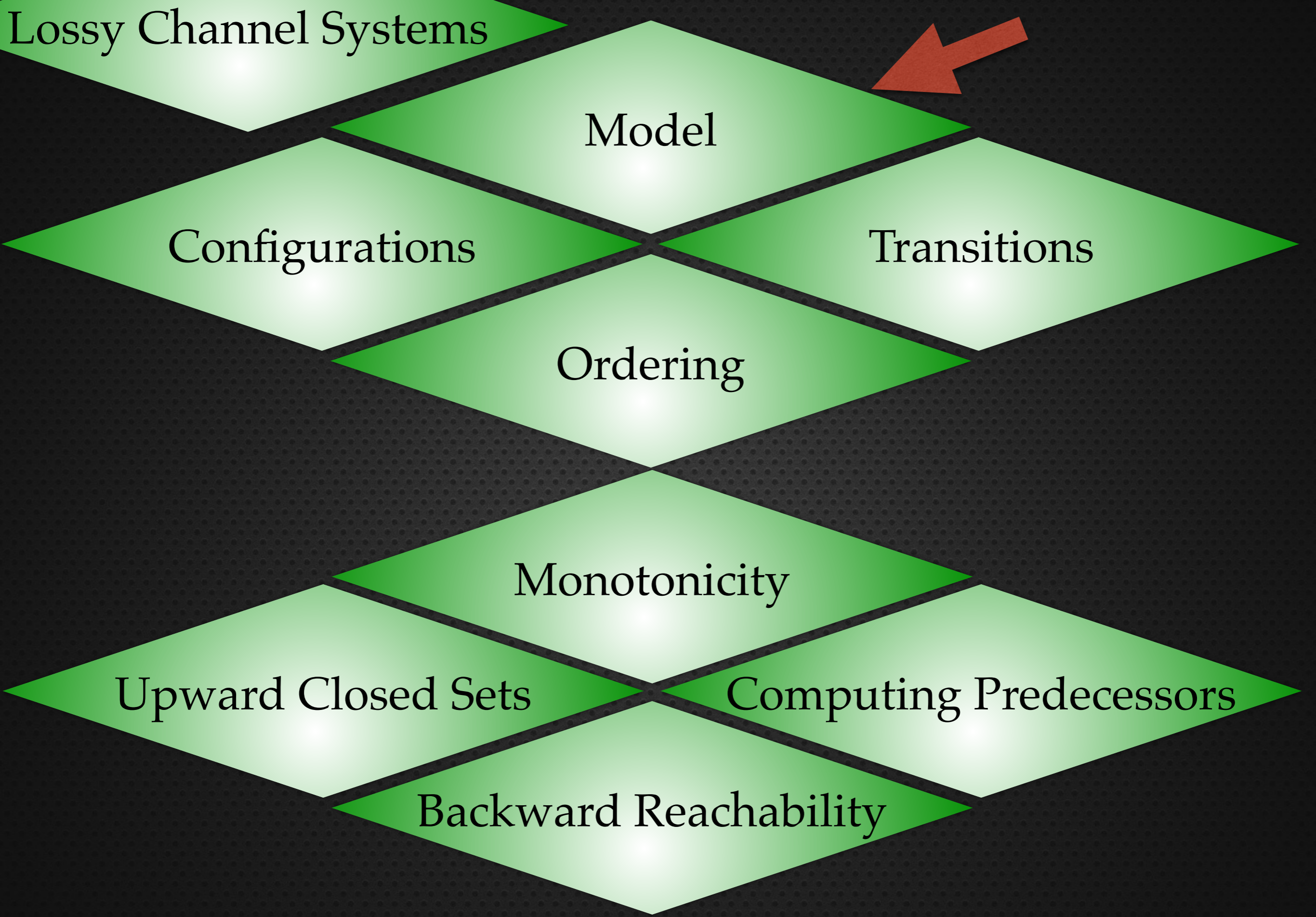
Upward Closed Sets

Computing Predecessors

Backward Reachability

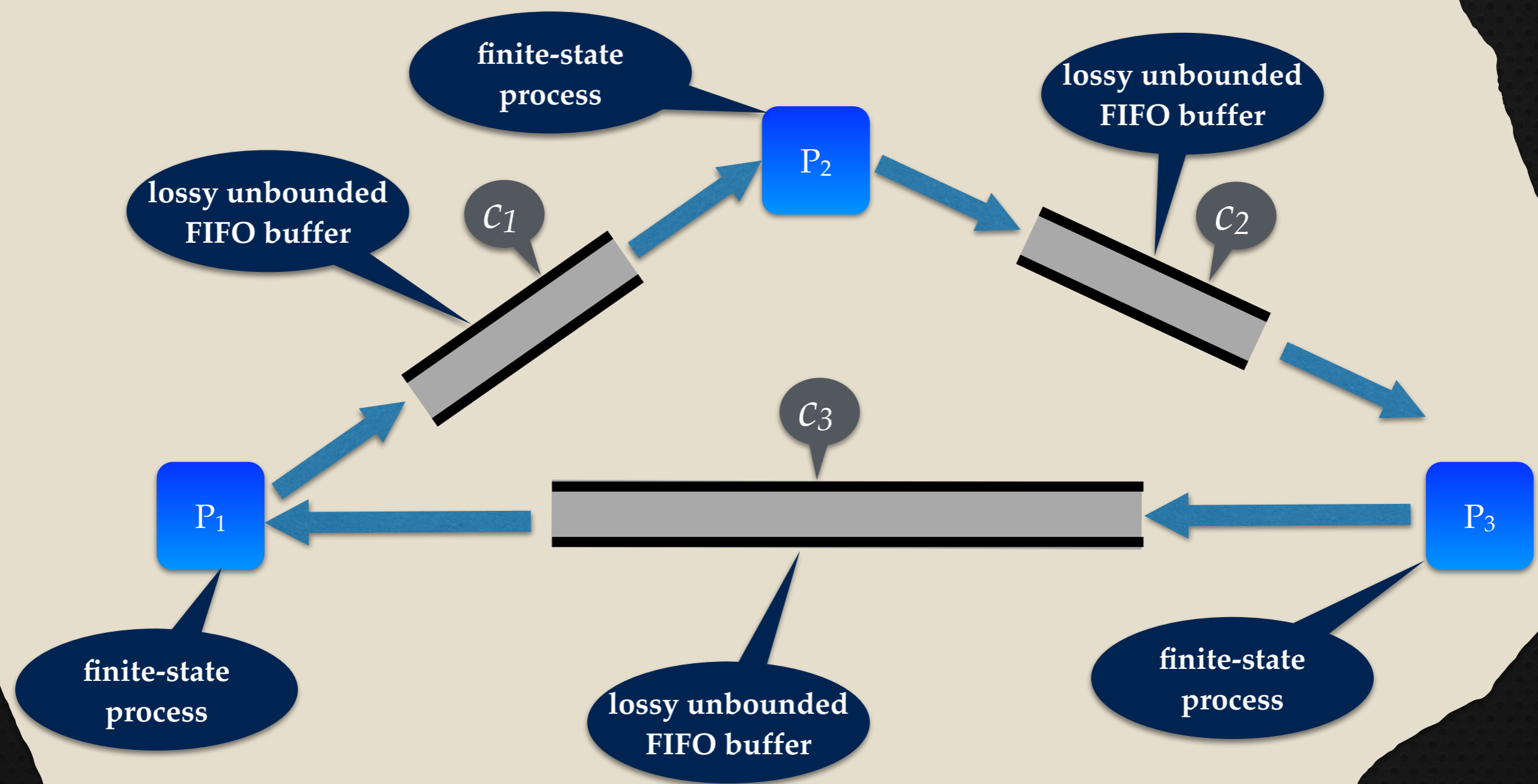


# Lossy Channel Systems



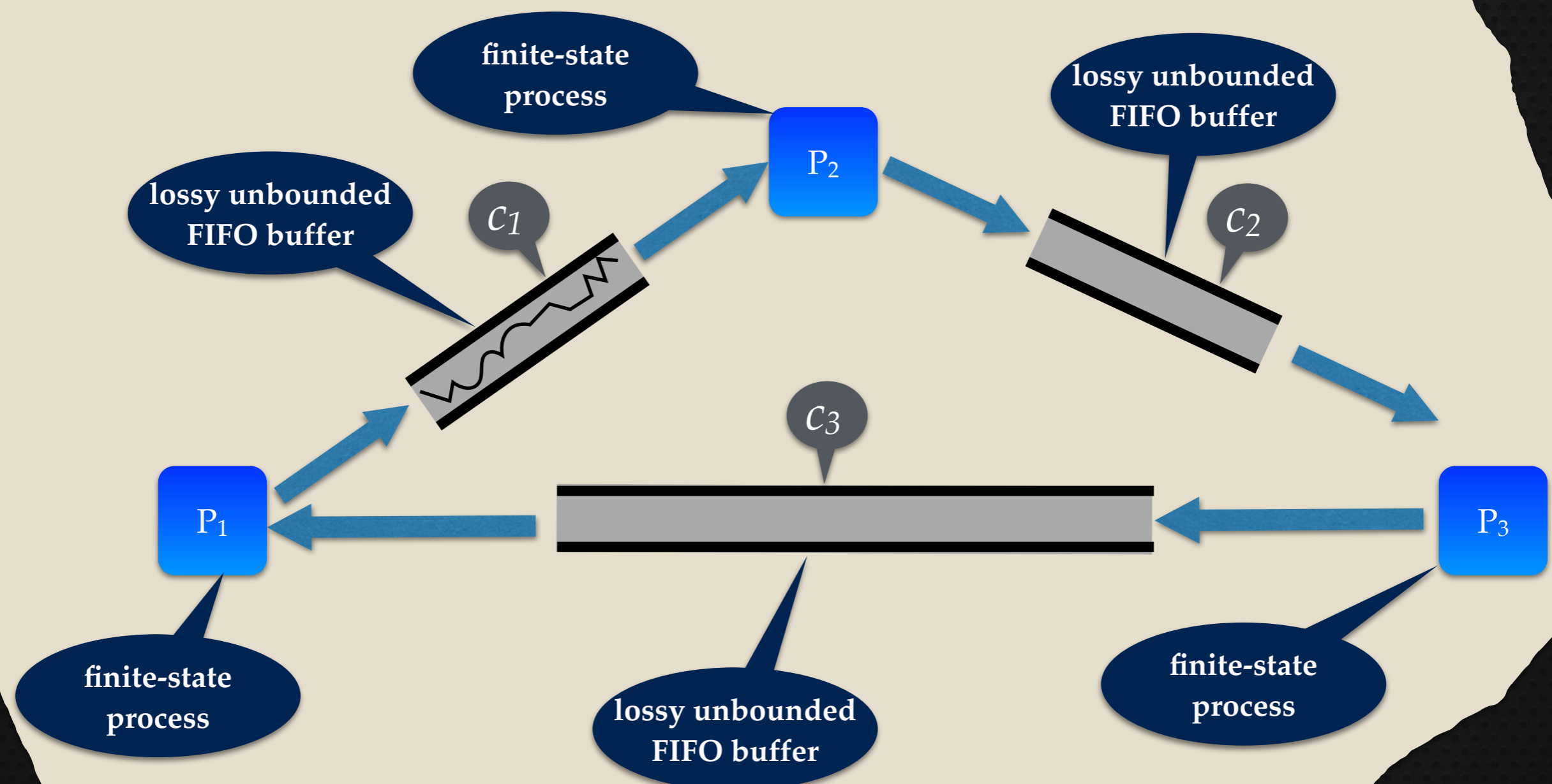


# Lossy Channel Model



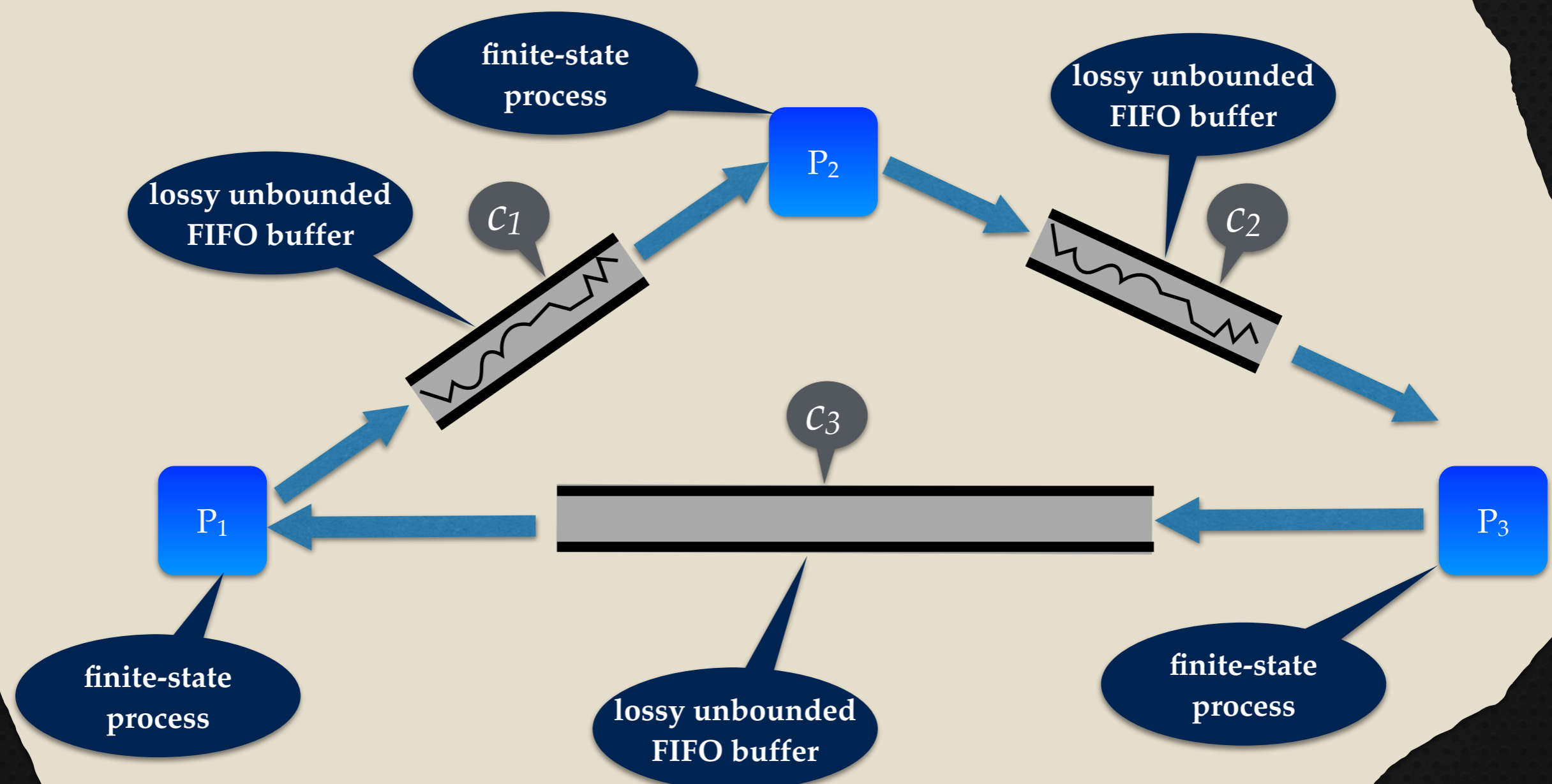


# Lossy Channel Model



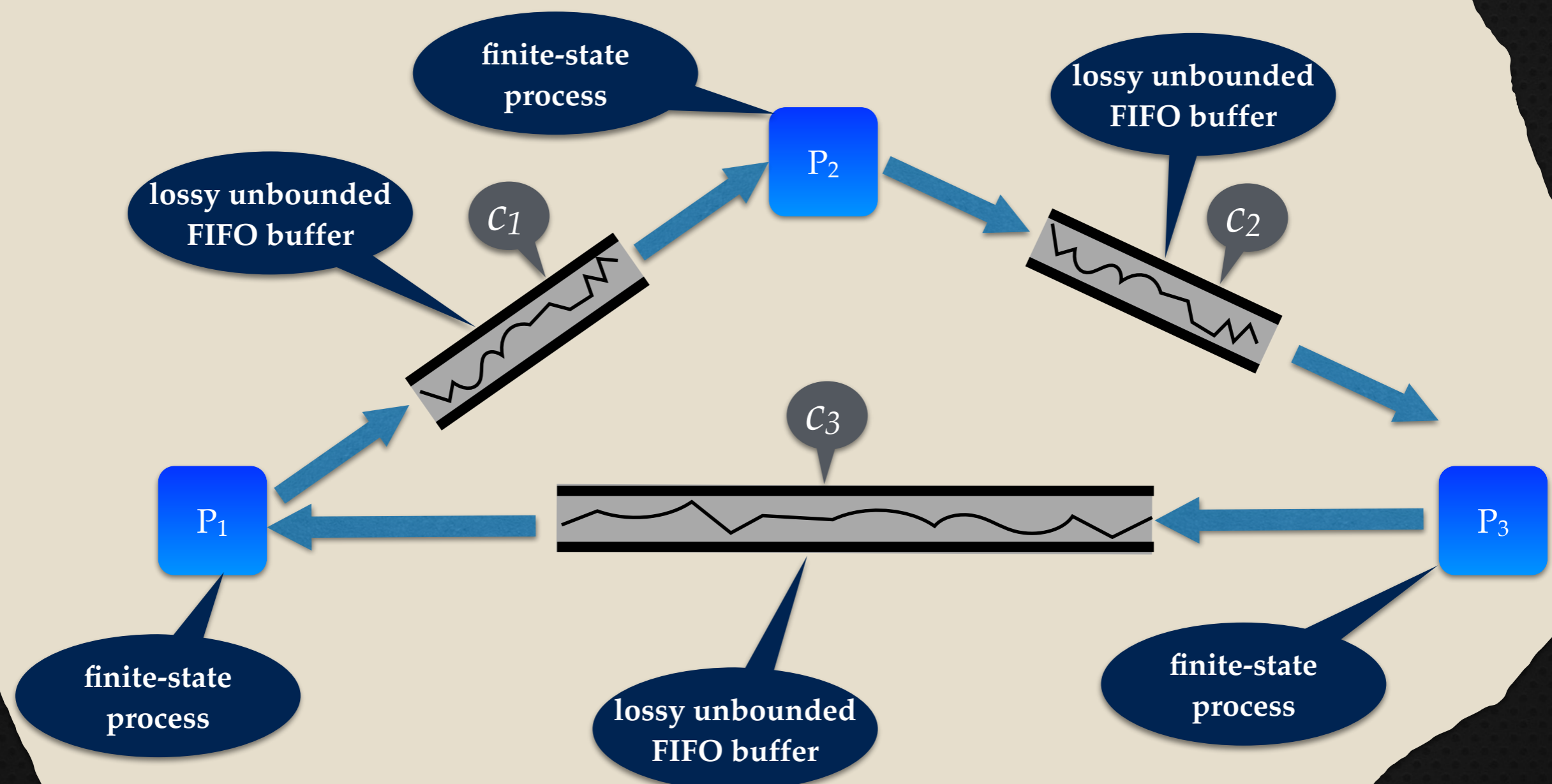


# Lossy Channel Model



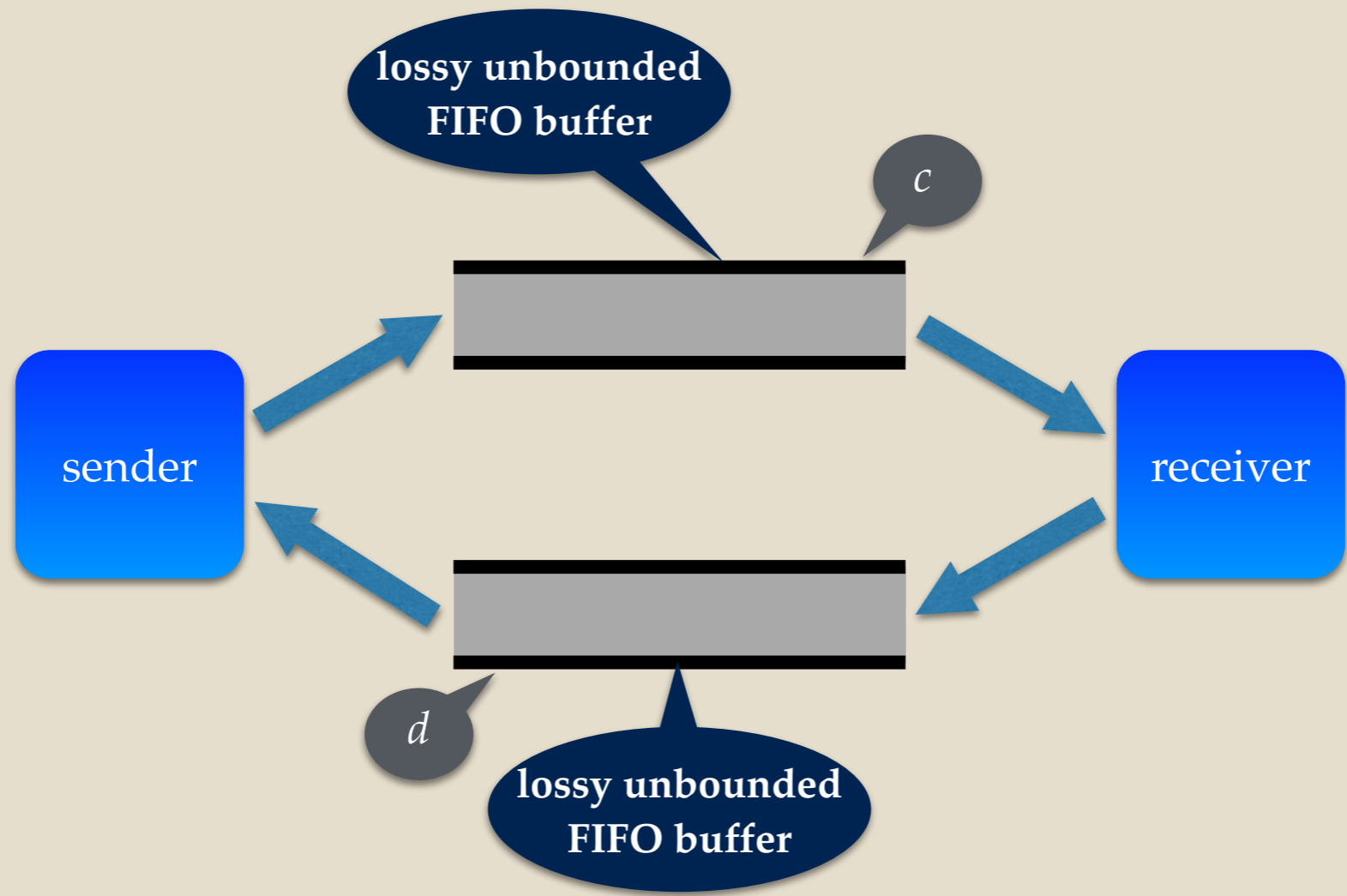


# Lossy Channel Model

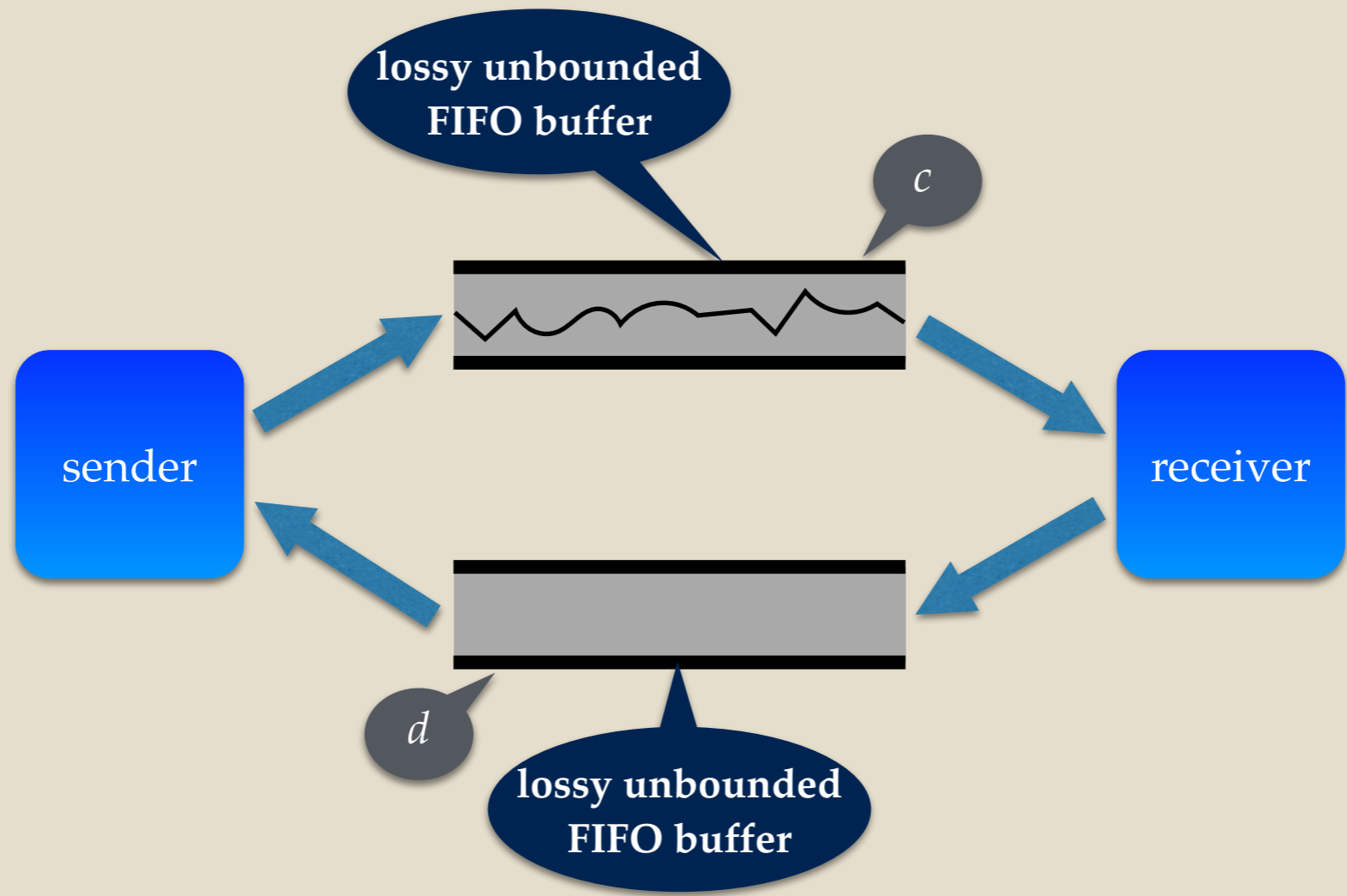




# Lossy Channel Model: Telecommunication Protocols

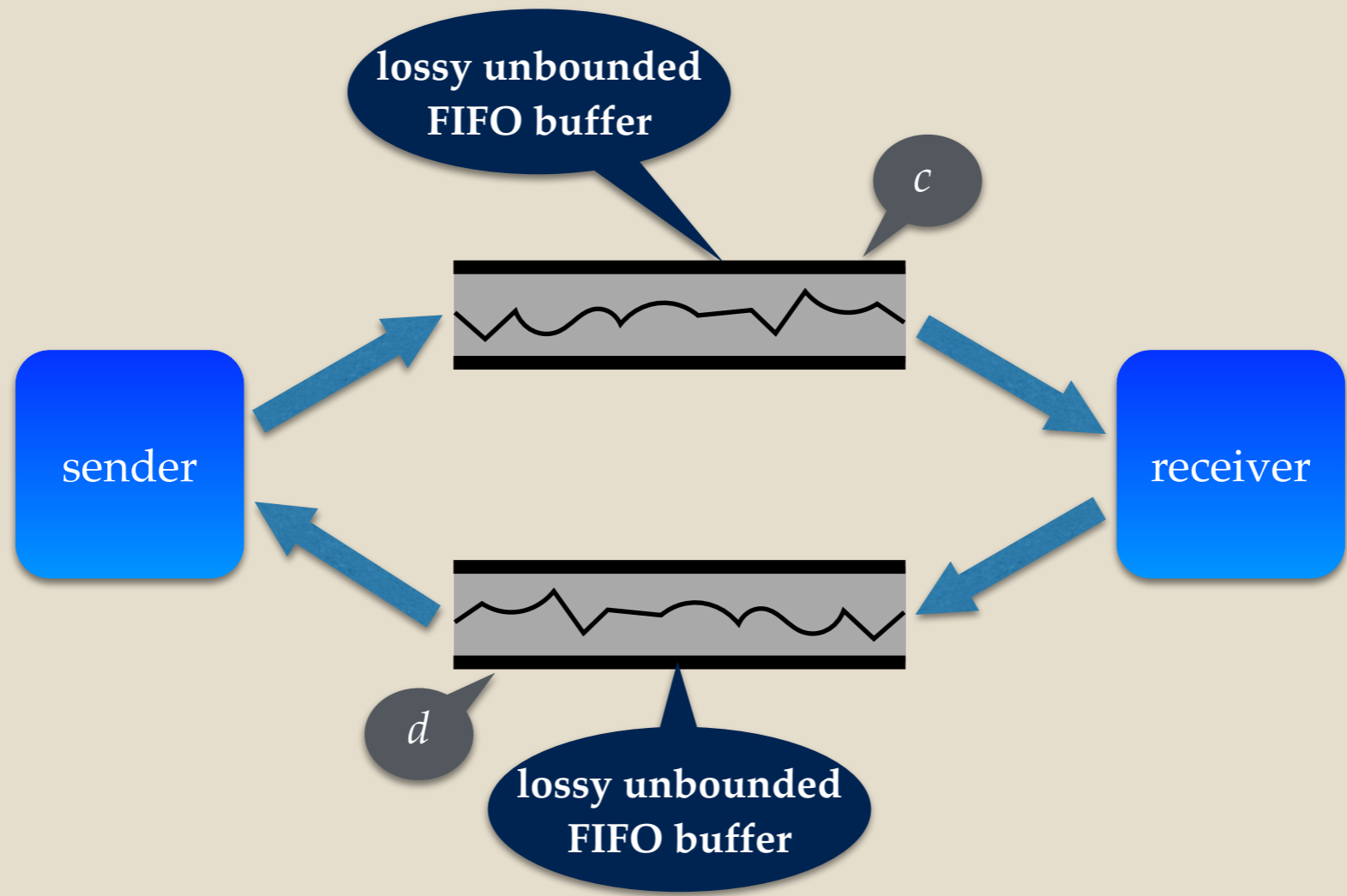


# Lossy Call Admission Control in Multirate Telecommunication Protocols





# Lossy Call Admission Control in Multirate Telecommunication Protocols



# Lossy Causal Memory Weak Memory Models

lossy unbounded FIFO buffer

Shared Memory

thread  
P<sub>1</sub>



lossy unbounded FIFO buffer

thread  
P<sub>2</sub>

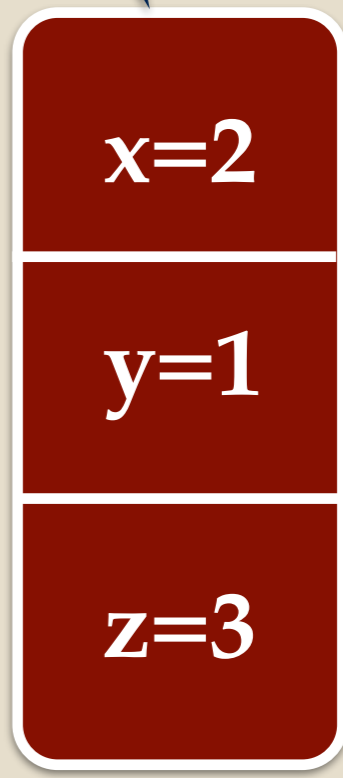


thread  
P<sub>3</sub>

thread



lossy unbounded FIFO buffer





# Lossy Cache Coherence Weak Memory Models

## Weak Memory Models

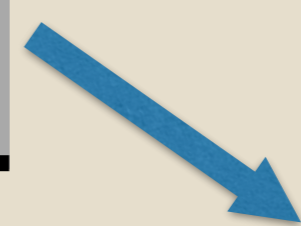
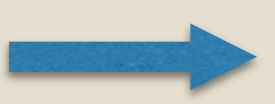
intel  
x86

lossy unbounded  
FIFO buffer

Shared Memory

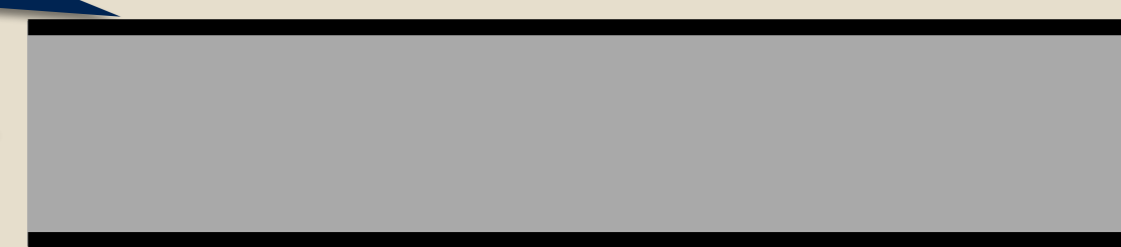
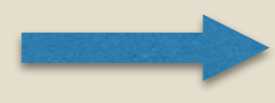
thread

P<sub>1</sub>



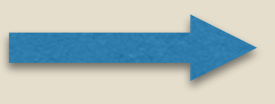
lossy unbounded  
FIFO buffer

P<sub>2</sub>



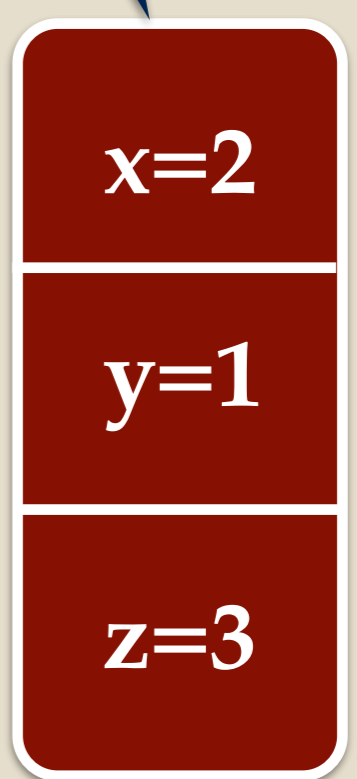
thread

P<sub>3</sub>



thread

lossy unbounded  
FIFO buffer



# Lossy CMM Weak Memory Models

## Weak Memory Models

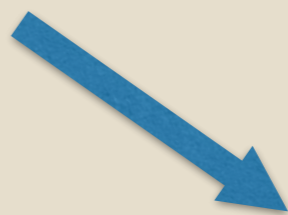
intel  
x86

lossy unbounded  
FIFO buffer

Shared Memory

thread

P<sub>1</sub>



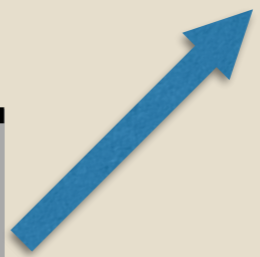
lossy unbounded  
FIFO buffer

P<sub>2</sub>



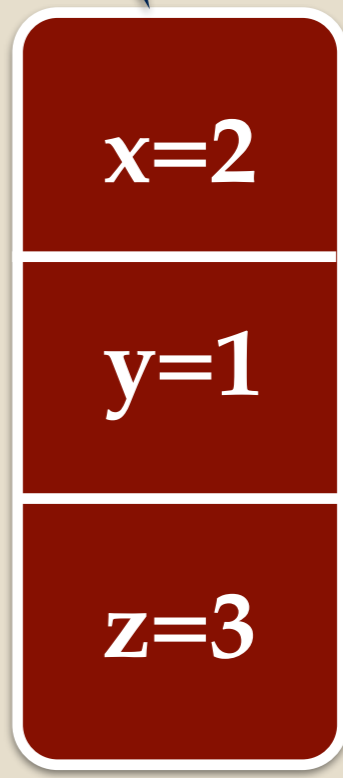
thread

P<sub>3</sub>



thread

lossy unbounded  
FIFO buffer





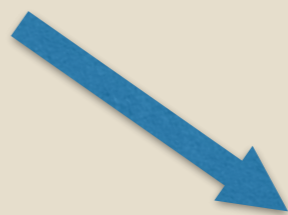
# Lossy Causal Memory Weak Memory Models

lossy unbounded FIFO buffer

Shared Memory

thread

P<sub>1</sub>



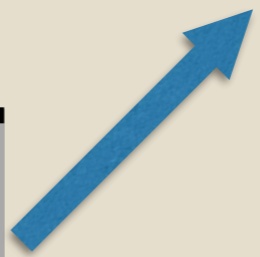
lossy unbounded FIFO buffer

P<sub>2</sub>



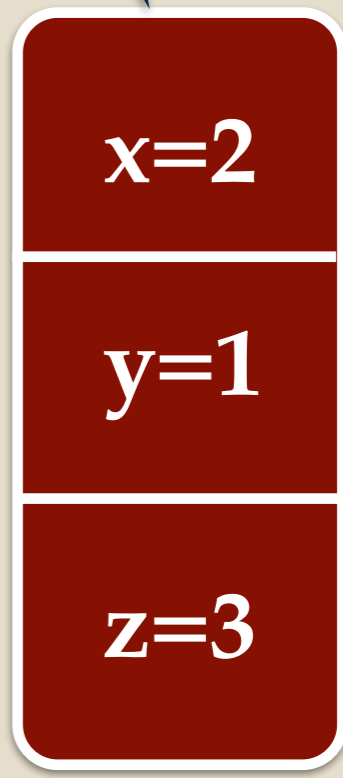
thread

P<sub>3</sub>



thread

lossy unbounded FIFO buffer



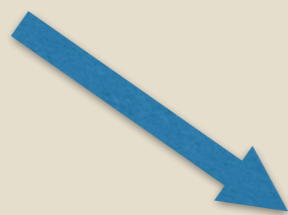
# Lossy Causal Memory Weak Memory Models

lossy unbounded FIFO buffer

Shared Memory

thread

P<sub>1</sub>



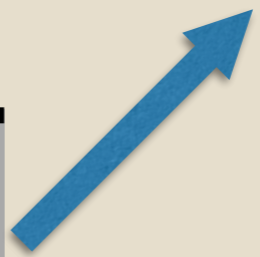
lossy unbounded FIFO buffer

P<sub>2</sub>



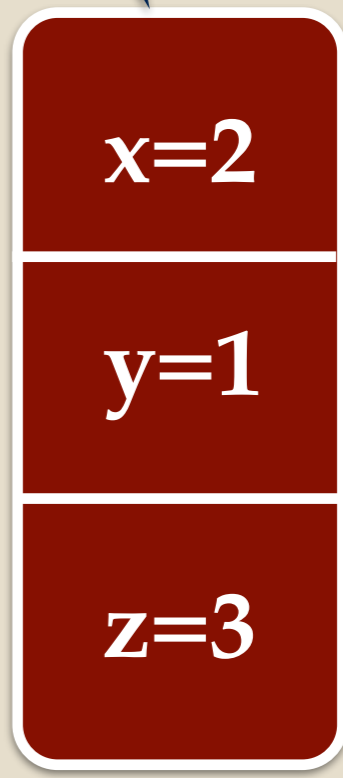
thread

P<sub>3</sub>



thread

lossy unbounded FIFO buffer



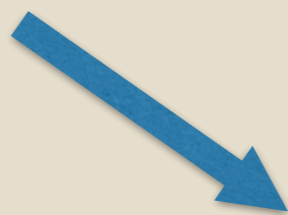


# Lossy Causal Memory Weak Memory Models

lossy unbounded  
FIFO buffer

Shared Memory

thread  
P<sub>1</sub>



lossy unbounded  
FIFO buffer

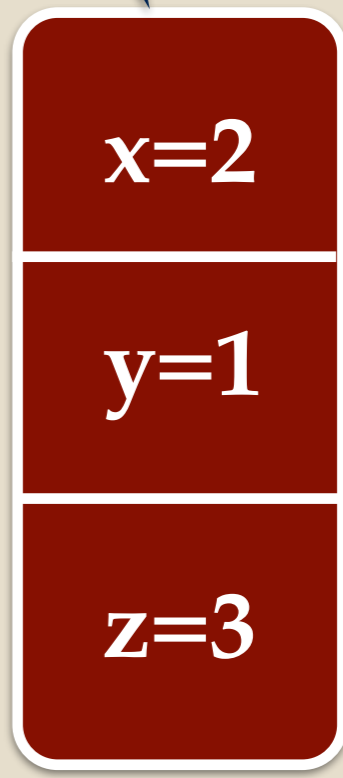
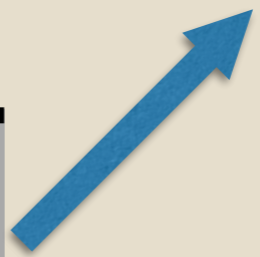
thread  
P<sub>2</sub>



thread  
P<sub>3</sub>

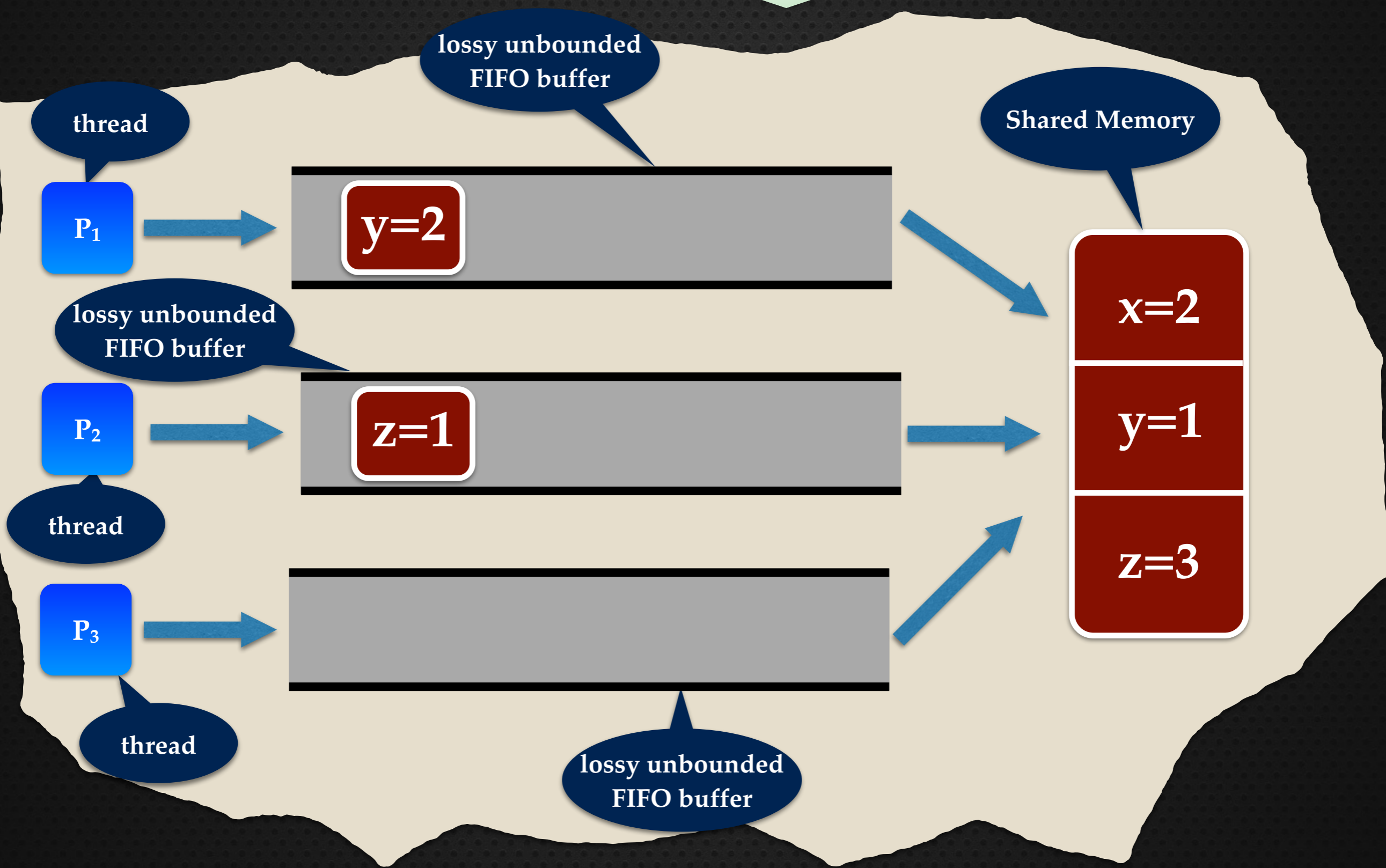


lossy unbounded  
FIFO buffer



# Lossy CMM Weak Memory Models

## Weak Memory Models





# Lossy Causal Memory Weak Memory Models

lossy unbounded  
FIFO buffer

Shared Memory

thread  
P<sub>1</sub>



lossy unbounded  
FIFO buffer

thread  
P<sub>2</sub>

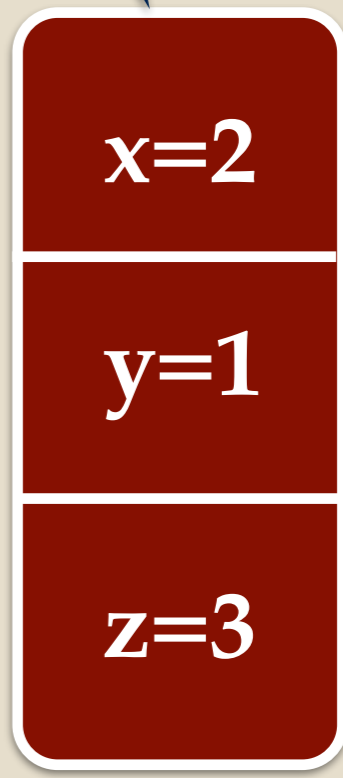


thread  
P<sub>3</sub>

thread  
P<sub>3</sub>



lossy unbounded  
FIFO buffer



# Lossy Causal Memory Weak Memory Models

lossy unbounded FIFO buffer

Shared Memory

thread  
P<sub>1</sub>



lossy unbounded FIFO buffer

thread  
P<sub>2</sub>

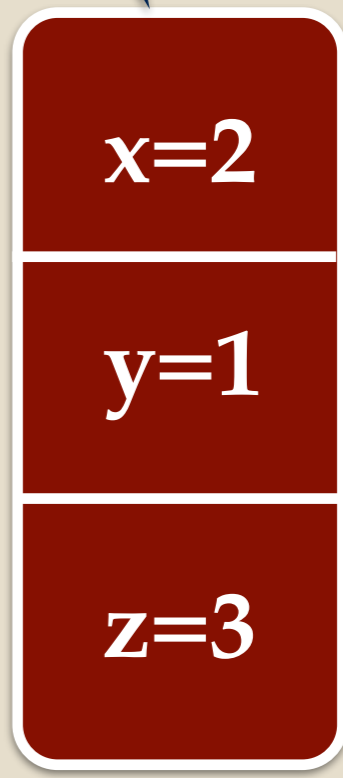


thread  
P<sub>3</sub>



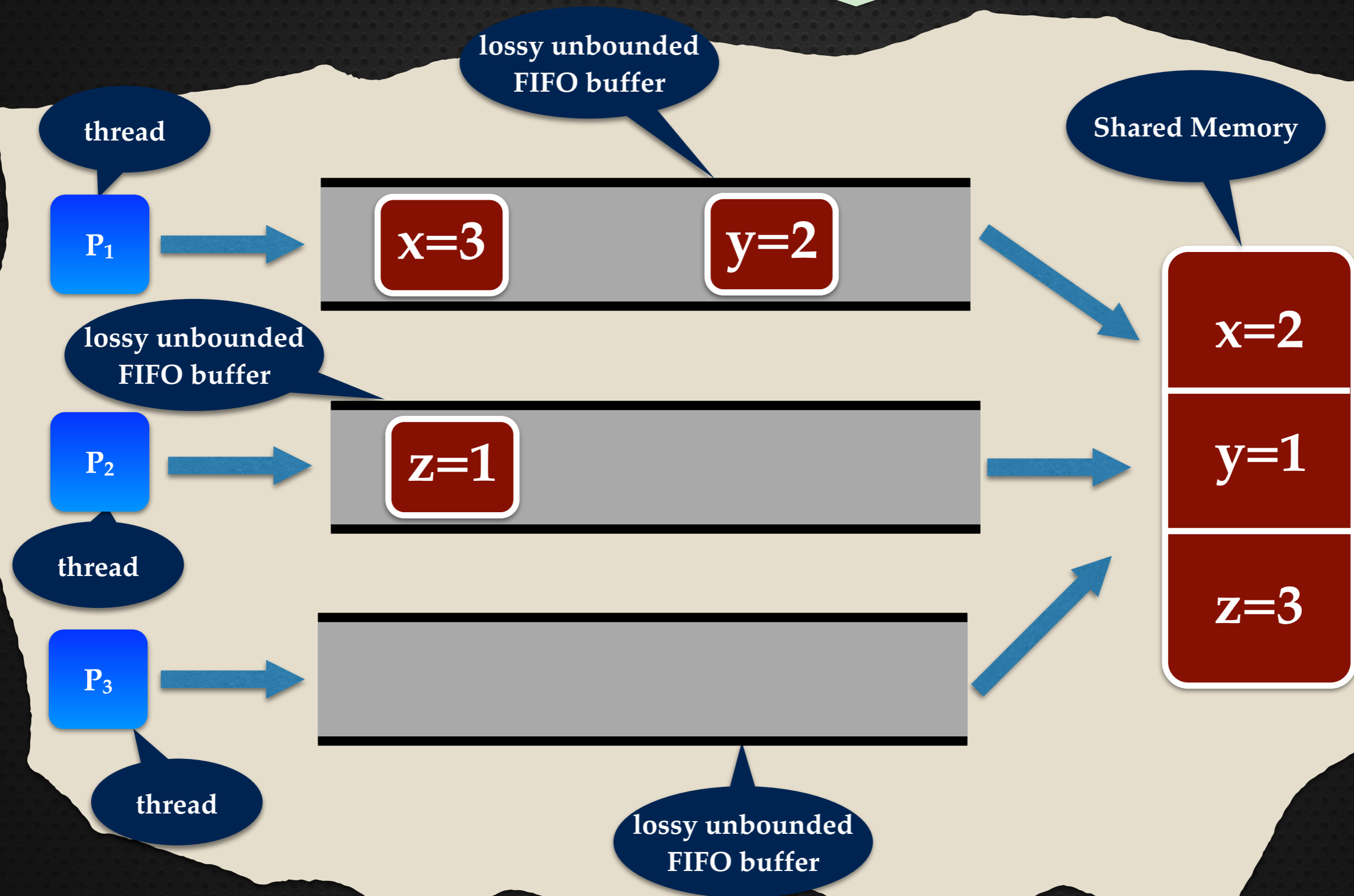
thread

lossy unbounded FIFO buffer





# Lossy Causal Memory Weak Memory Models

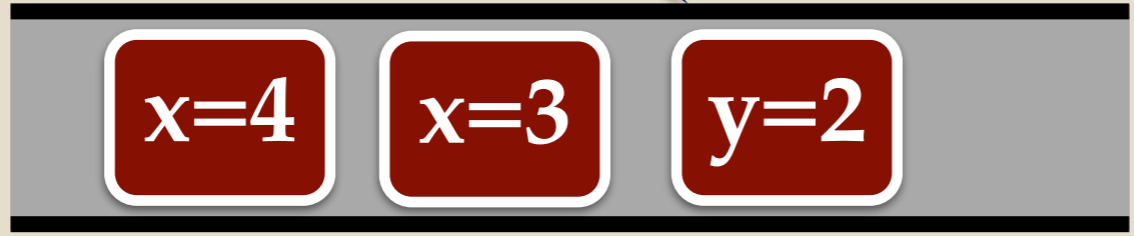


# Lossy Causal Memory Weak Memory Models

lossy unbounded FIFO buffer

Shared Memory

thread  
P<sub>1</sub>



lossy unbounded FIFO buffer

thread  
P<sub>2</sub>



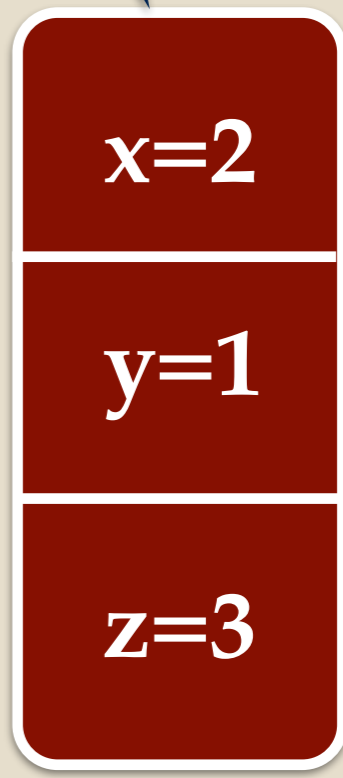
thread

thread  
P<sub>3</sub>



thread

lossy unbounded FIFO buffer



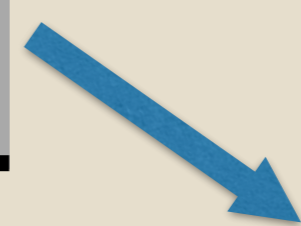
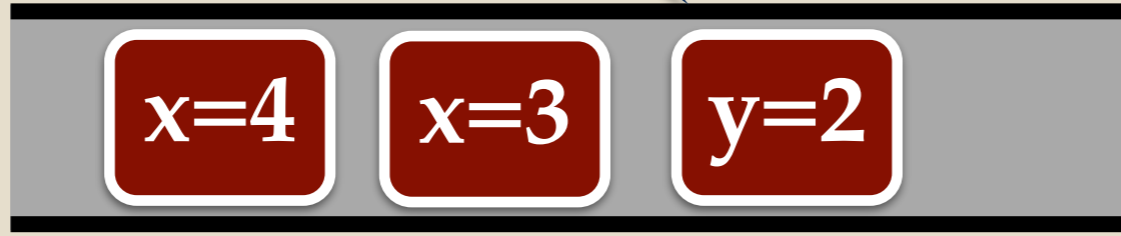


lossy unbounded  
FIFO buffer

Shared Memory

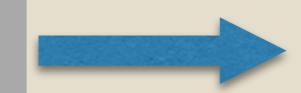
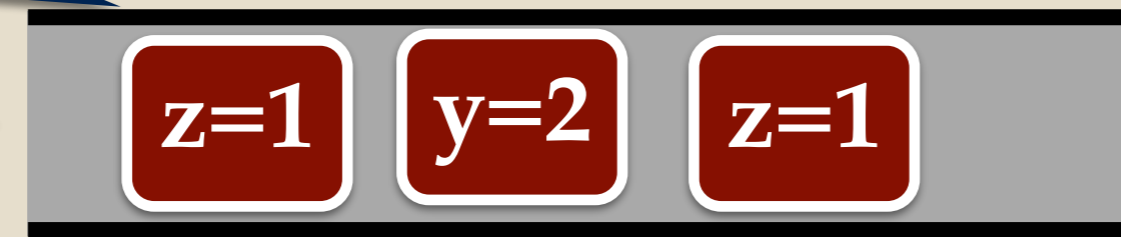
thread

P<sub>1</sub>



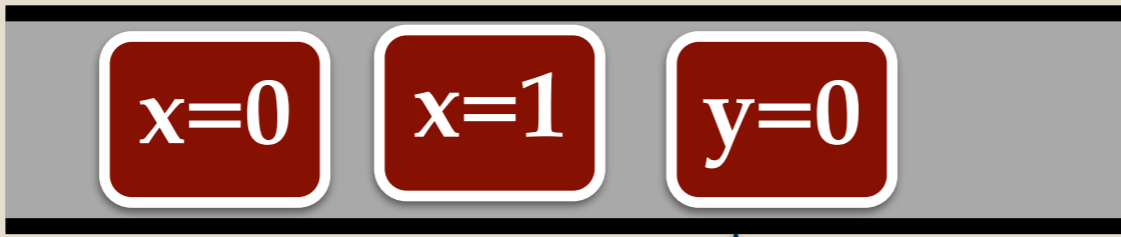
lossy unbounded  
FIFO buffer

P<sub>2</sub>



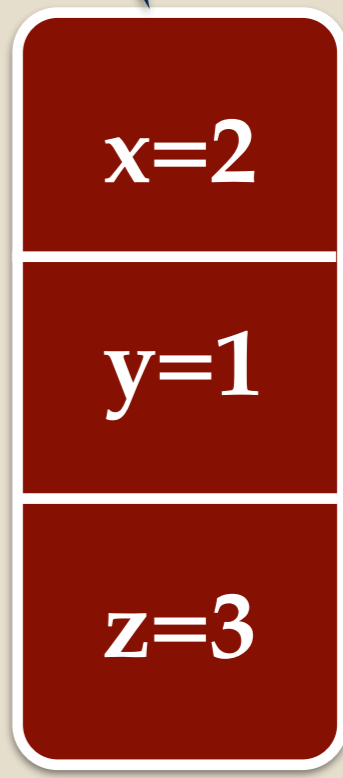
thread

P<sub>3</sub>



thread

lossy unbounded  
FIFO buffer

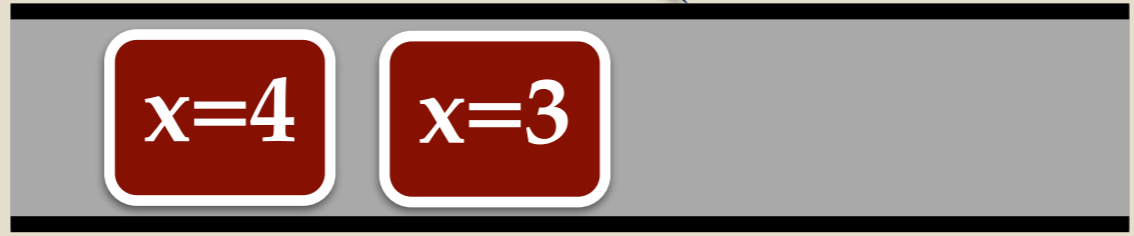


# Lossy Causal Memory Weak Memory Models

lossy unbounded FIFO buffer

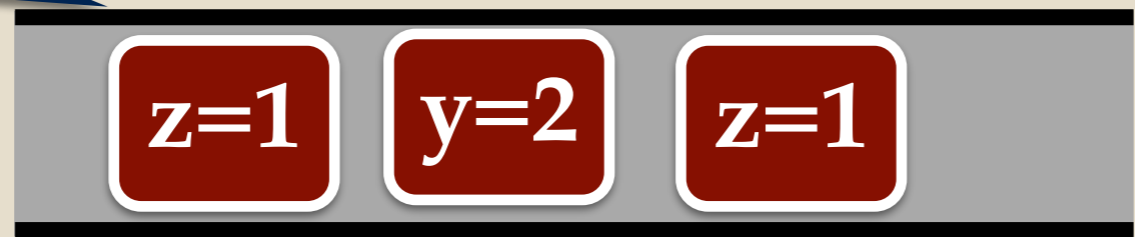
Shared Memory

thread  
P<sub>1</sub>



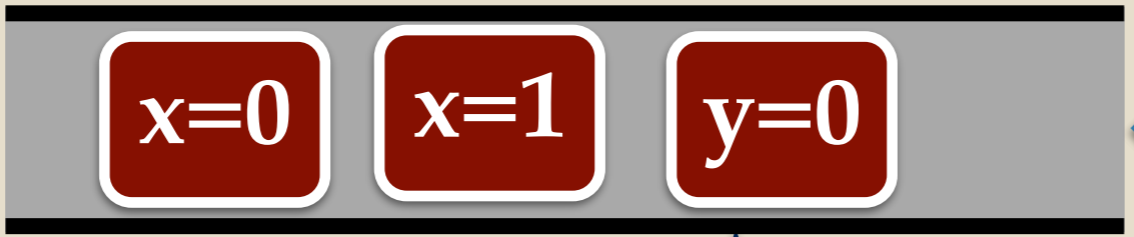
lossy unbounded FIFO buffer

thread  
P<sub>2</sub>

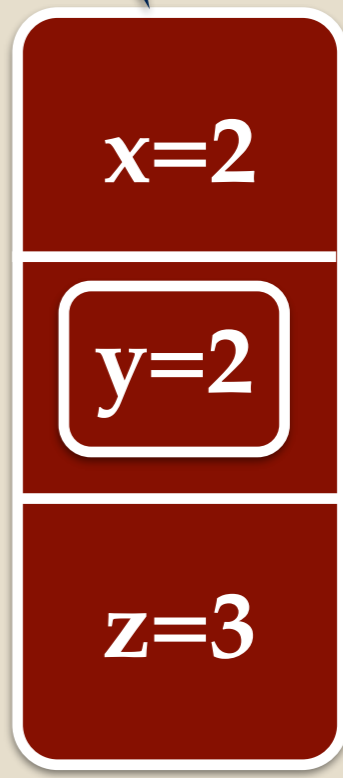


thread  
P<sub>3</sub>

thread  
P<sub>3</sub>



lossy unbounded FIFO buffer



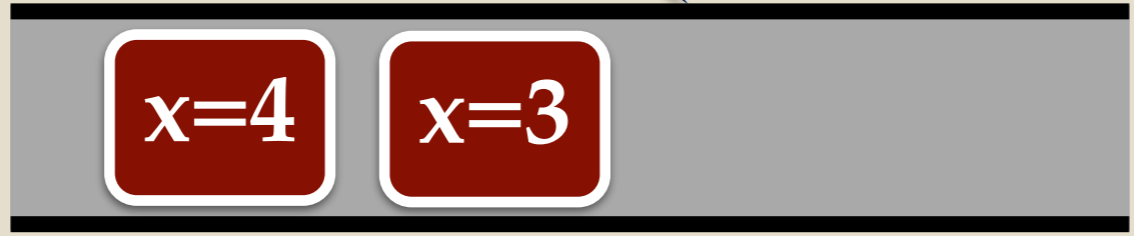


# Lossy Causal Memory Weak Memory Models

lossy unbounded FIFO buffer

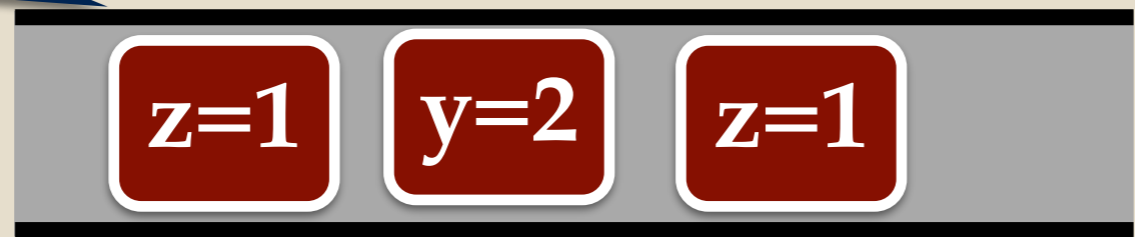
Shared Memory

thread  
P<sub>1</sub>



lossy unbounded FIFO buffer

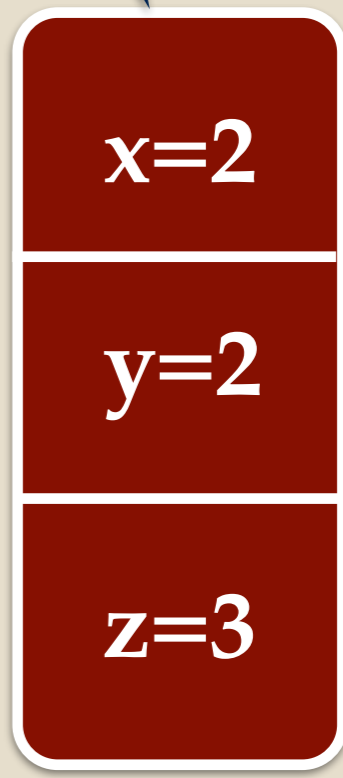
thread  
P<sub>2</sub>



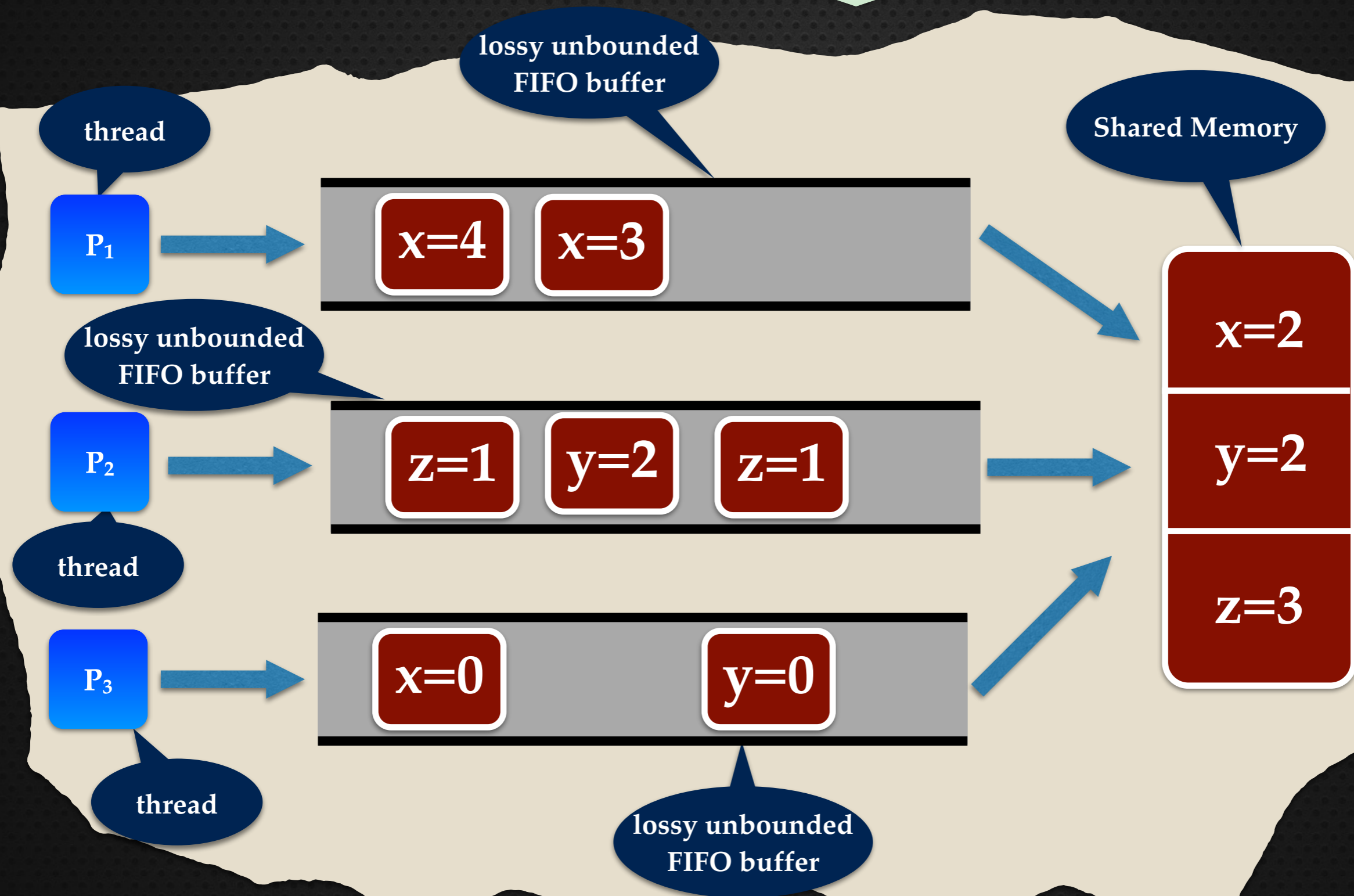
thread  
P<sub>3</sub>



lossy unbounded FIFO buffer

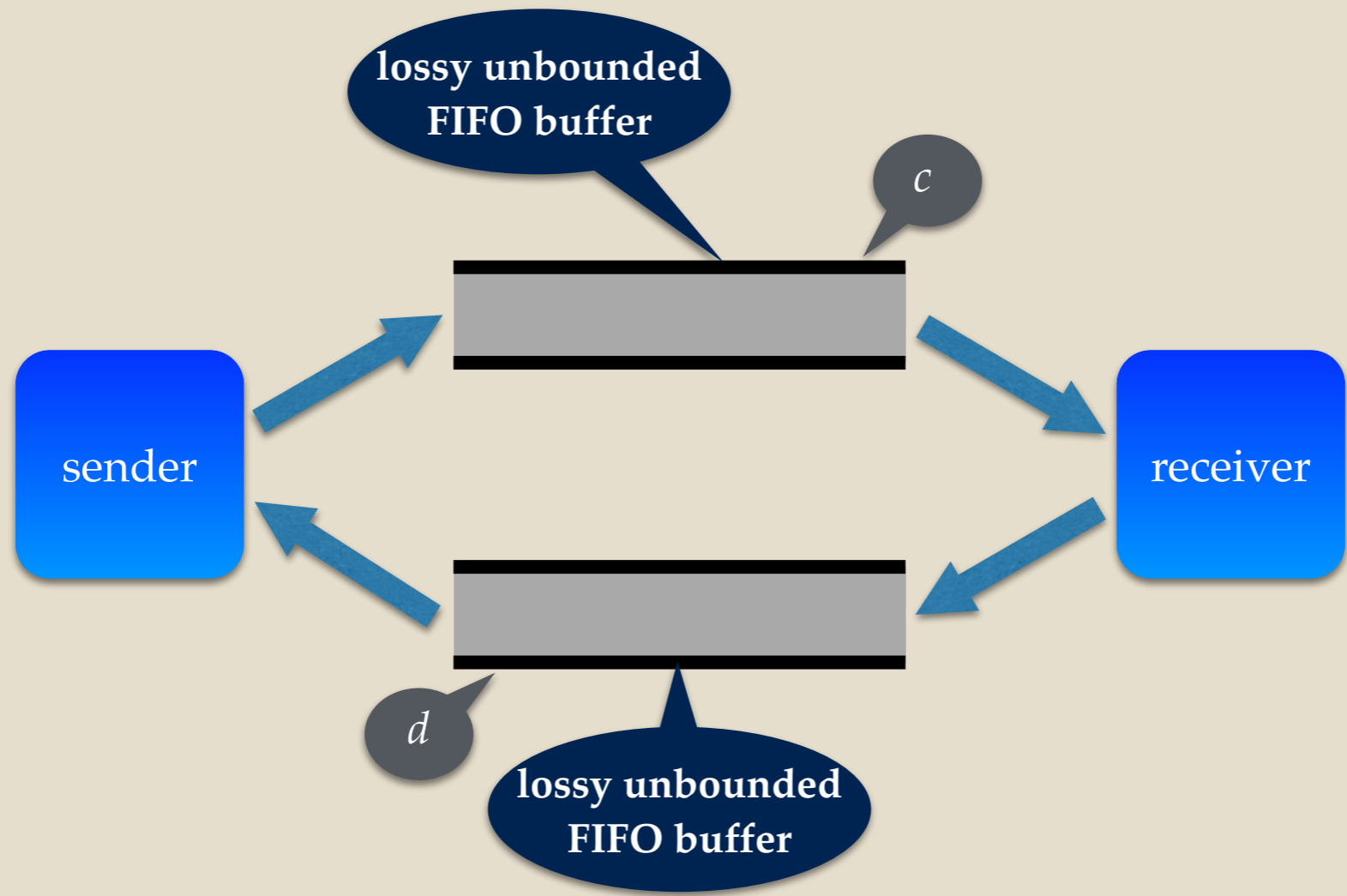


# Lossy Causal Memory Weak Memory Models

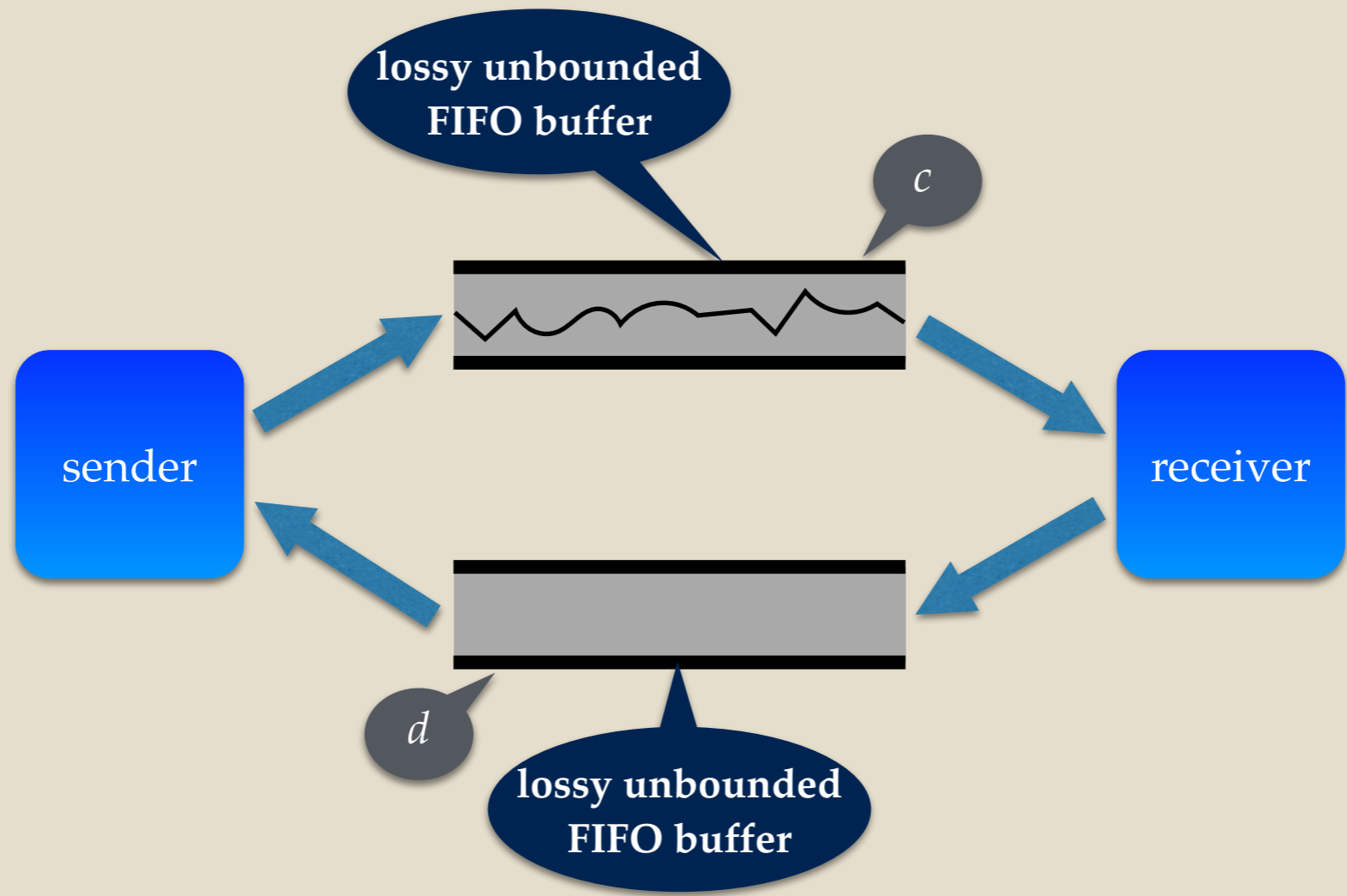




# Lossy Call Multiplexing Telecommunication Protocol

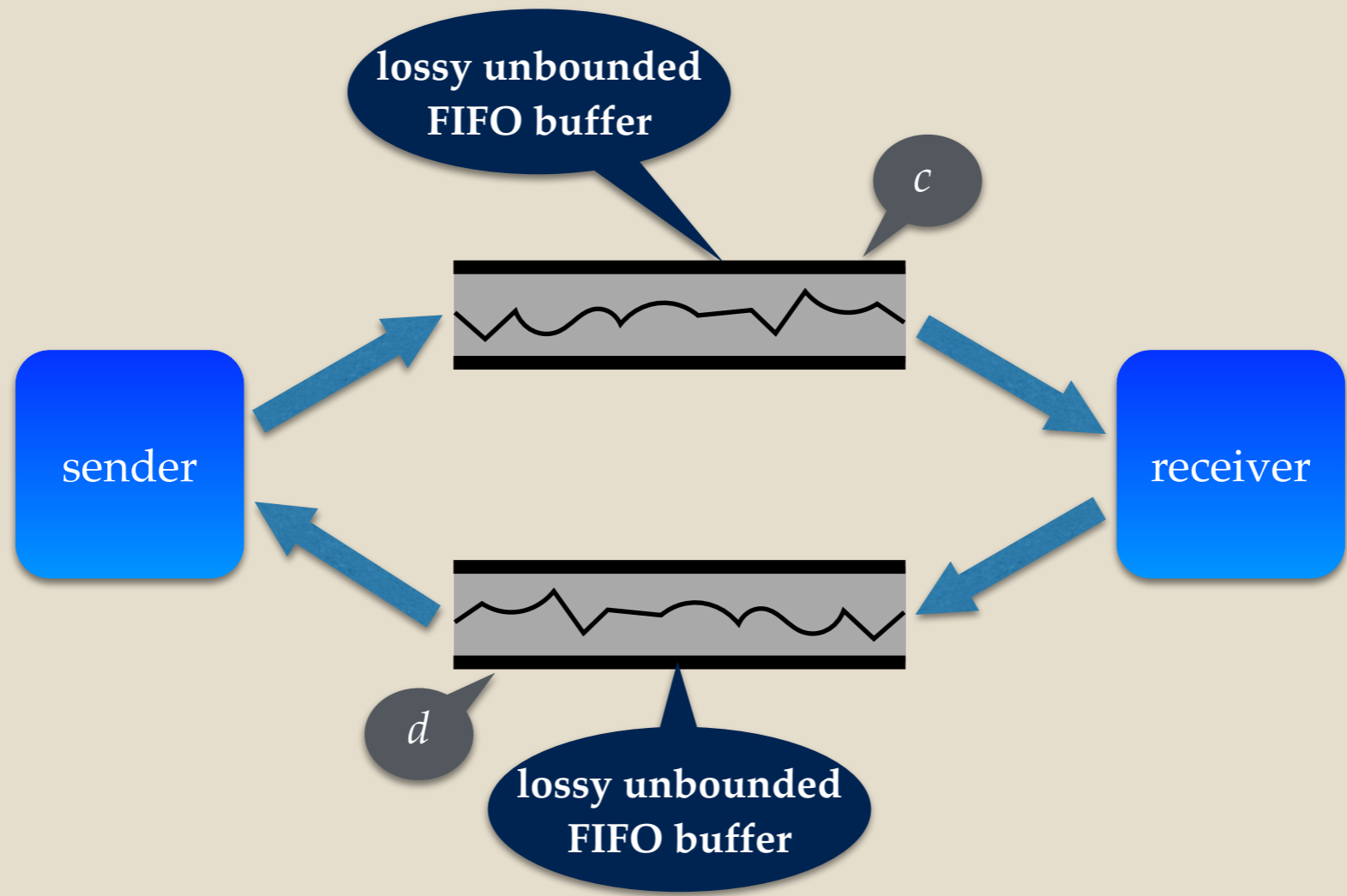


# Lossy Call Admission Control in Multirate Telecommunication Protocol

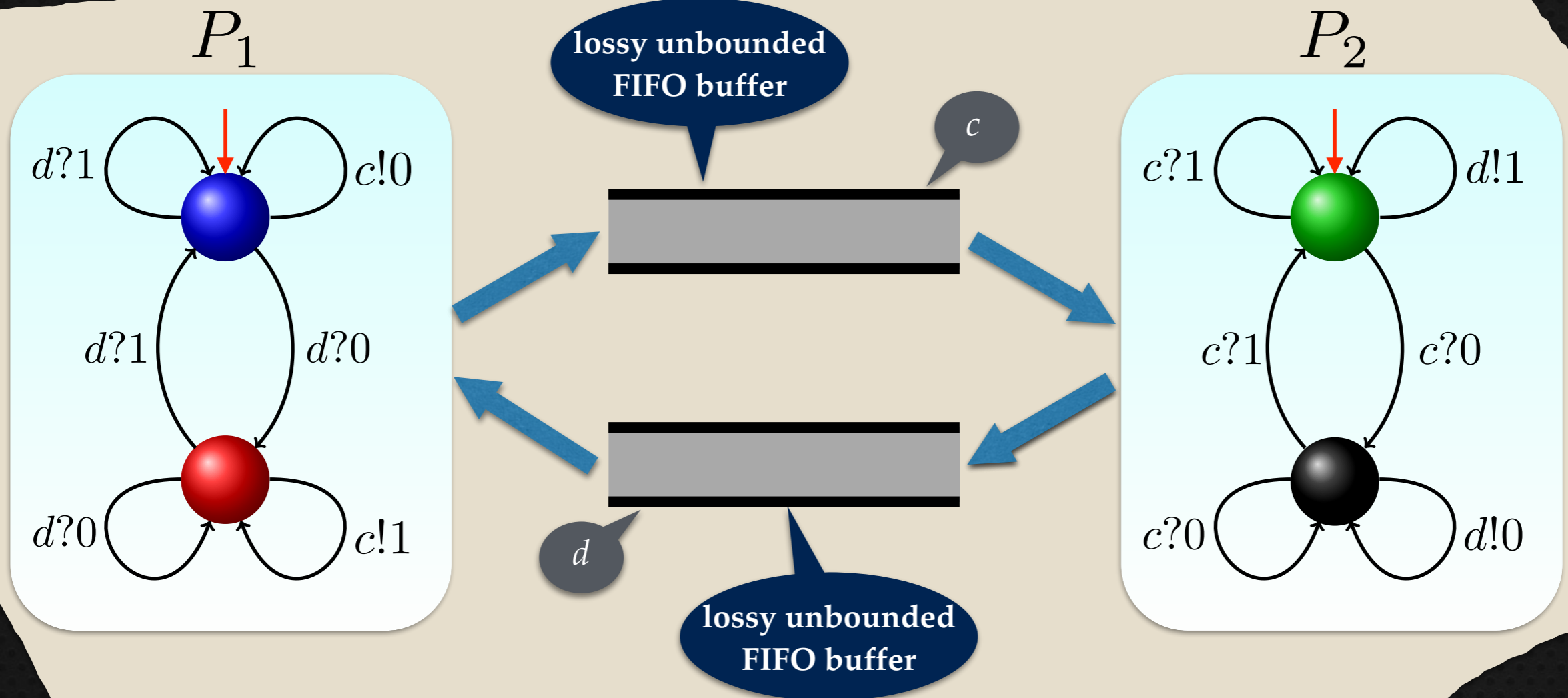




# Lossy Call Admission Control in a Multi-Service Telecommunication Protocol

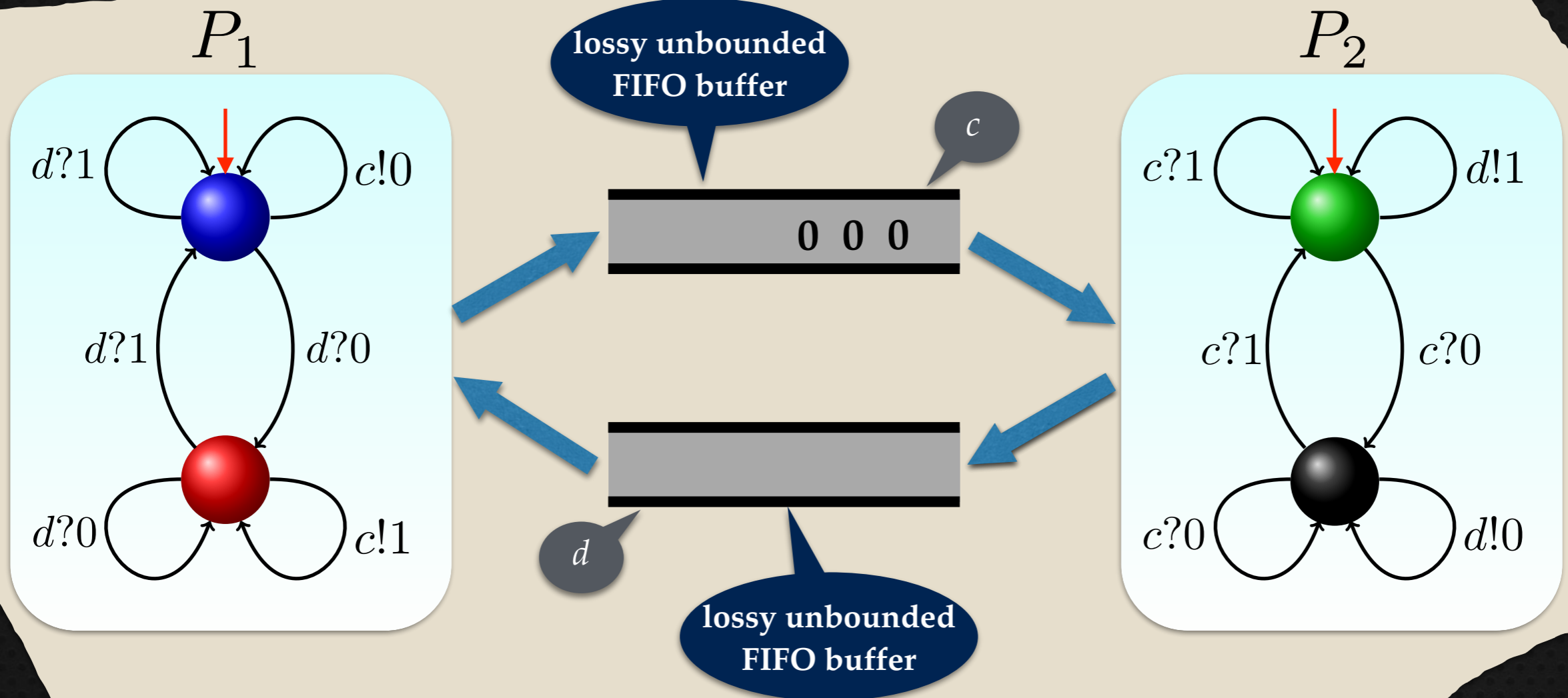


# Lossy Channel Systems

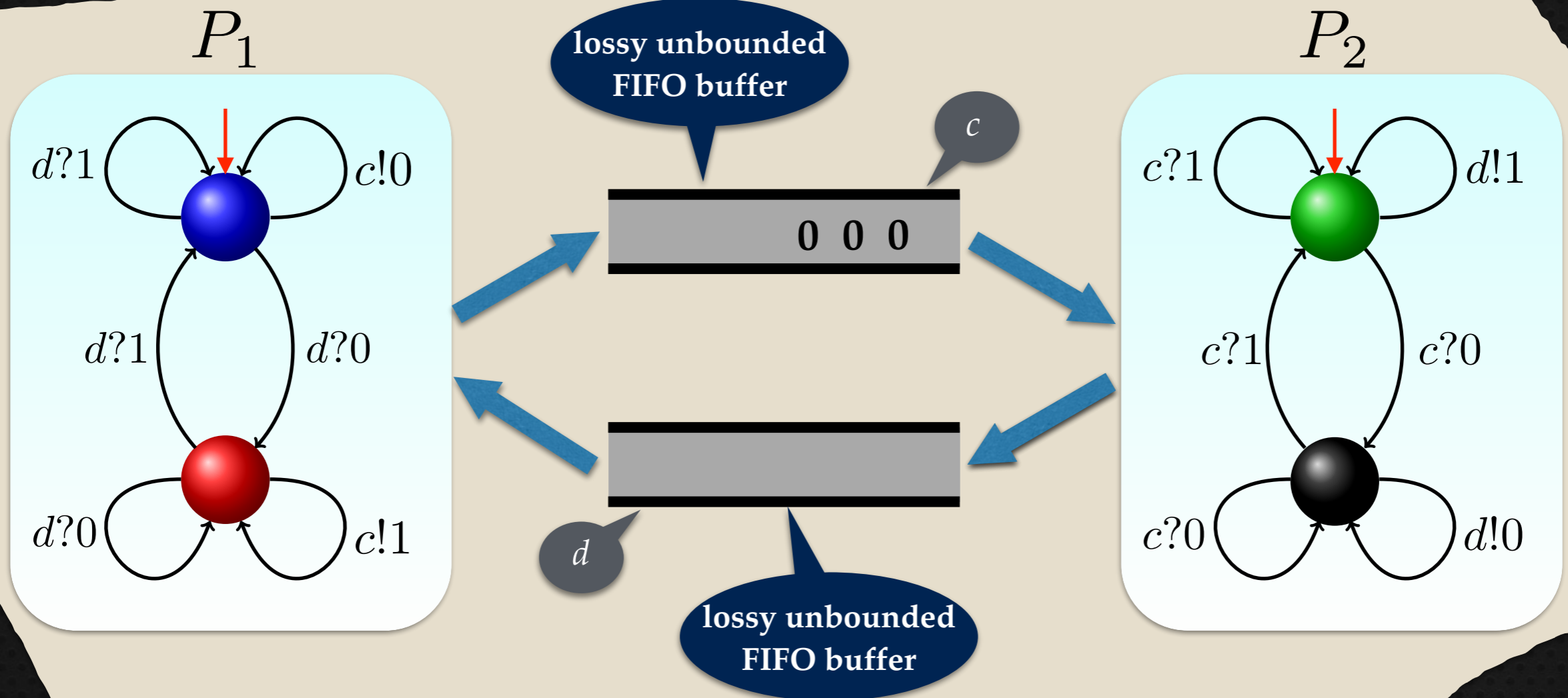




# Lossy Channel Systems

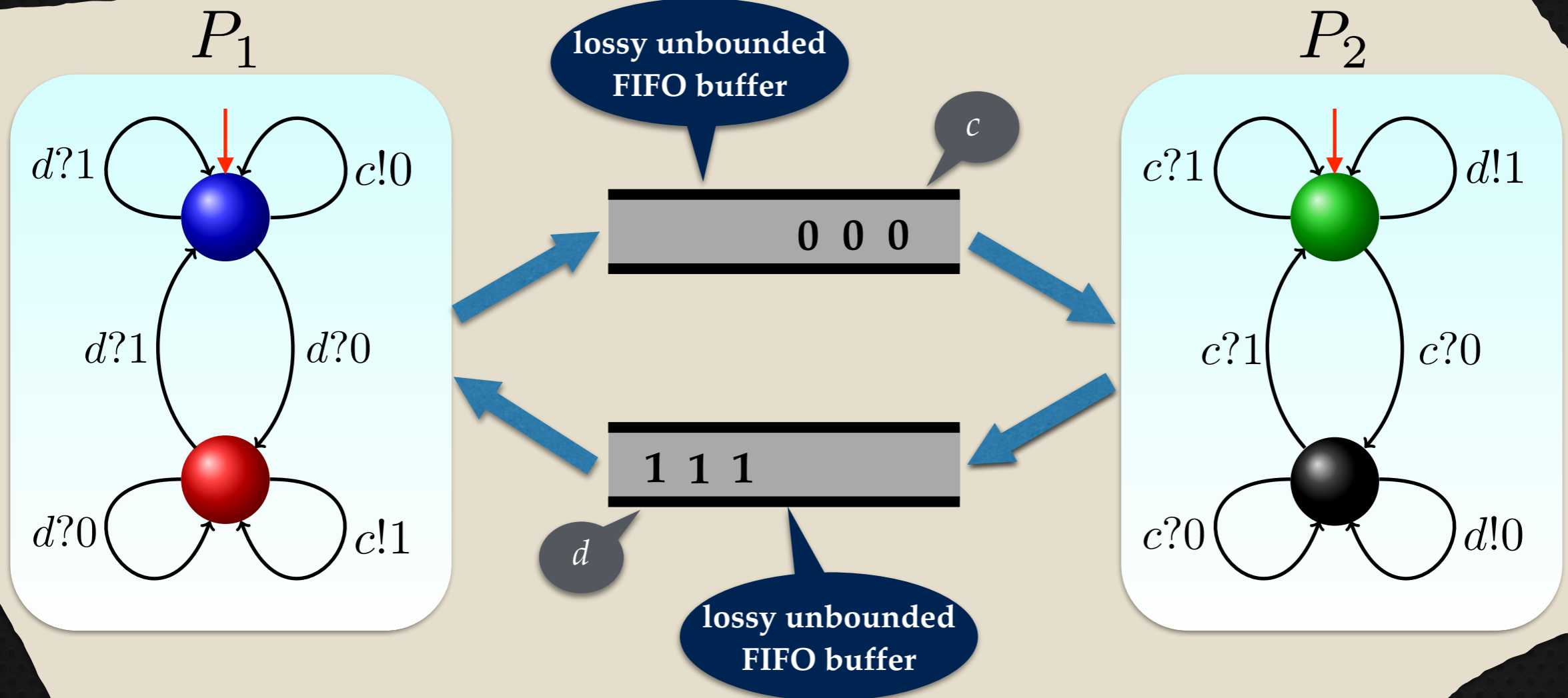


# Lossy Channel Systems

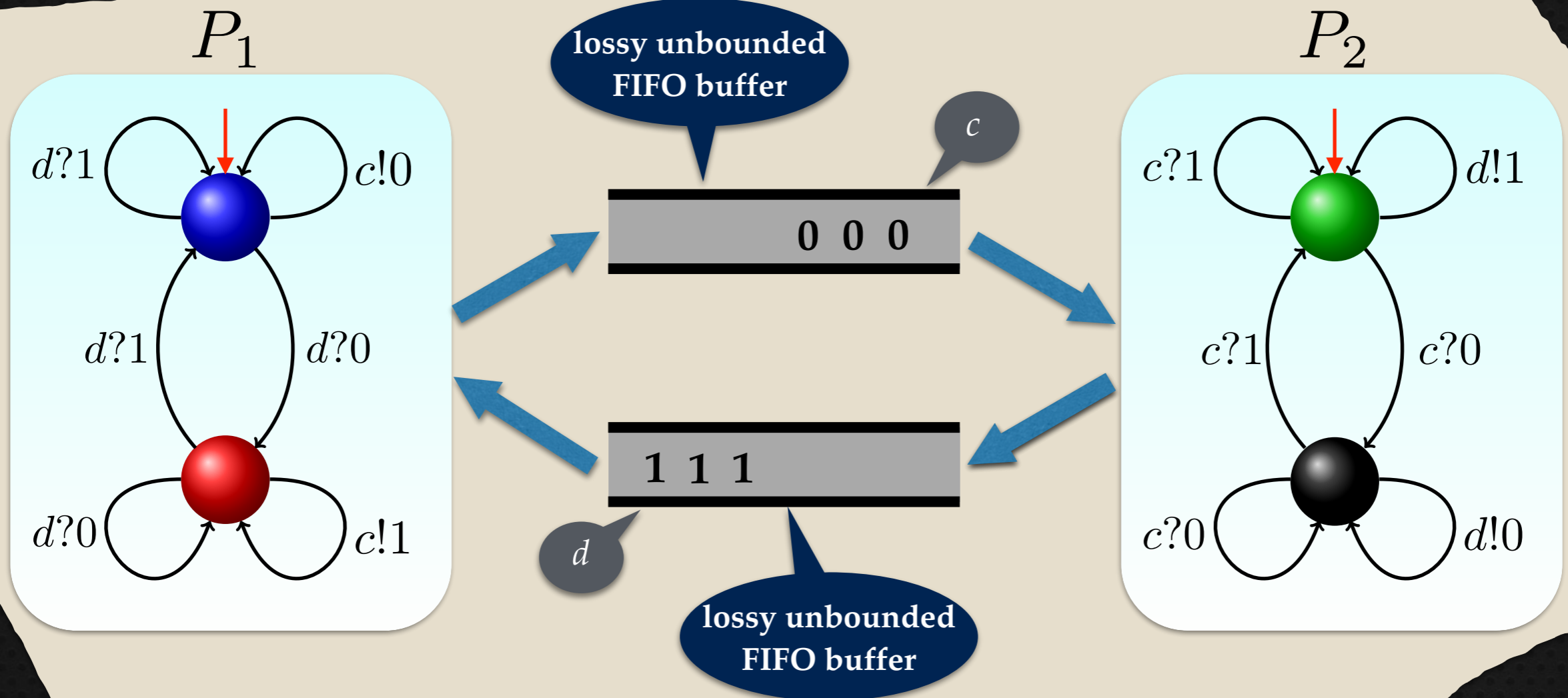




# Lossy Channel Systems

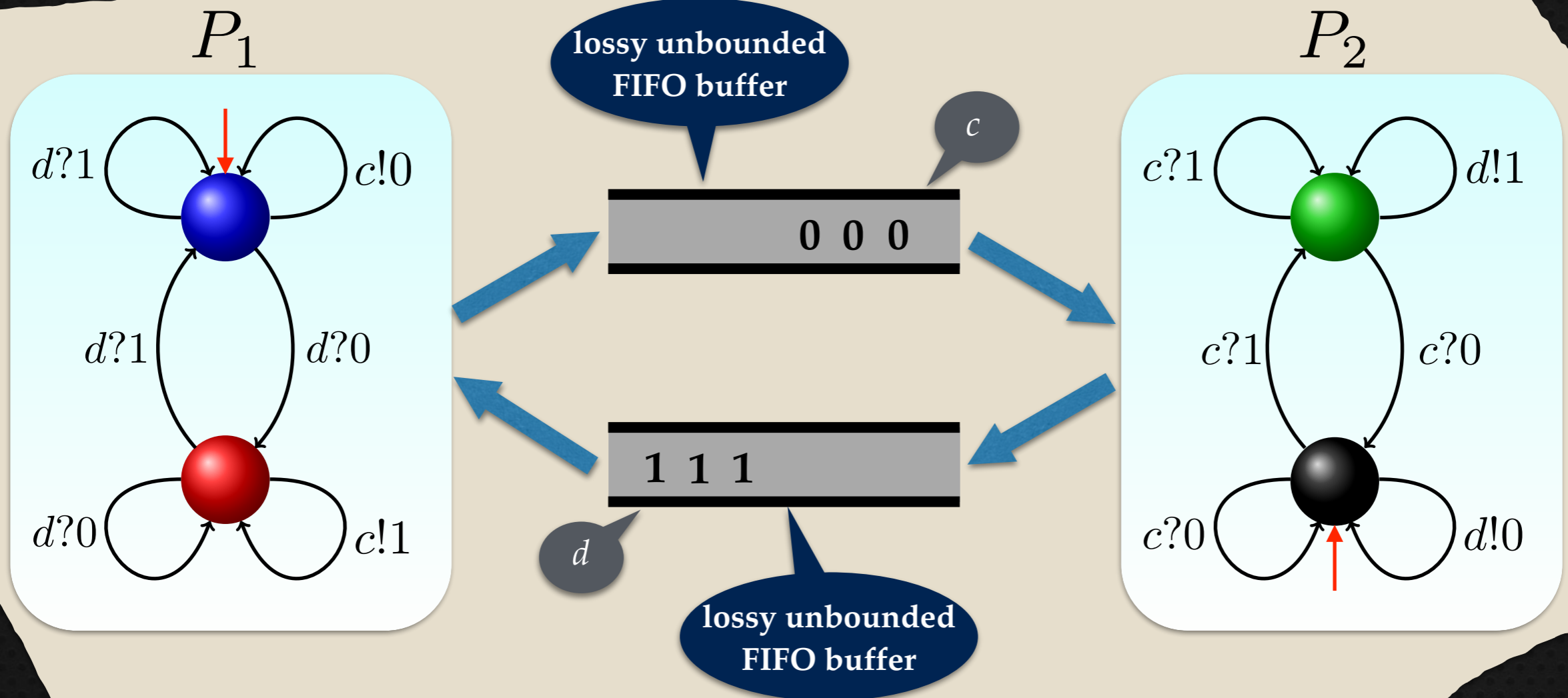


# Lossy Channel Systems

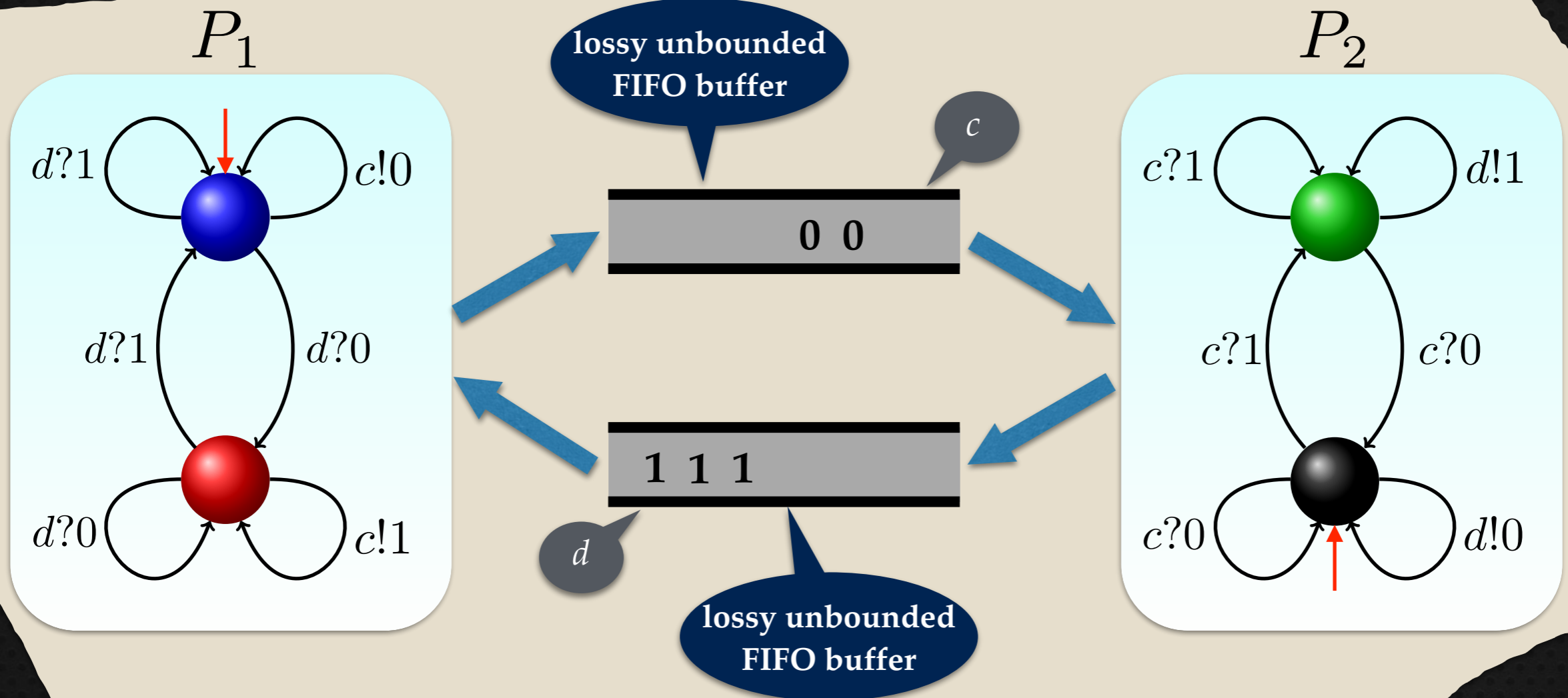




# Lossy Channel Systems

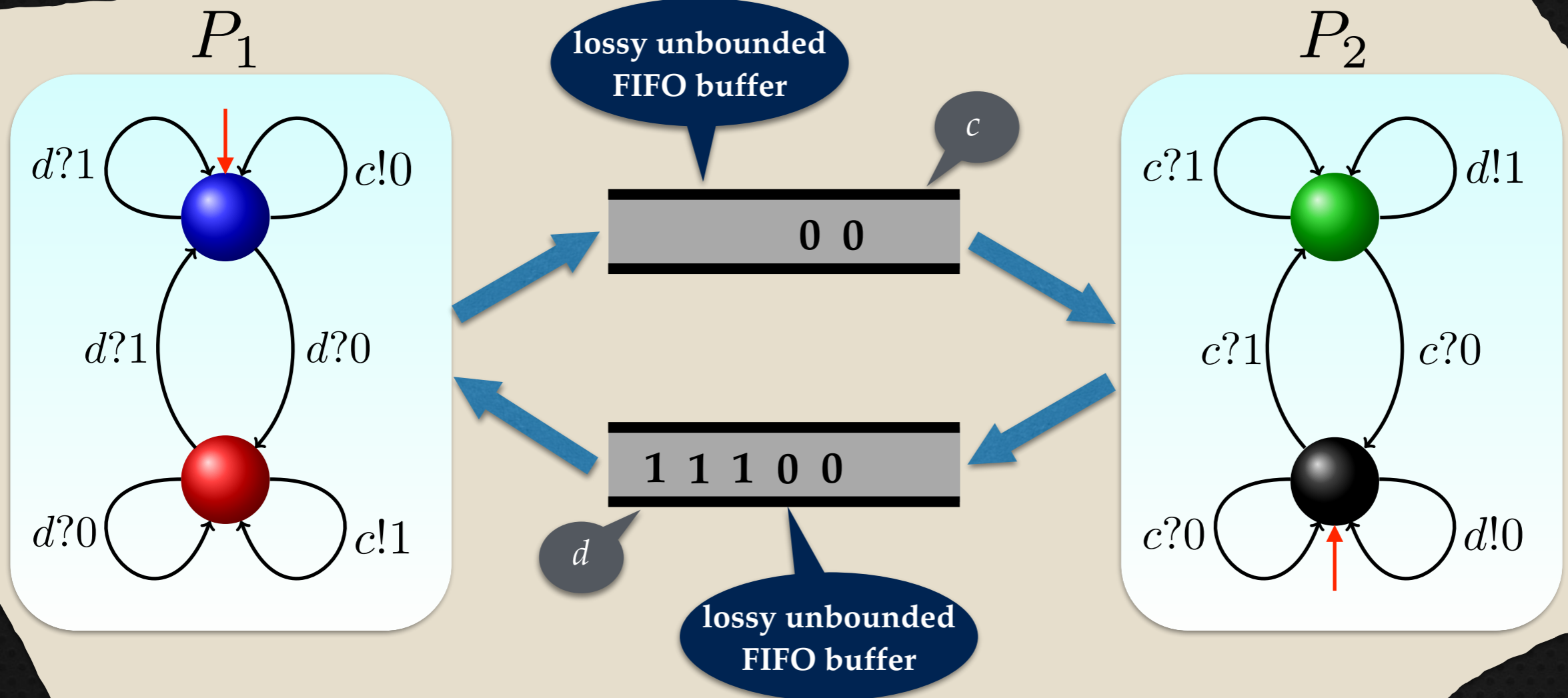


# Lossy Channel Systems

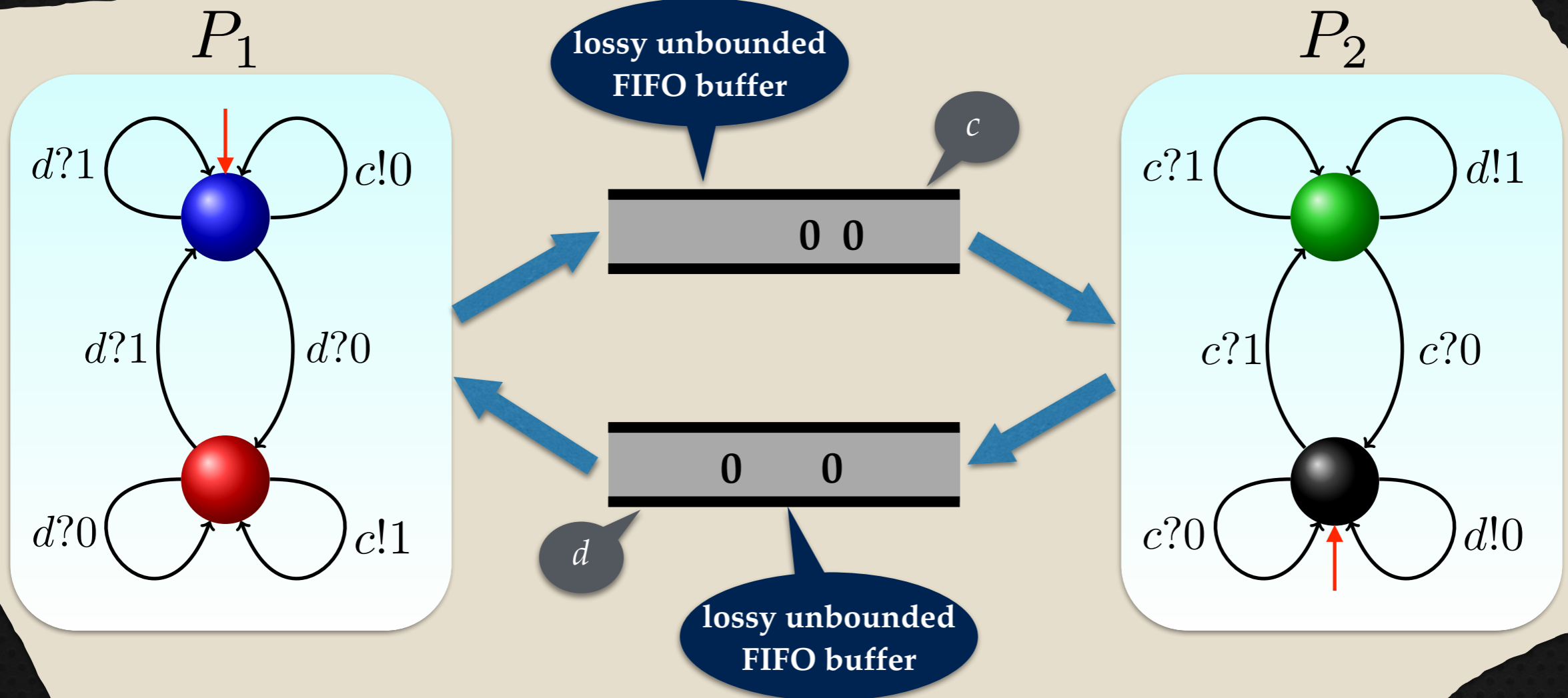




# Lossy Channel Systems

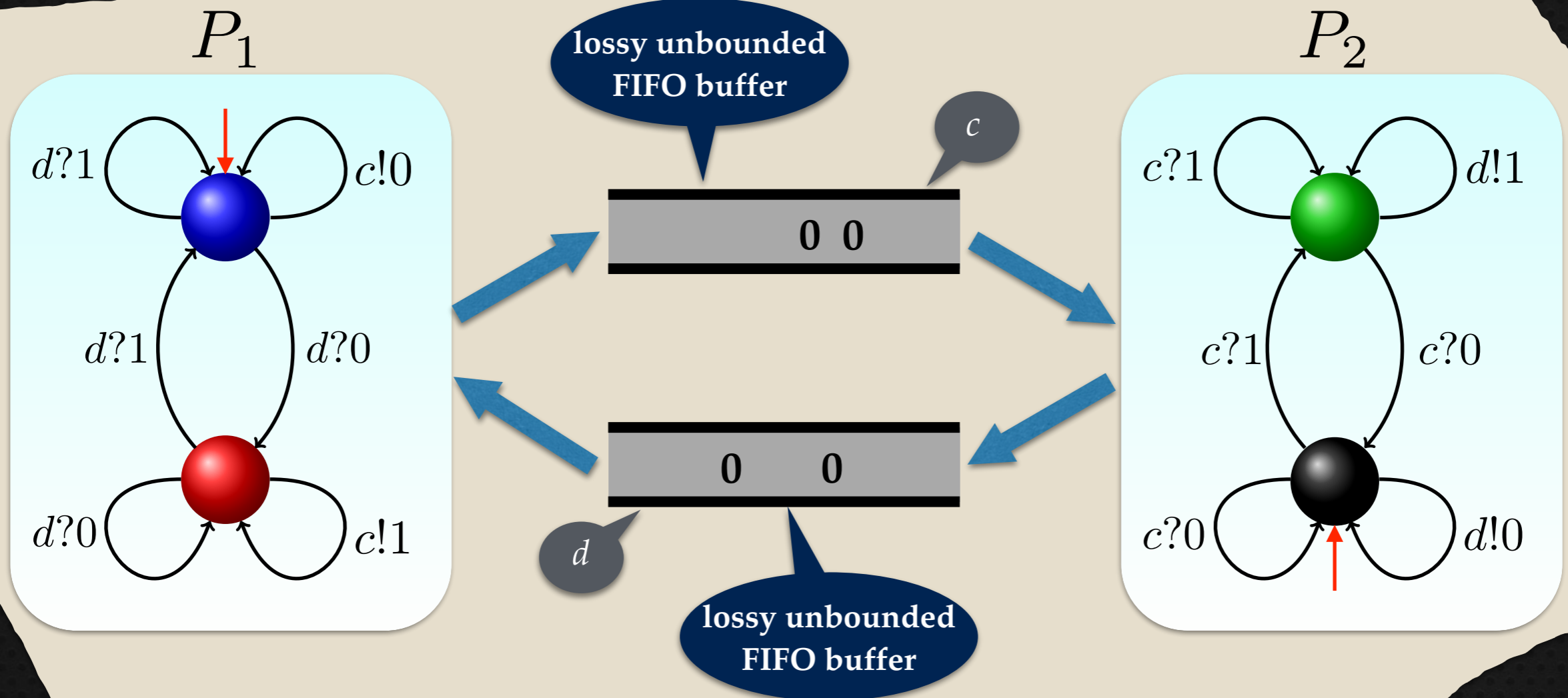


# Lossy Channel Systems

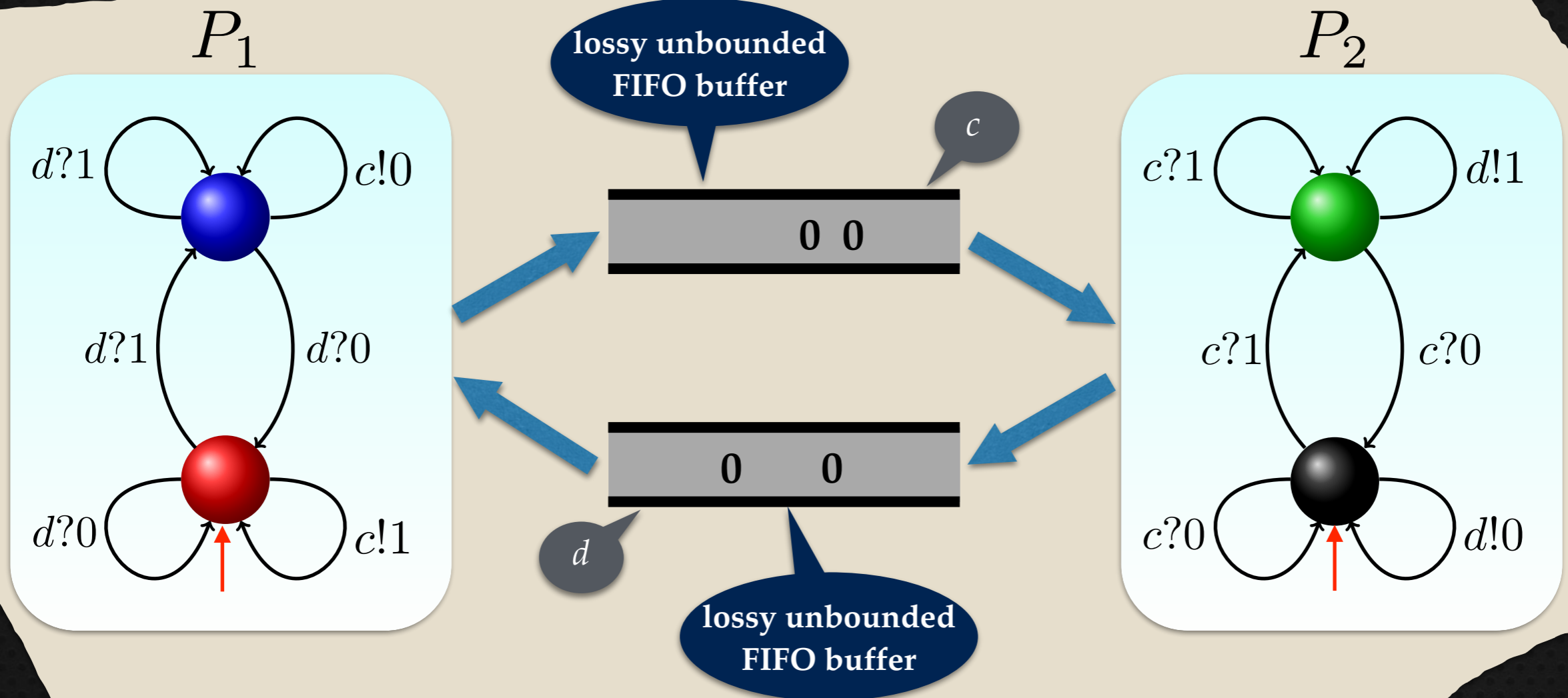




# Lossy Channel Systems

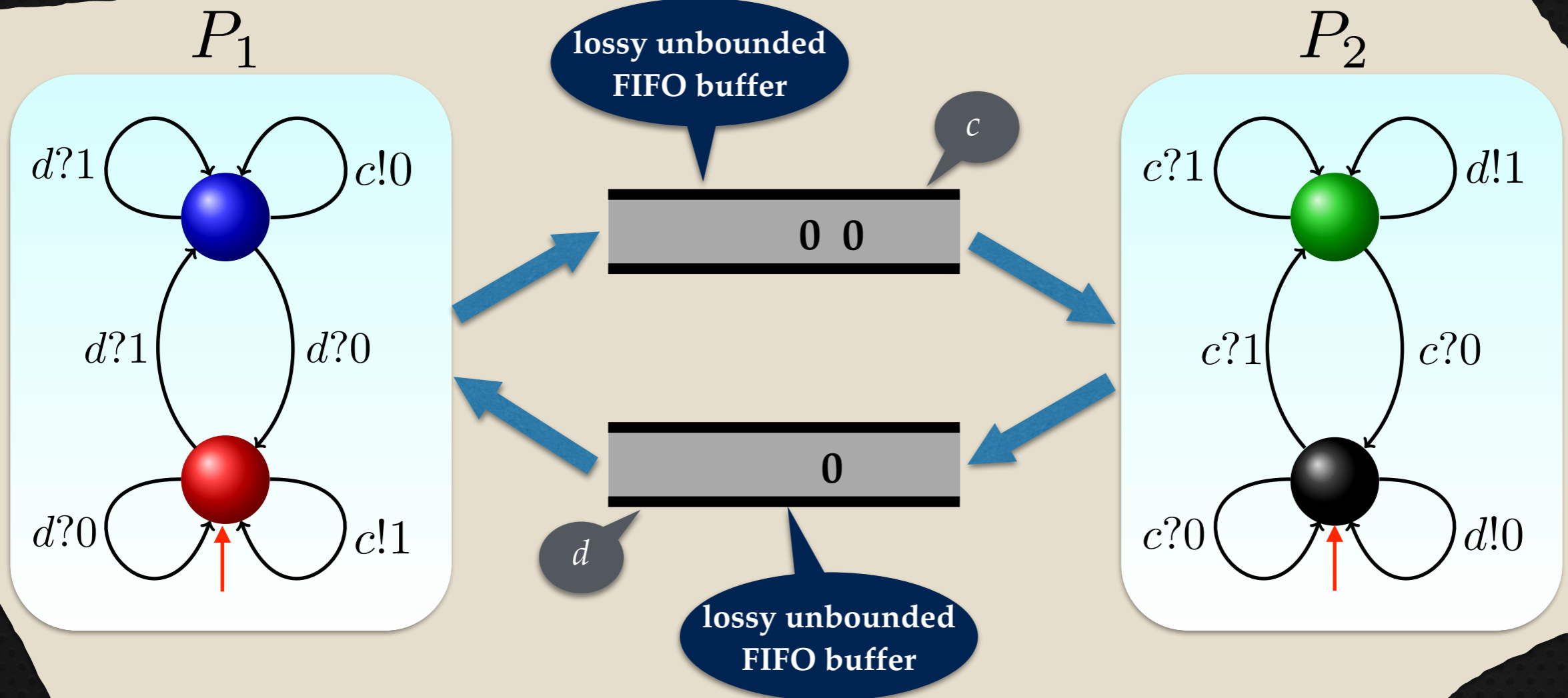


# Lossy Channel Systems

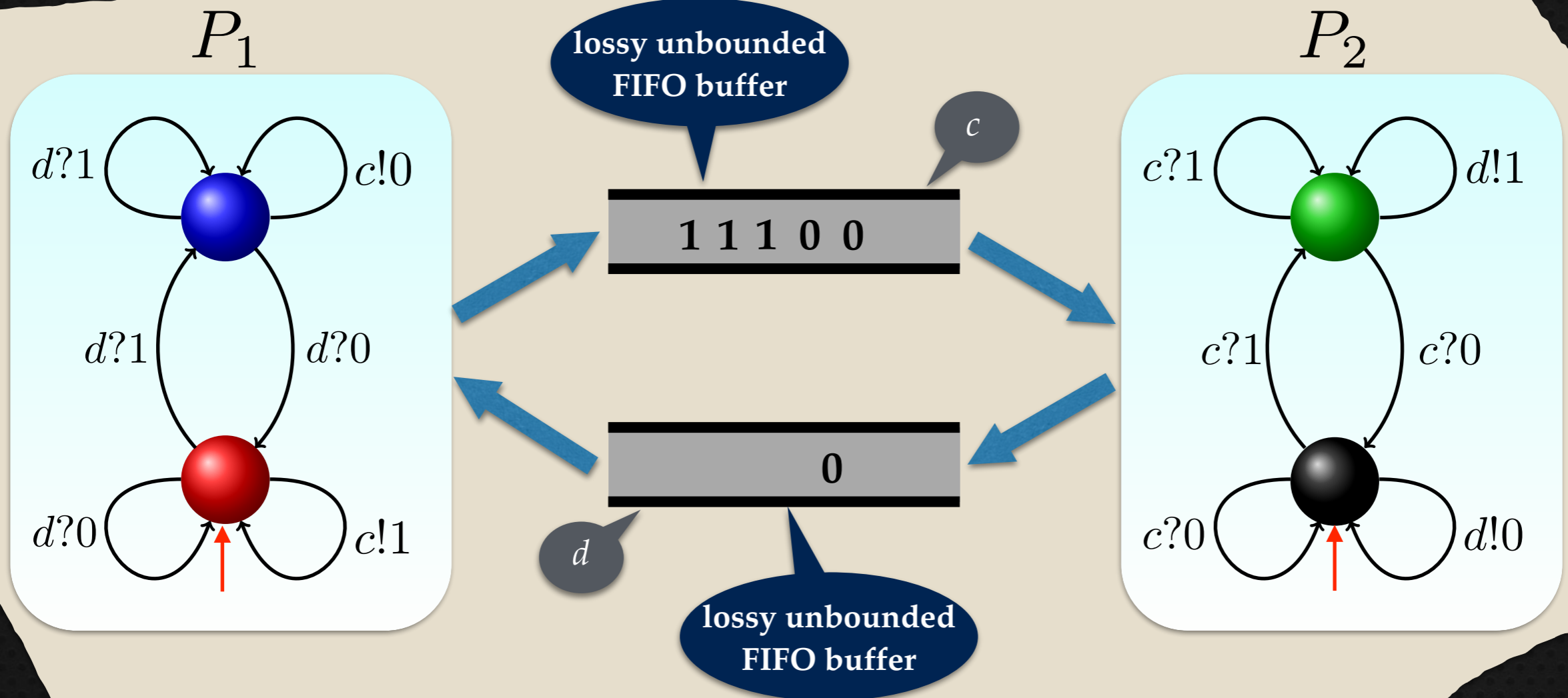




# Lossy Channel Systems



# Lossy Channel Systems





# Lossy Channel Systems



Model

Configurations

Transitions

Ordering

Monotonicity

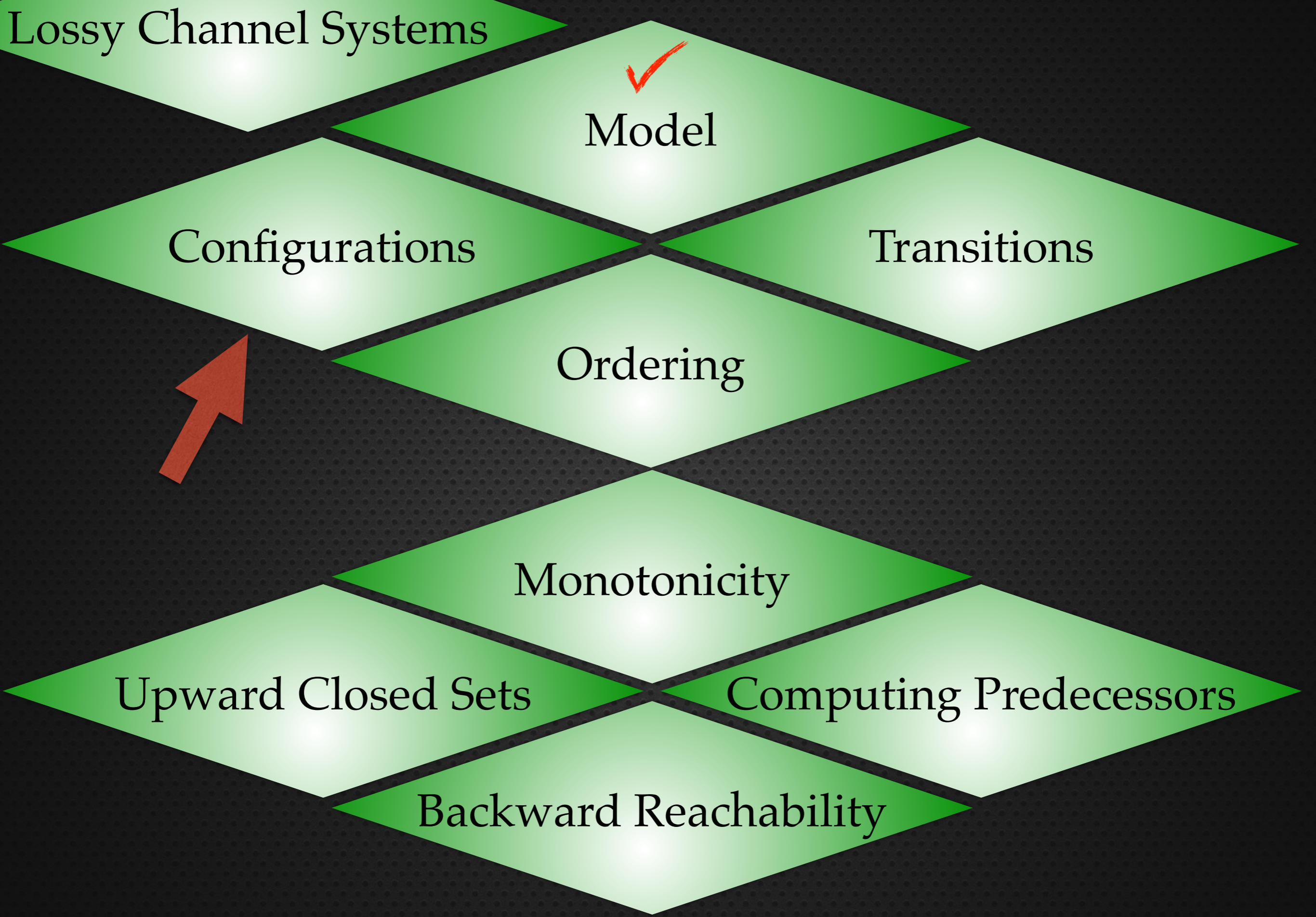
Upward Closed Sets

Computing Predecessors

Backward Reachability



# Lossy Channel Systems



Model ✓

Configurations

Transitions

Ordering

Monotonicity

Upward Closed Sets

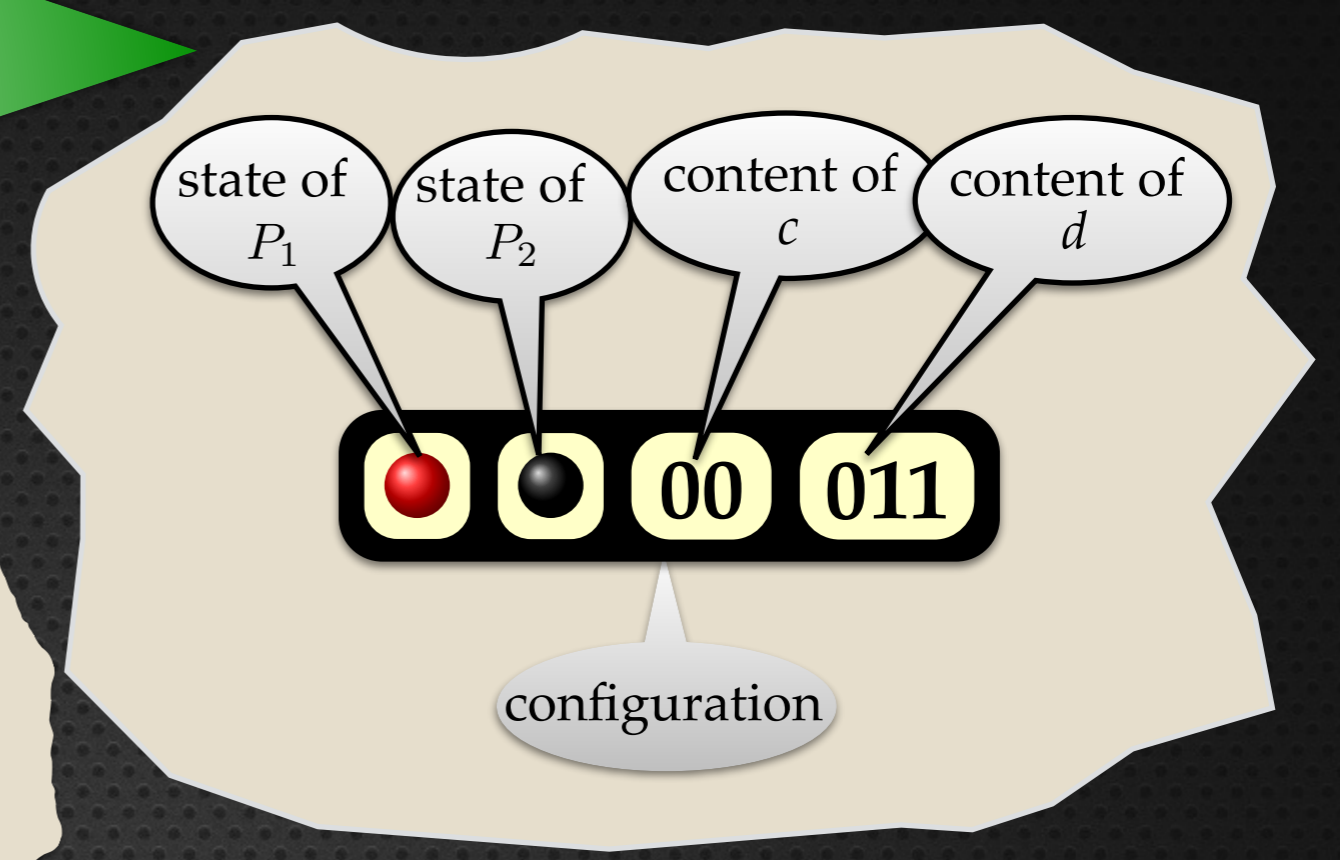
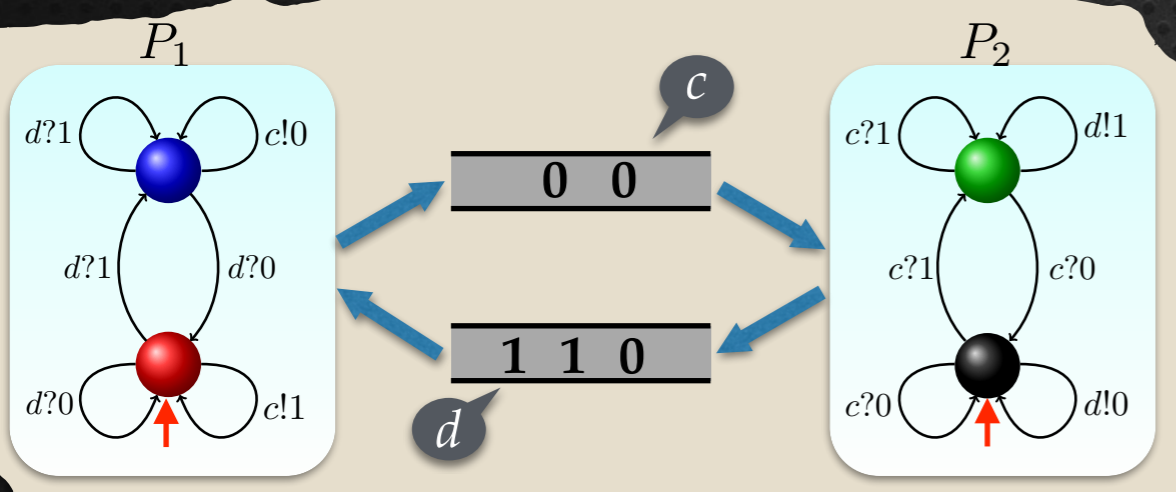
Computing Predecessors

Backward Reachability



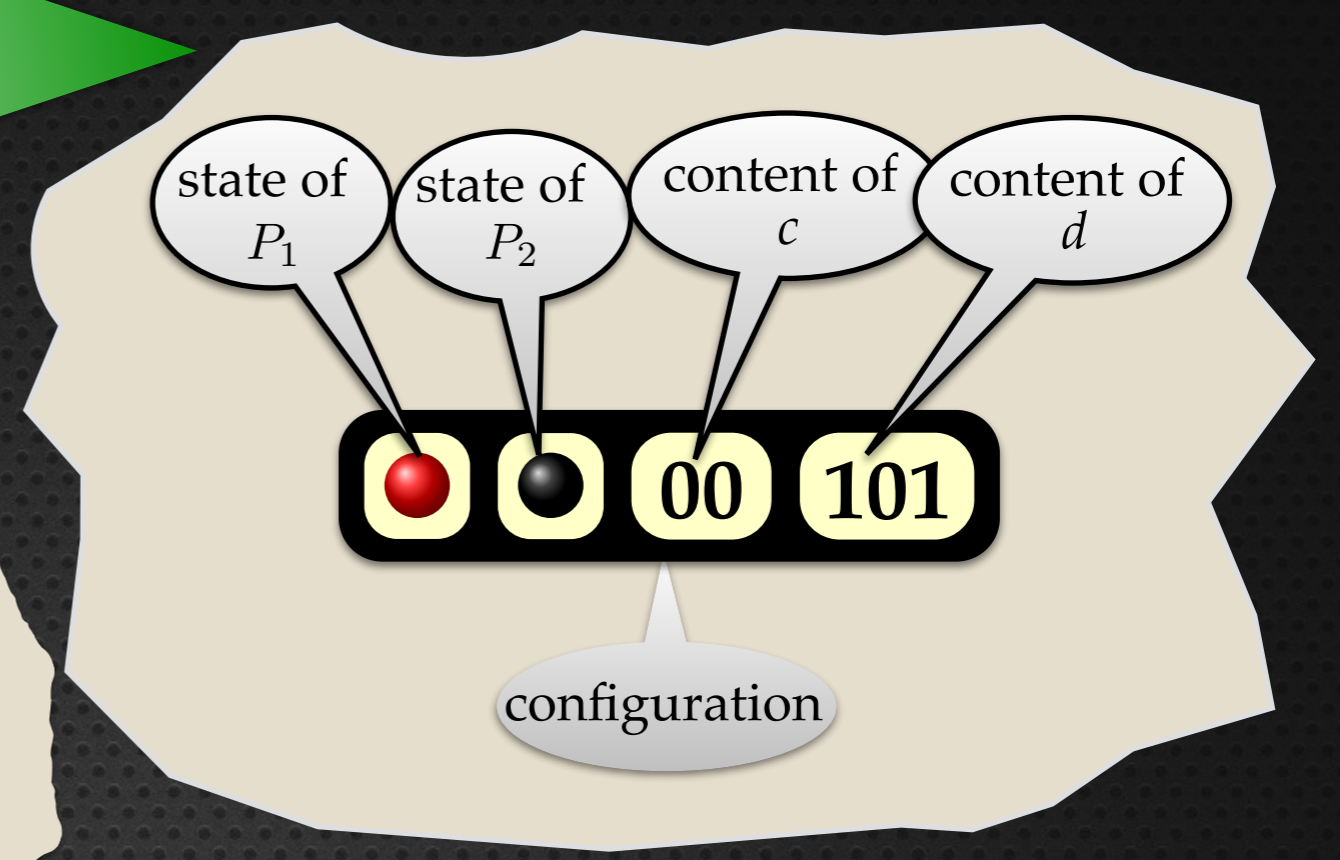
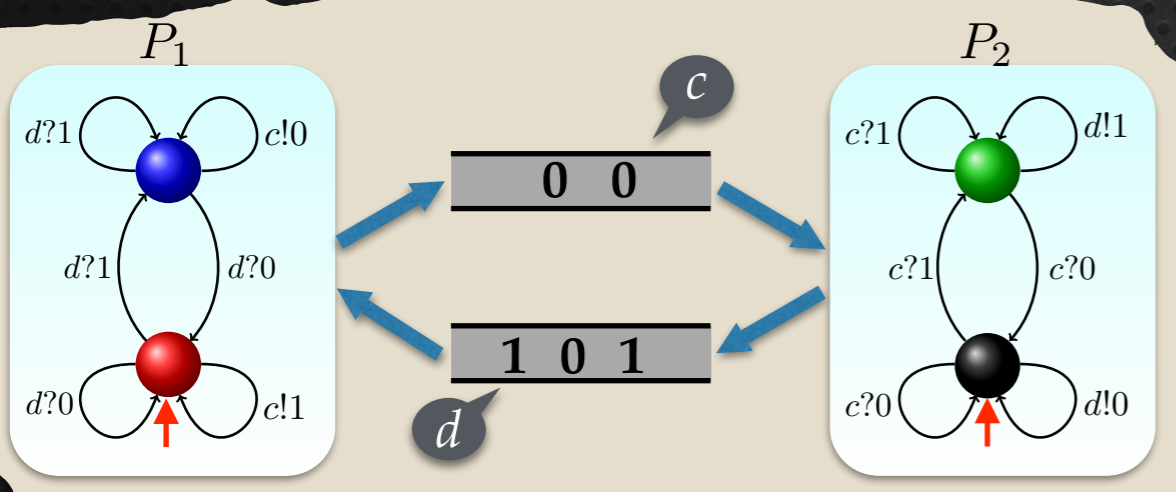


# Lossy Configurations



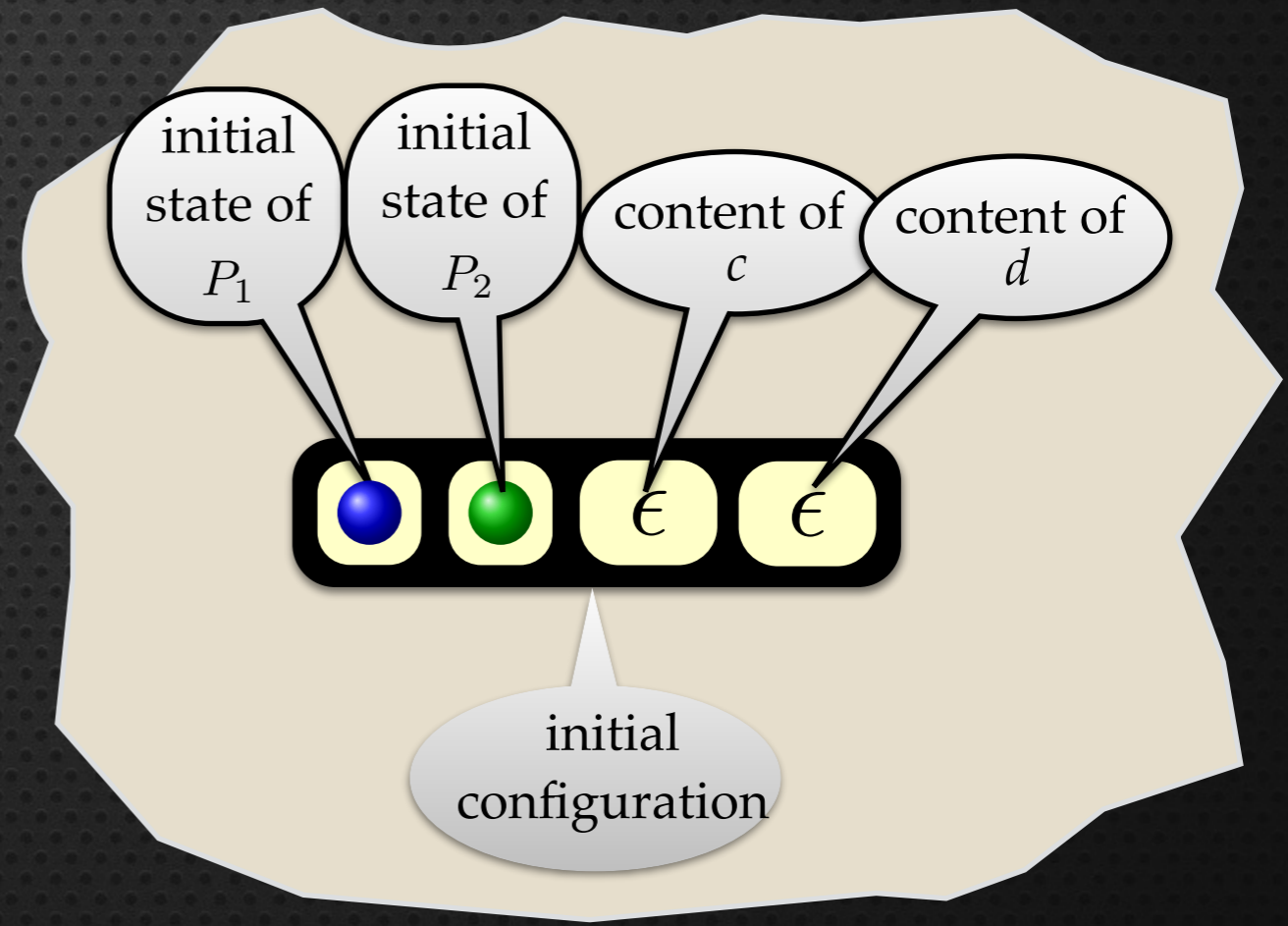
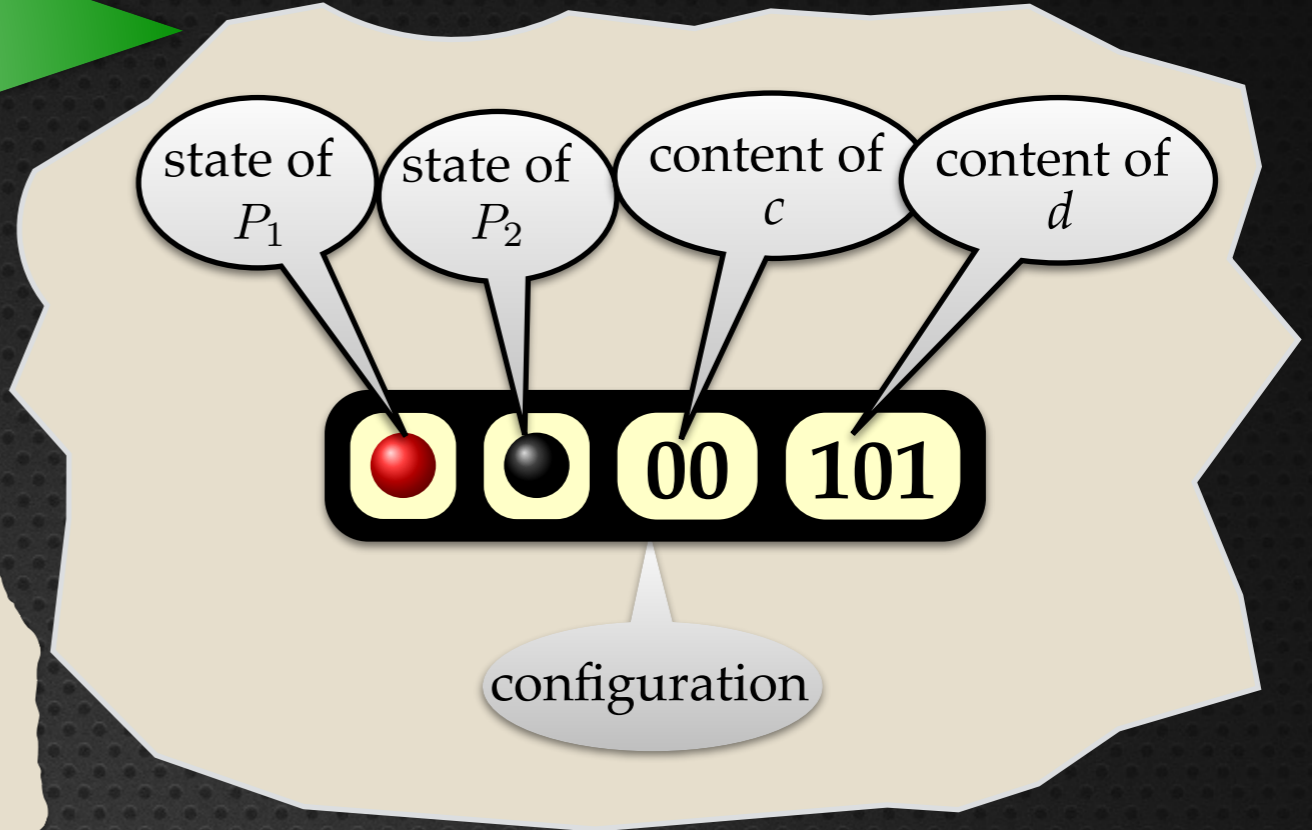
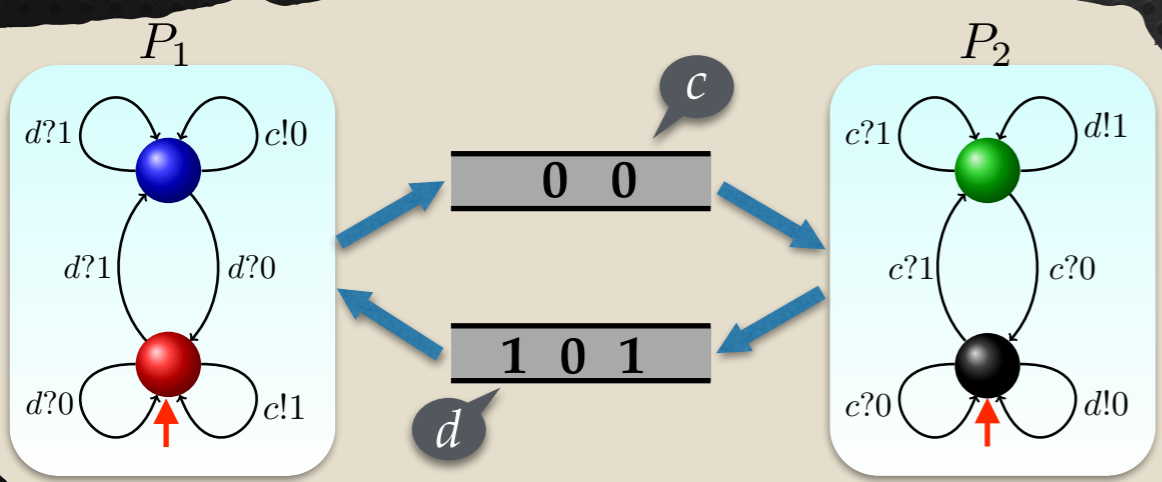


# Lossy Configurations



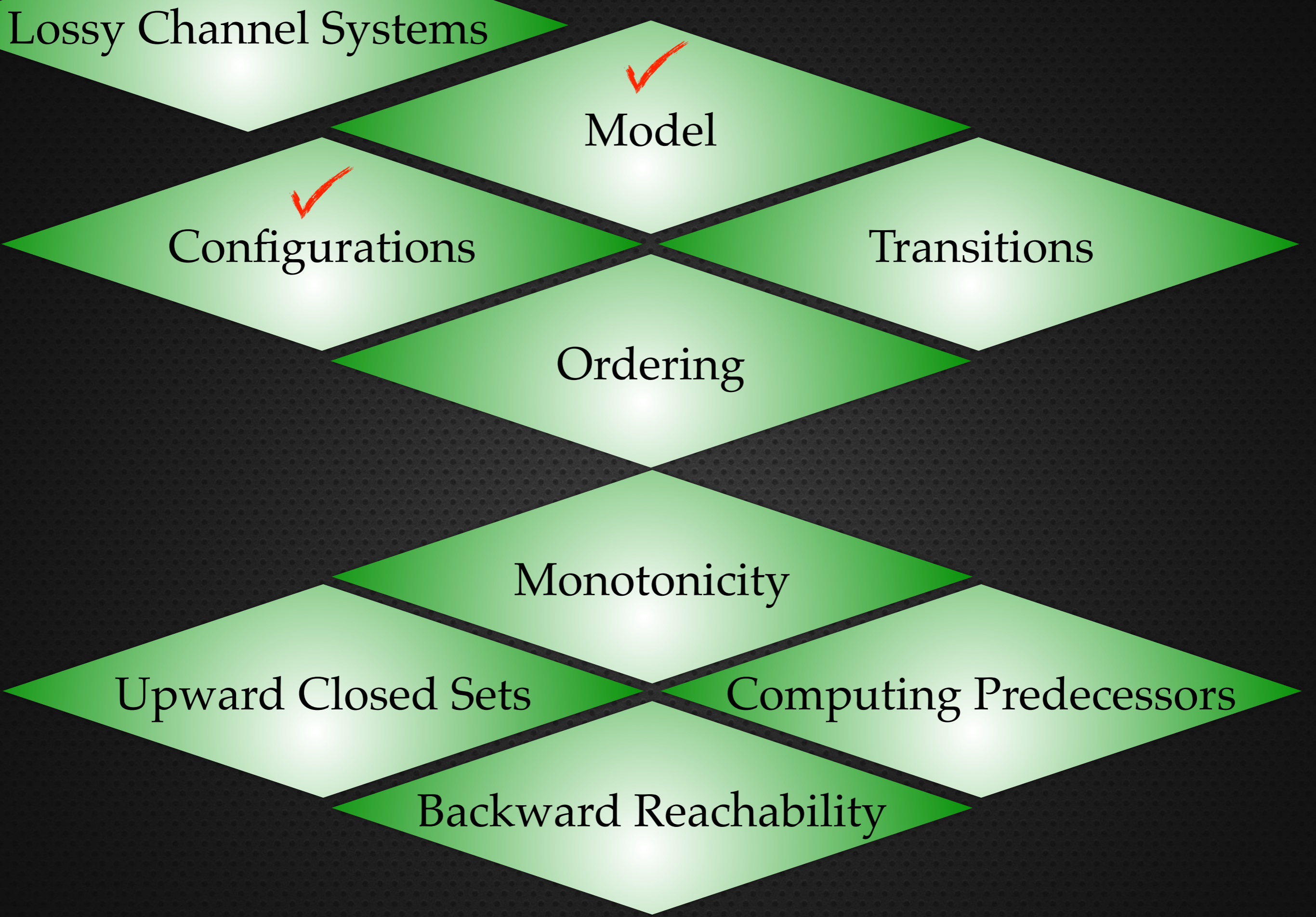


# Lossy Configurations



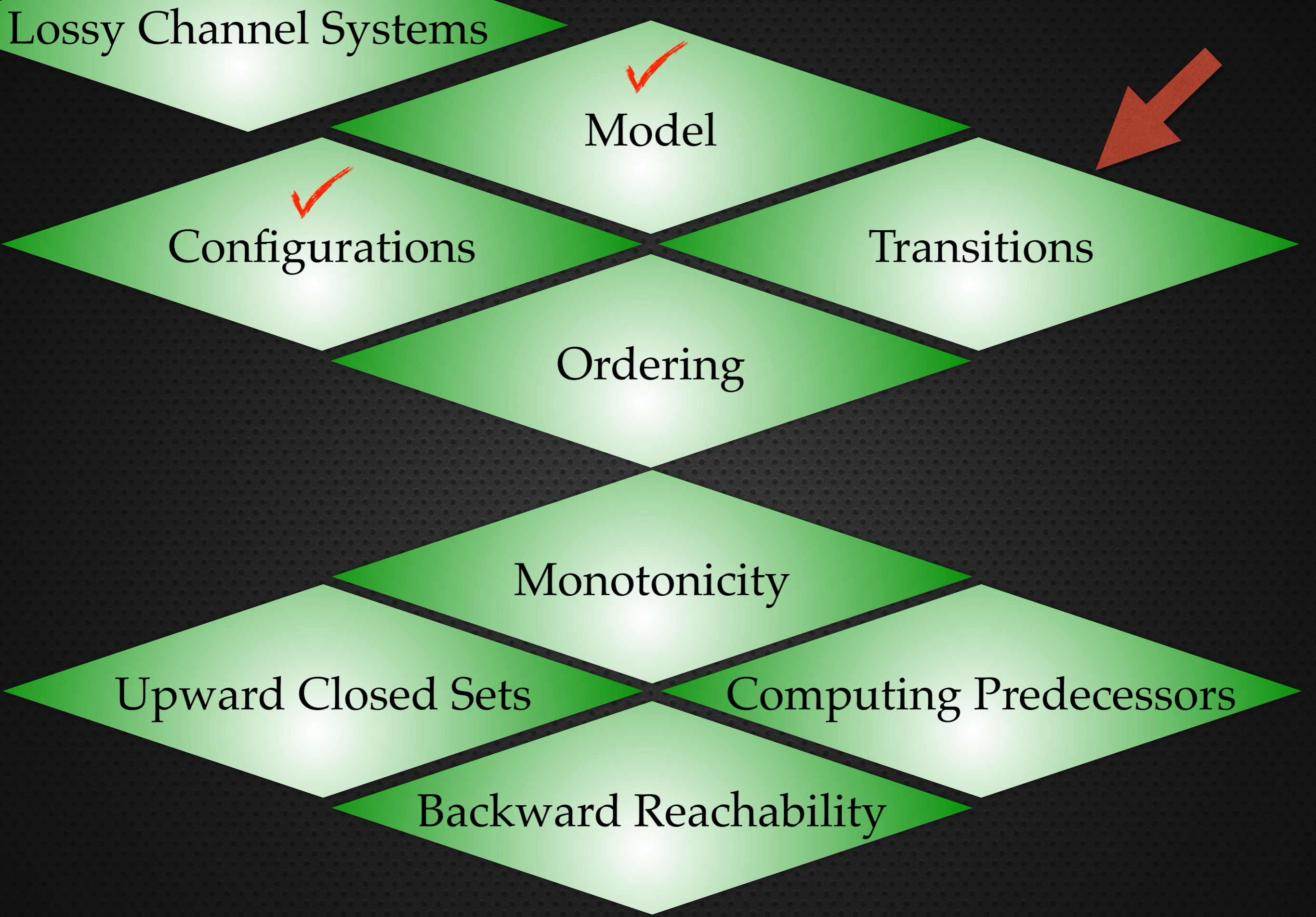


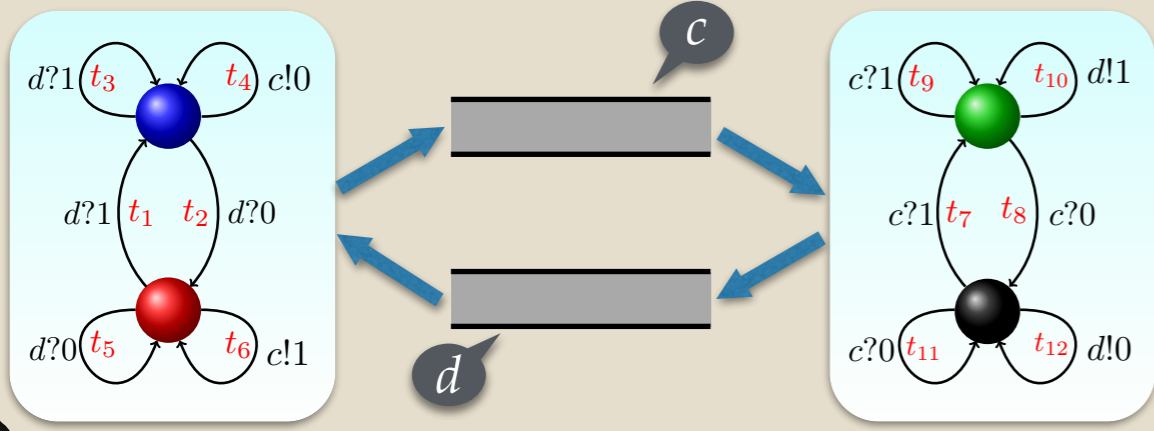
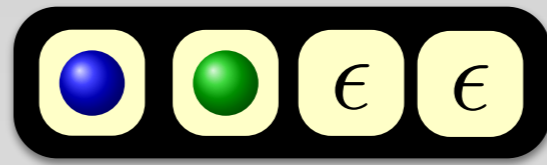
# Lossy Channel Systems



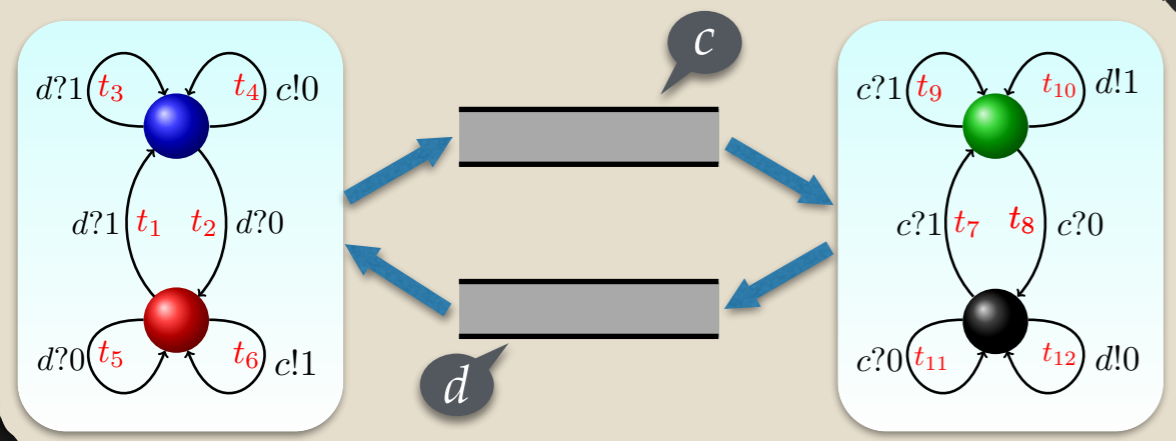
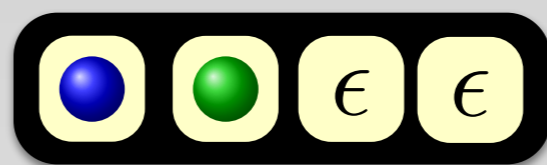


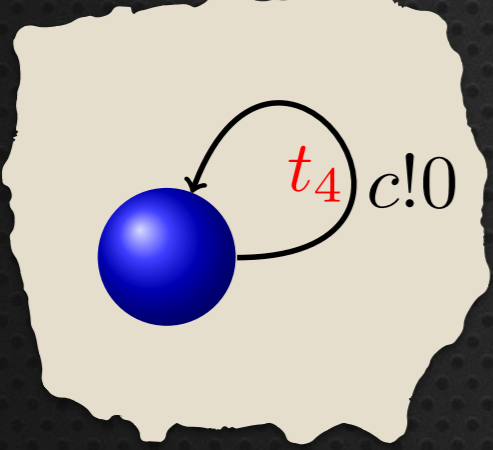
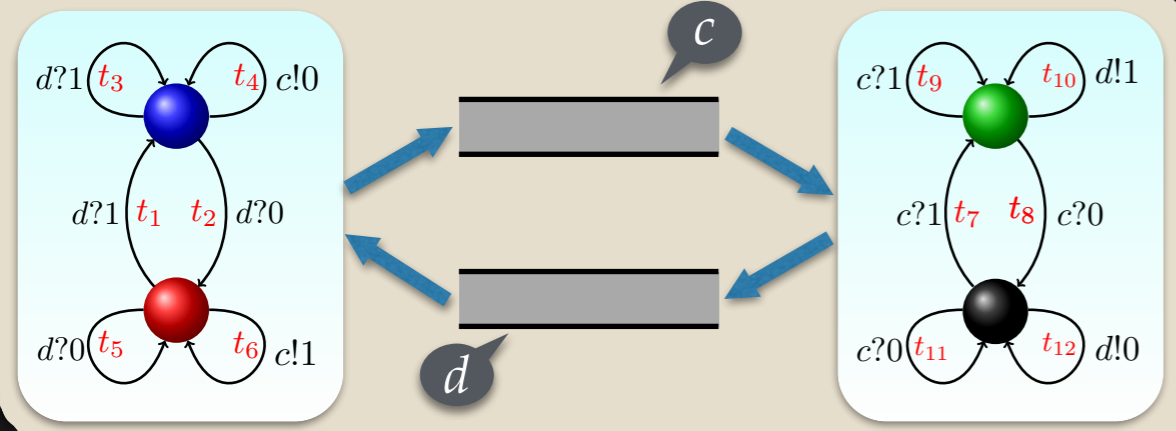
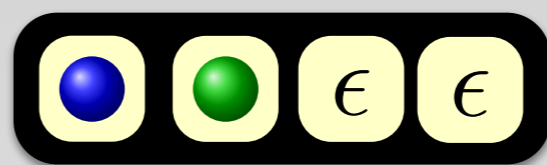
# Lossy Channel Systems







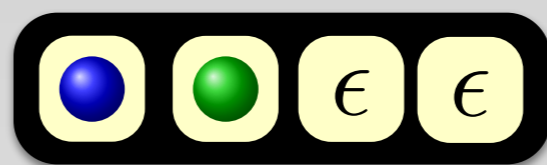




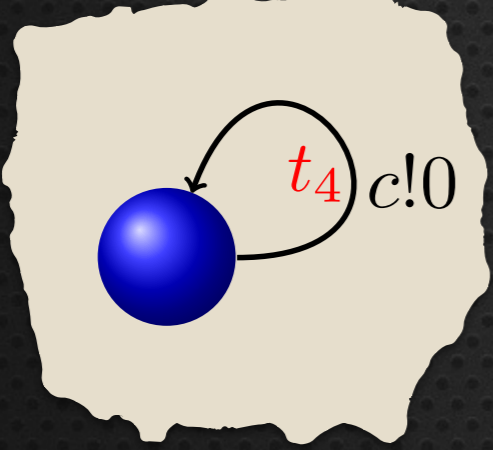
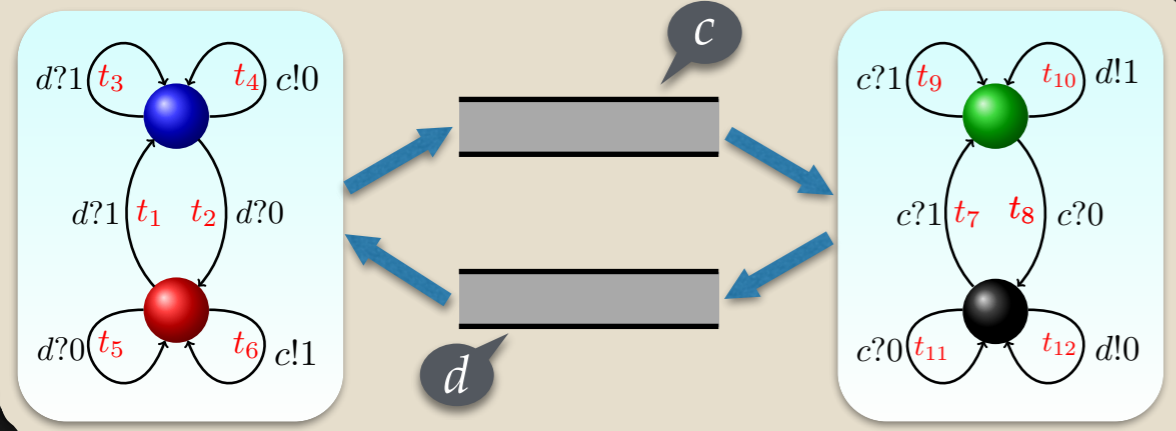


Lossy

# Transitions

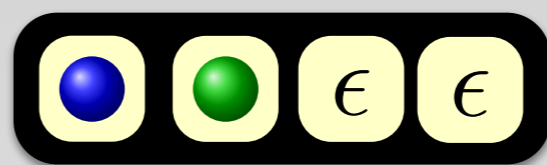


$t_4$  →

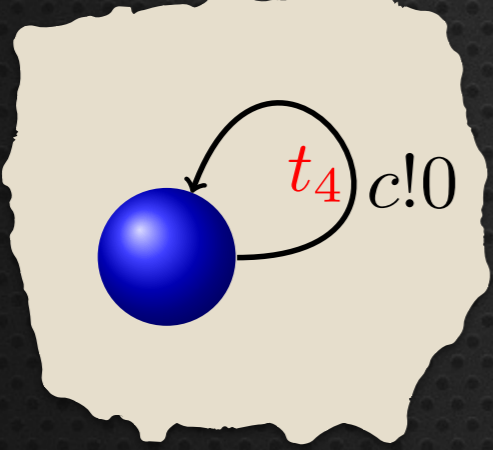
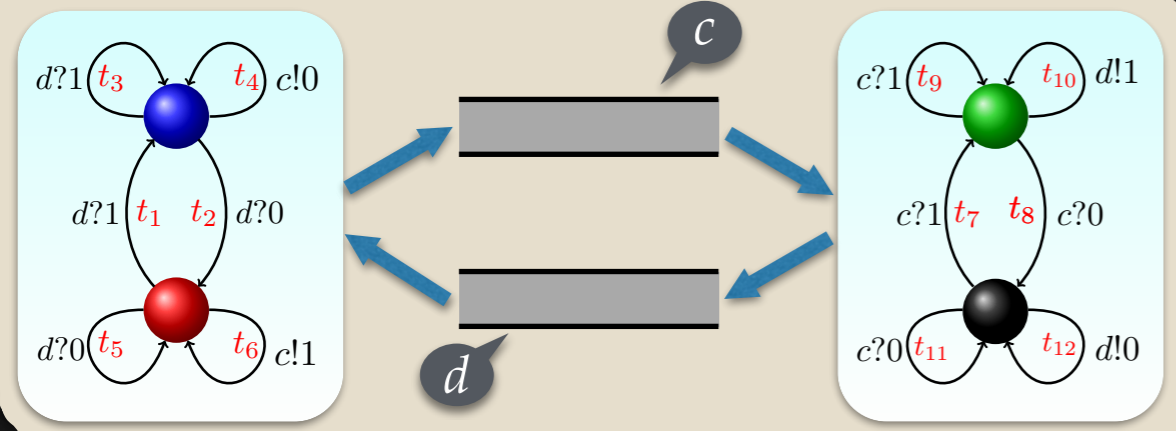


Lossy

# Transitions



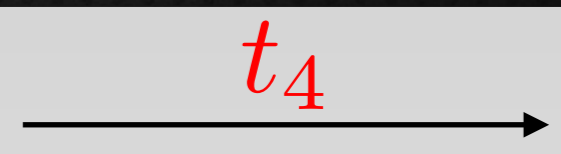
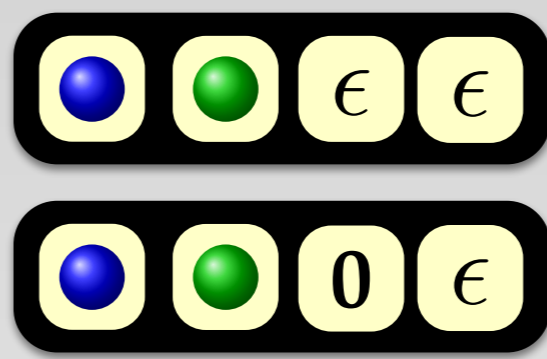
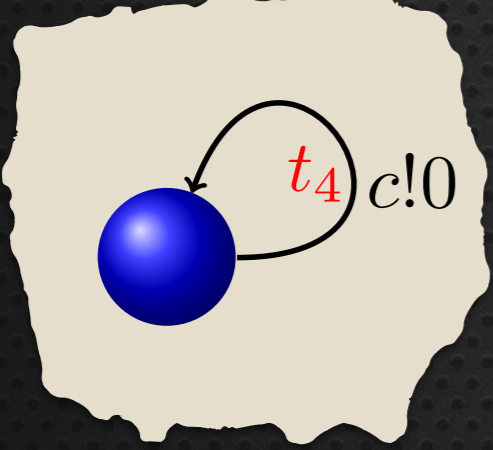
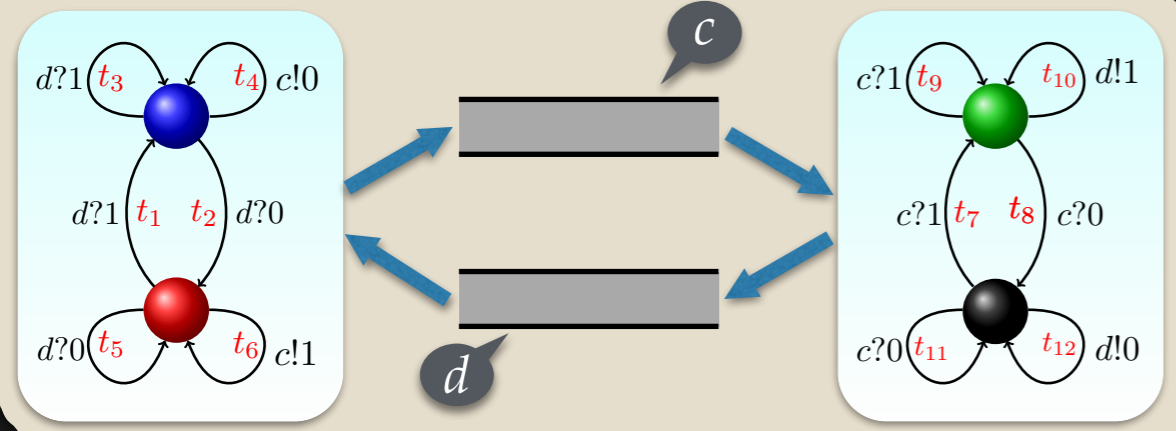
$t_4$  →





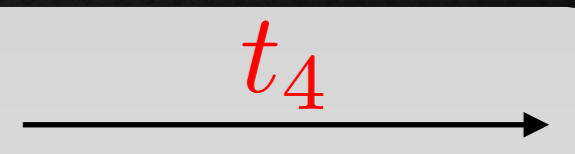
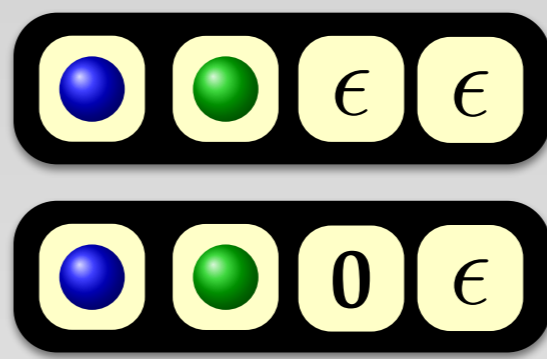
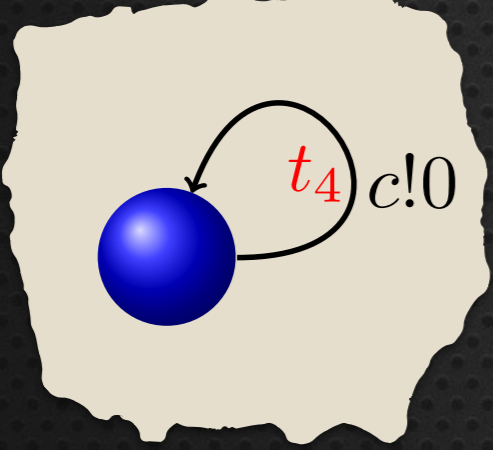
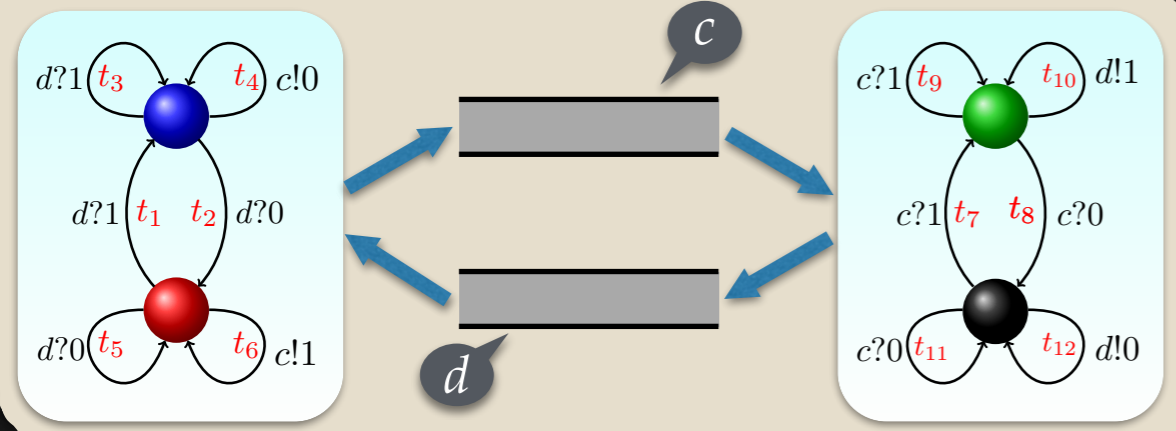
Lossy

# Transitions



Lossy

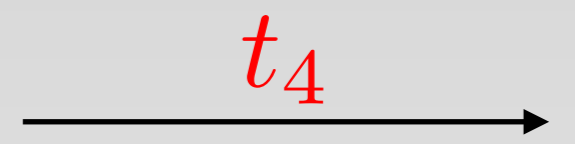
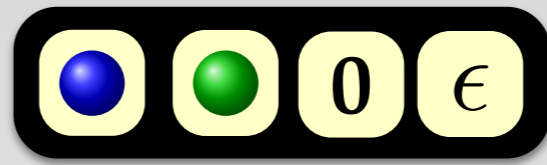
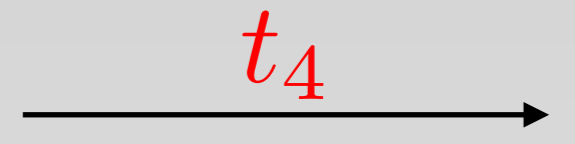
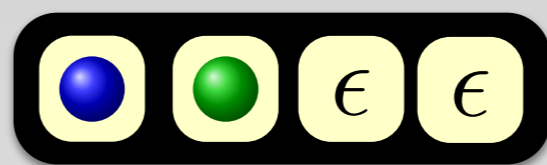
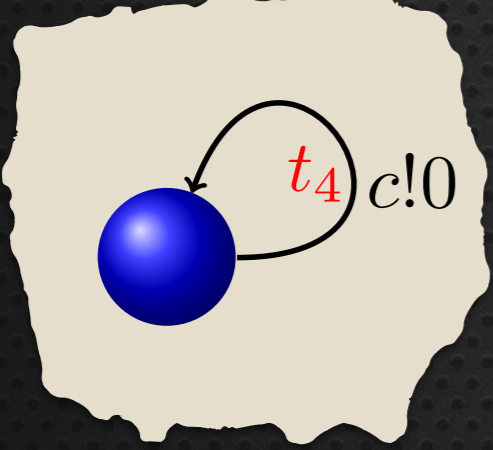
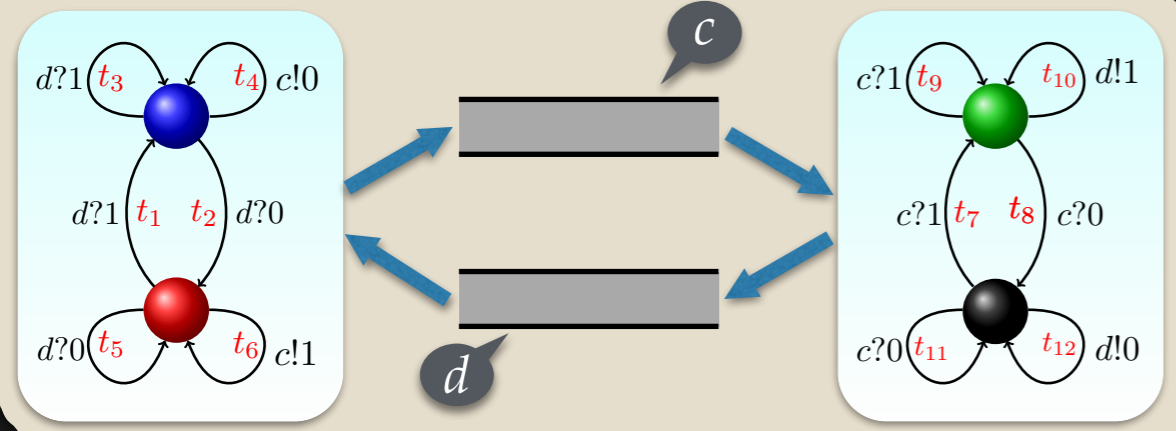
# Transitions





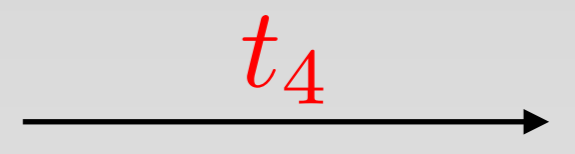
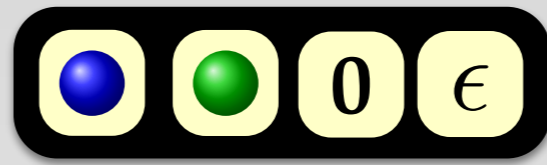
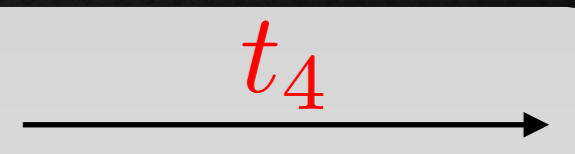
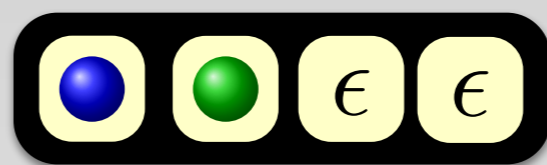
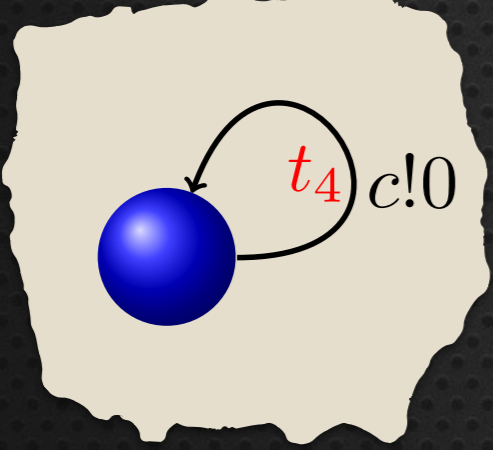
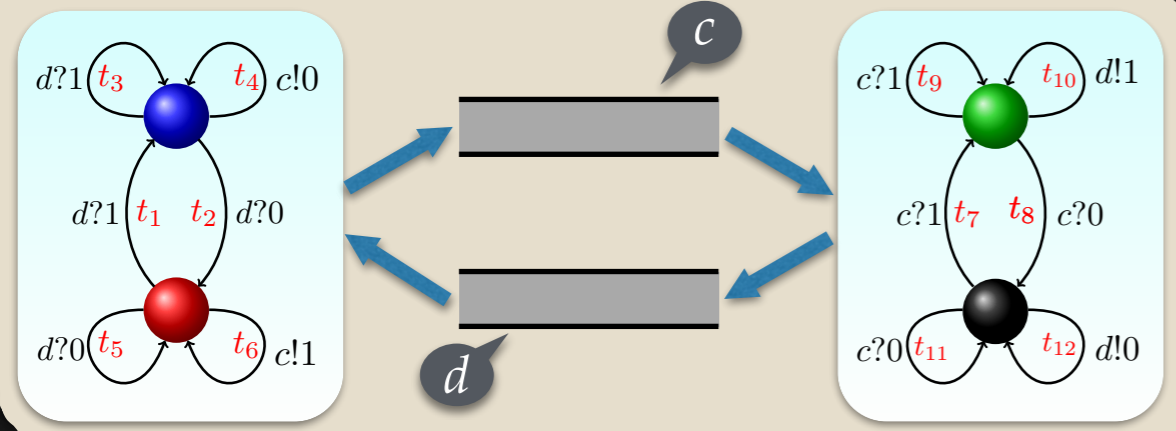
Lossy

# Transitions



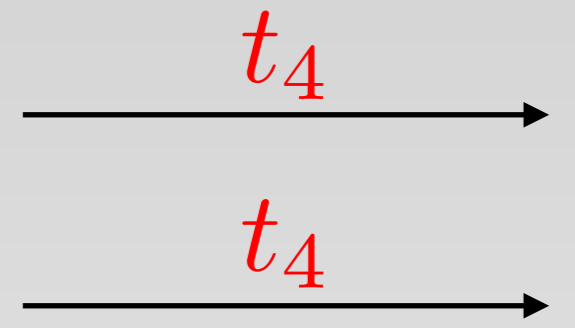
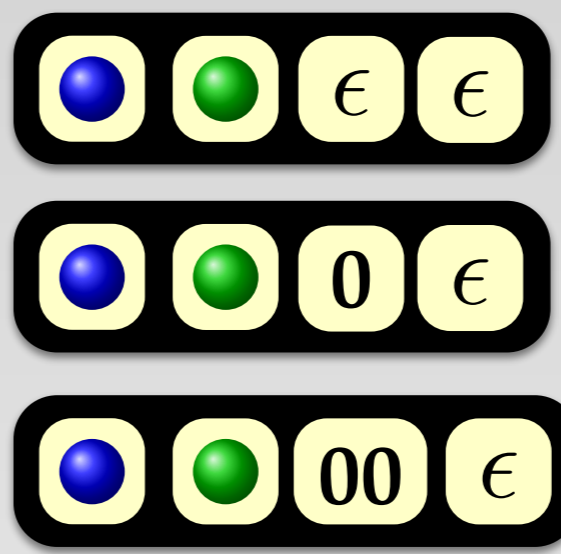
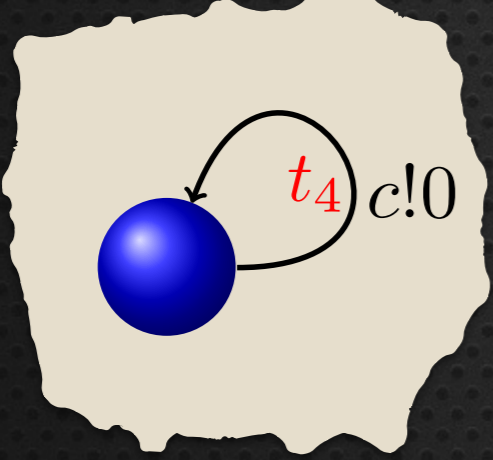
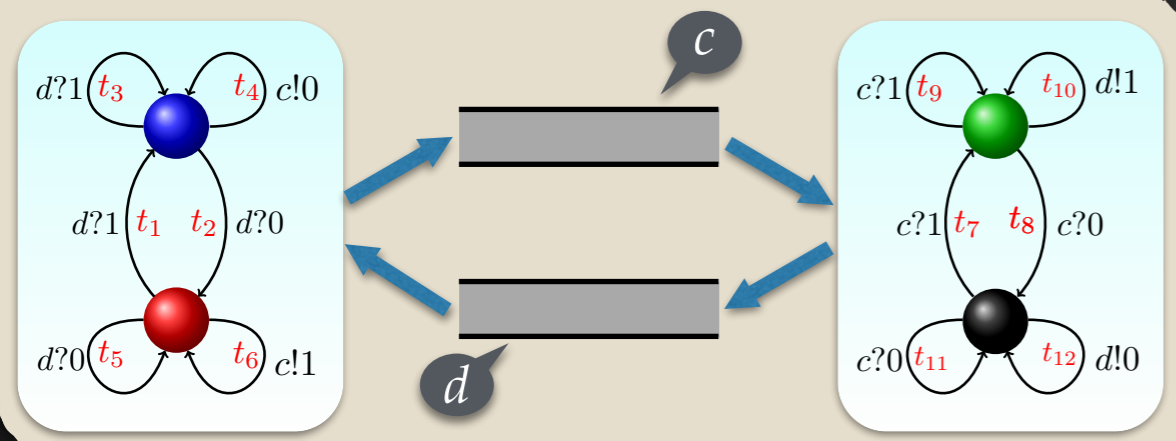
Lossy

# Transitions



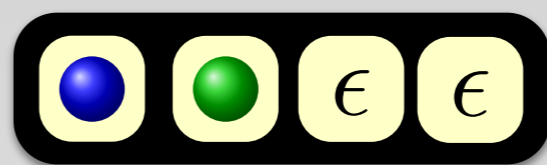
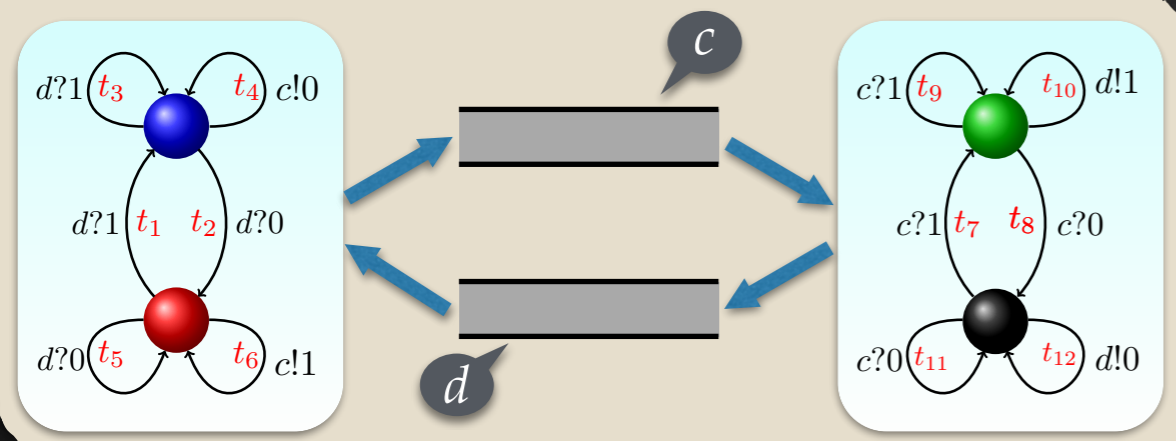


# Lossy Transitions

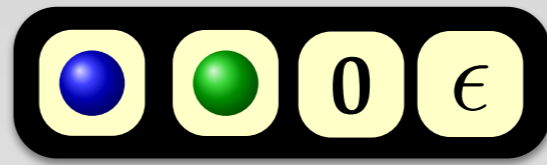


Lossy

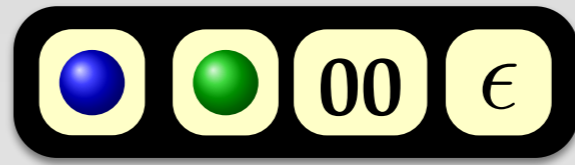
# Transitions



$t_4$

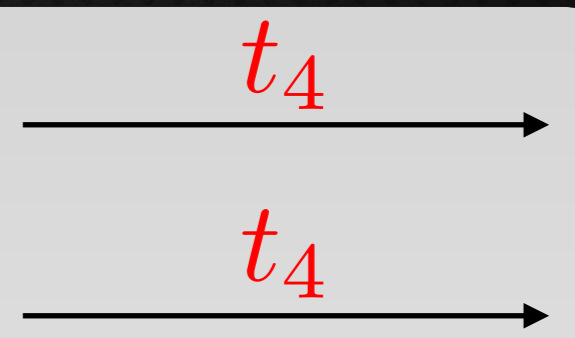
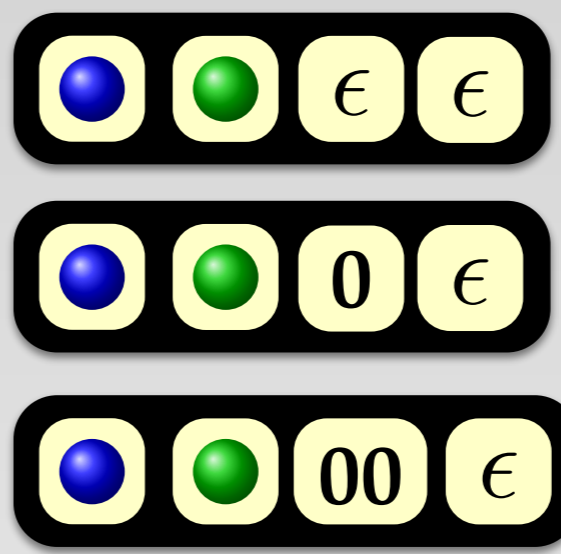
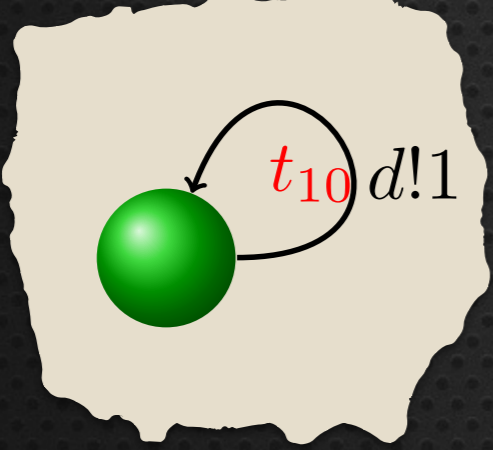
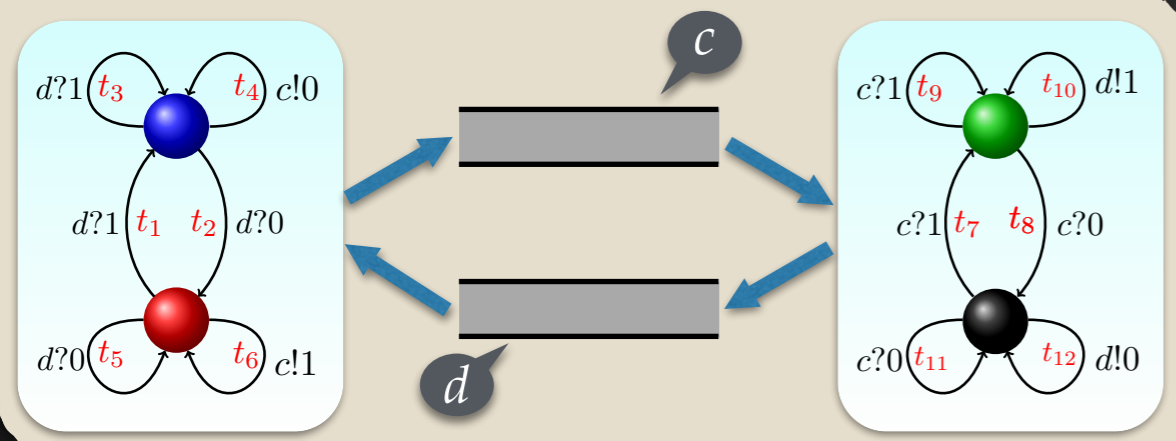


$t_4$

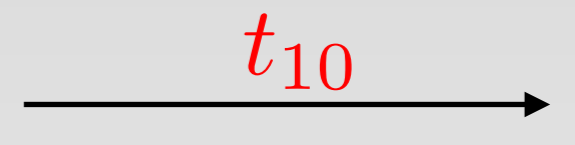
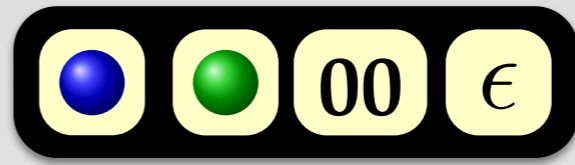
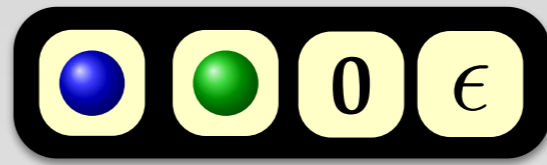
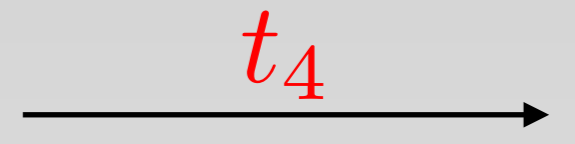
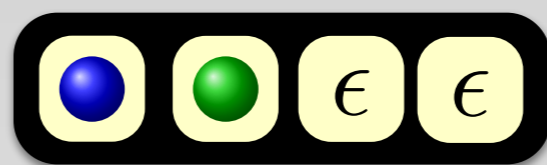
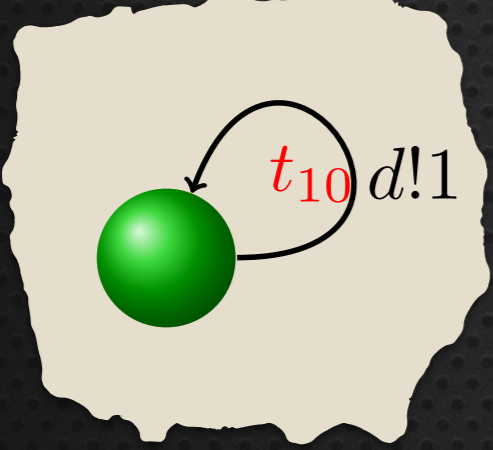
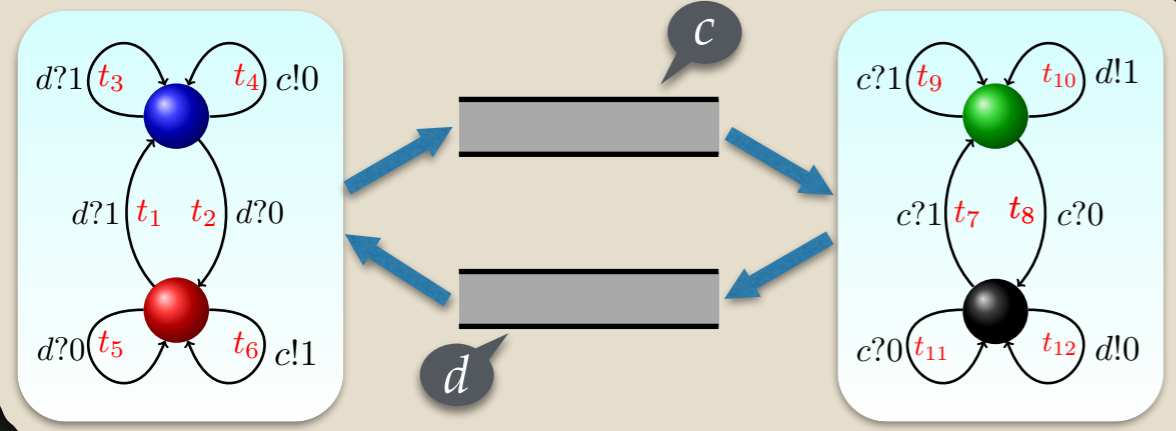




# Lossy Transitions

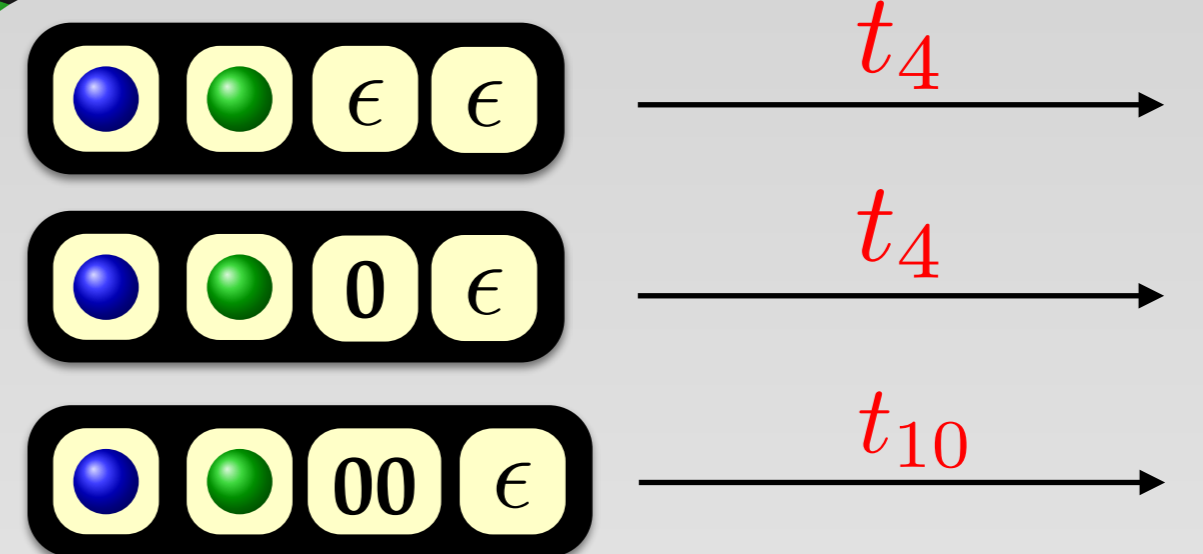
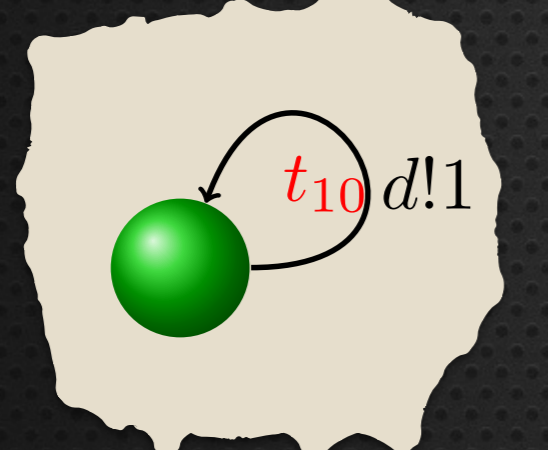
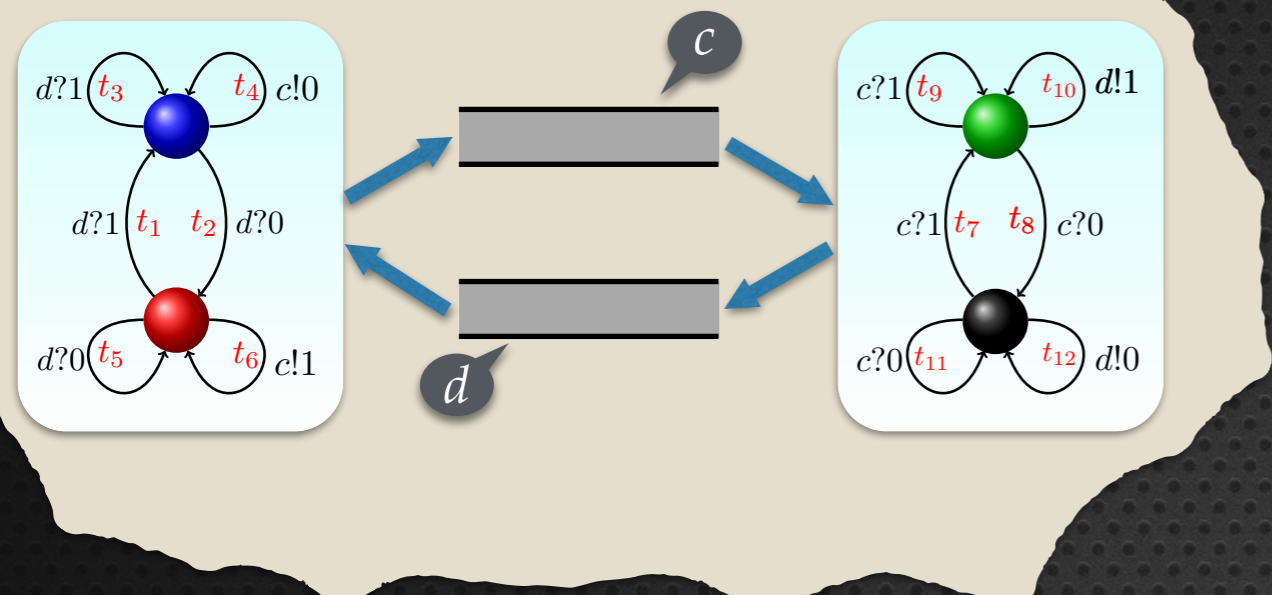


# Lossy Transitions



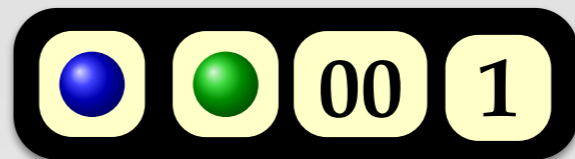
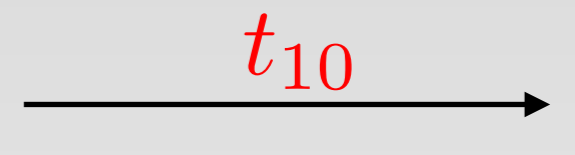
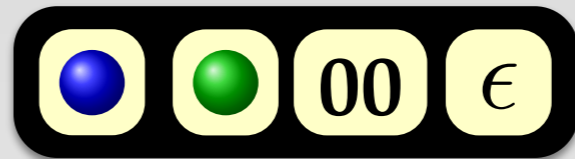
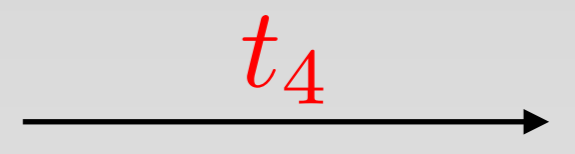
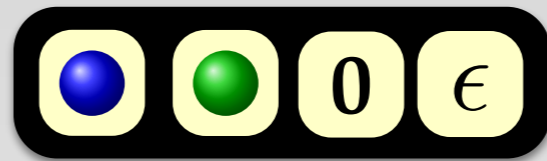
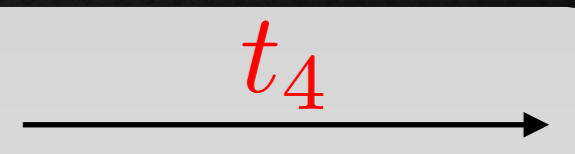
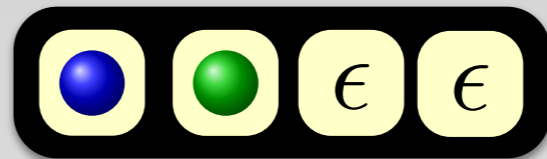
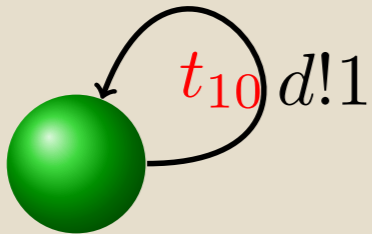
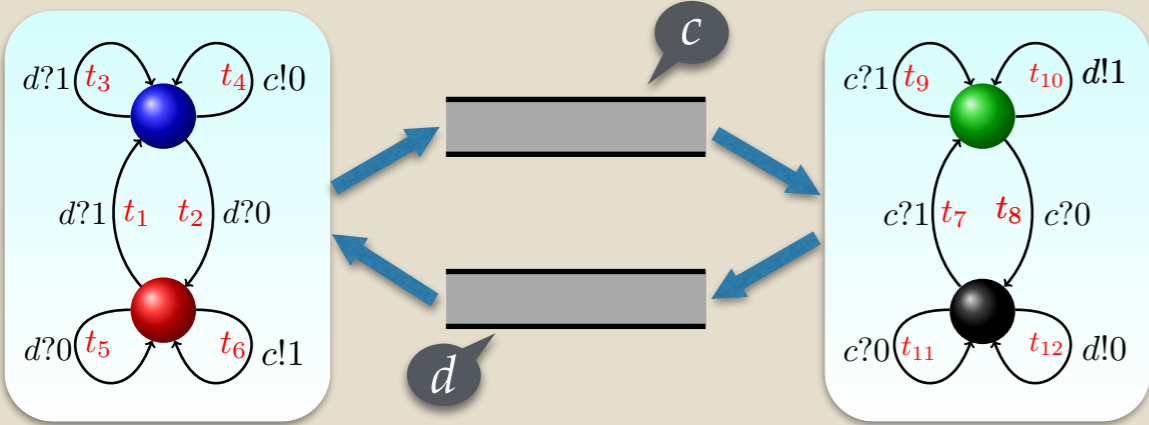


# Lossy Transitions



Lossy

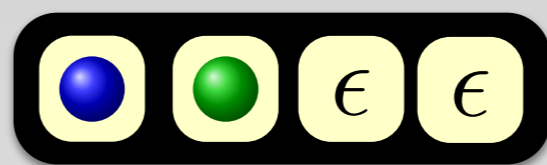
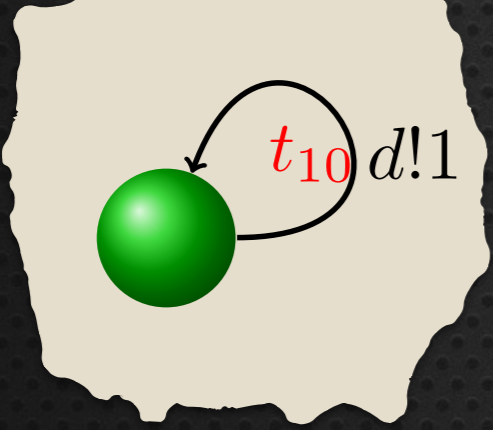
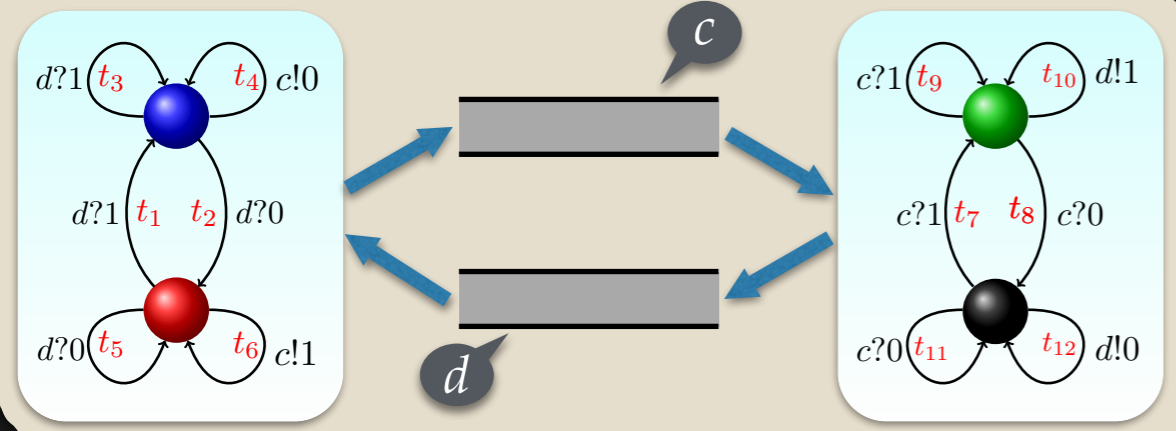
# Transitions



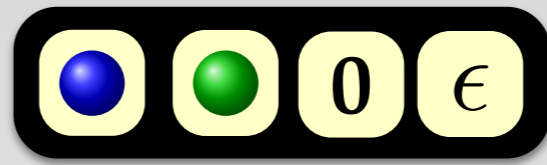


Lossy

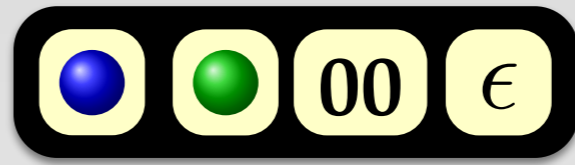
# Transitions



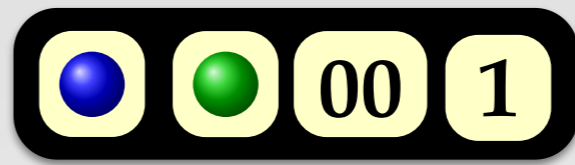
$t_4$



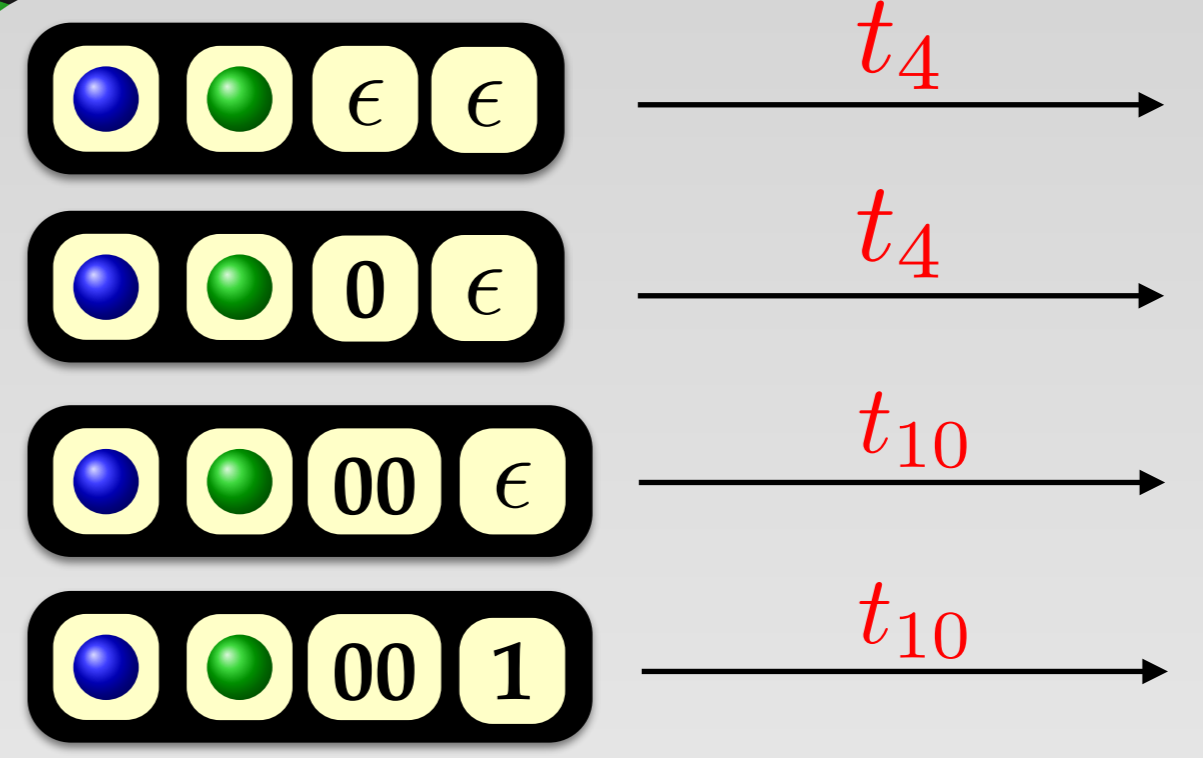
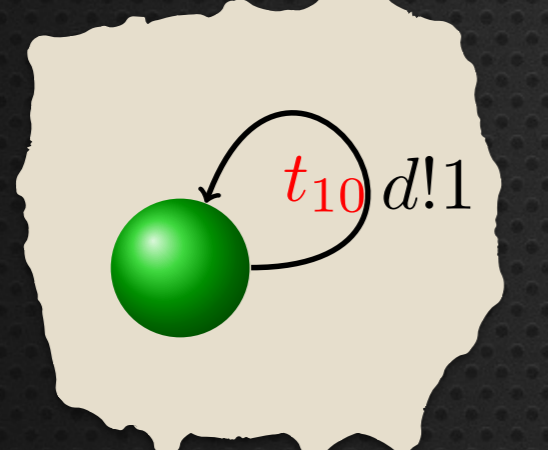
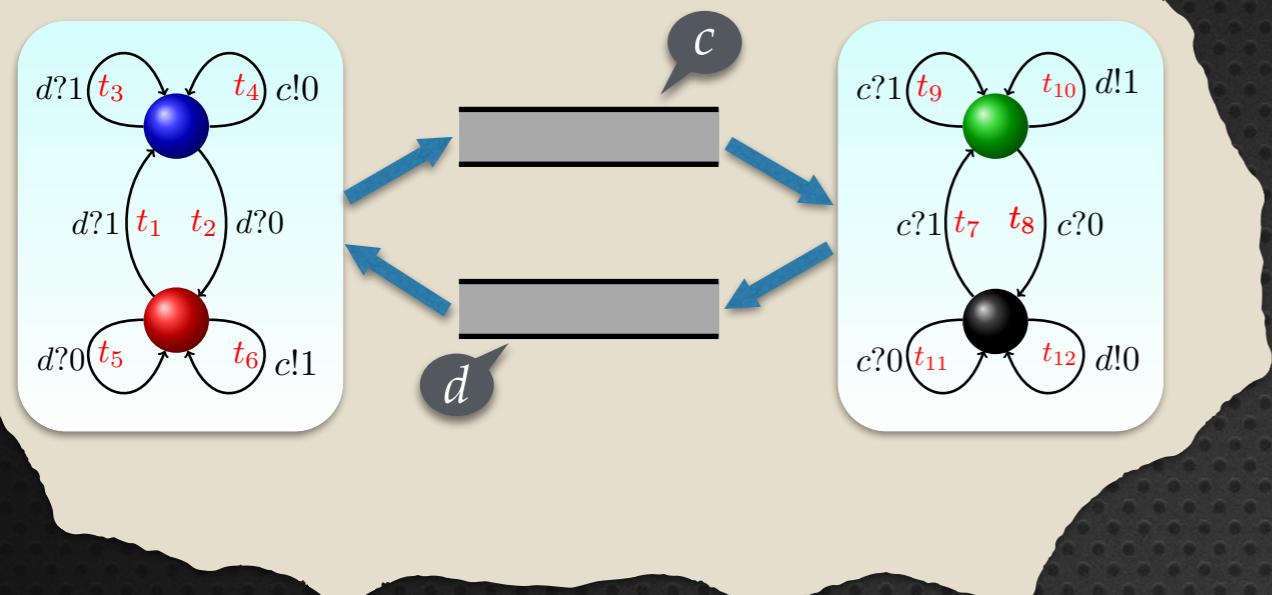
$t_4$



$t_{10}$

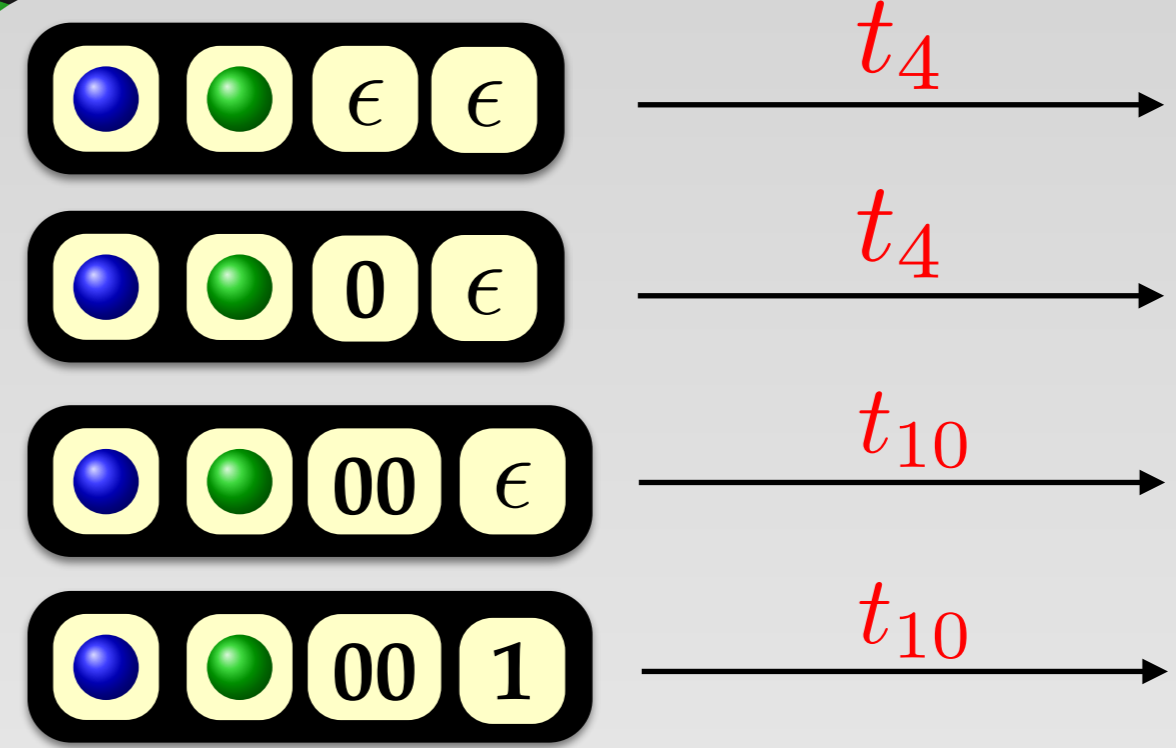
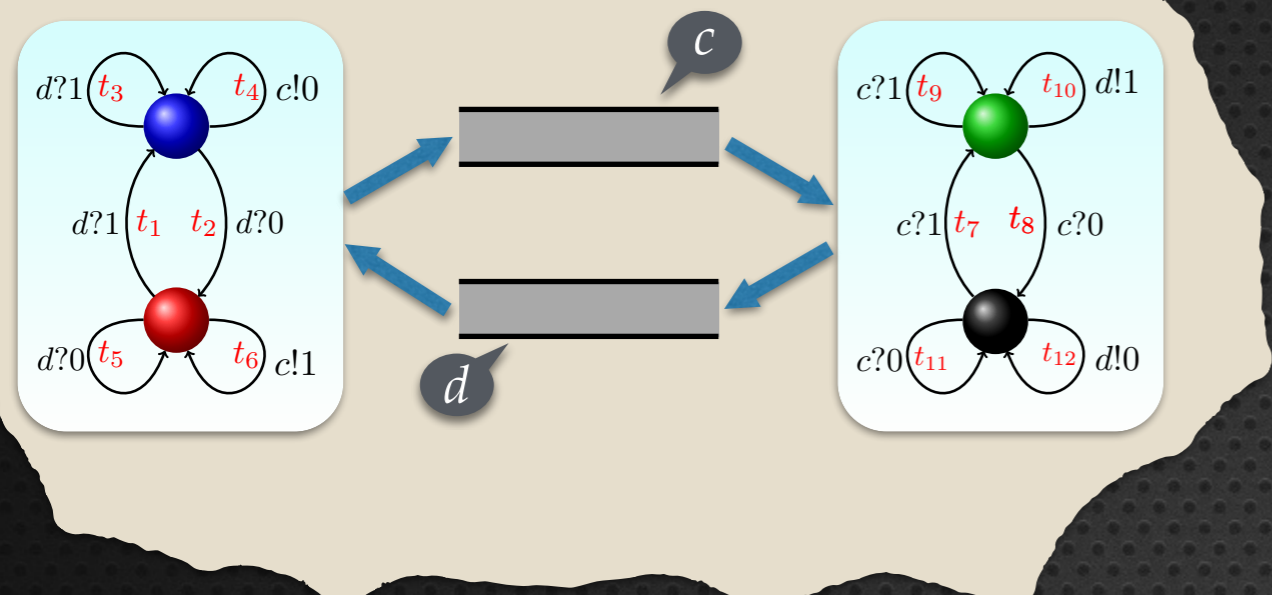


# Lossy Transitions



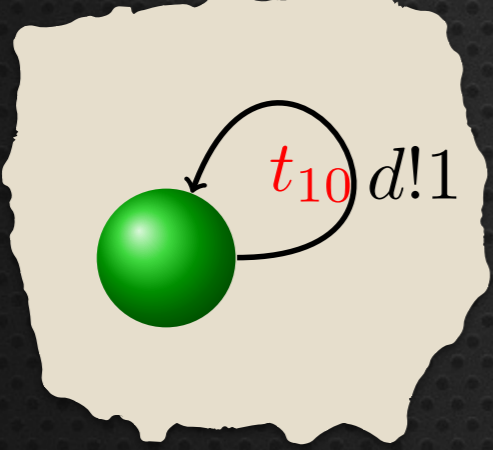
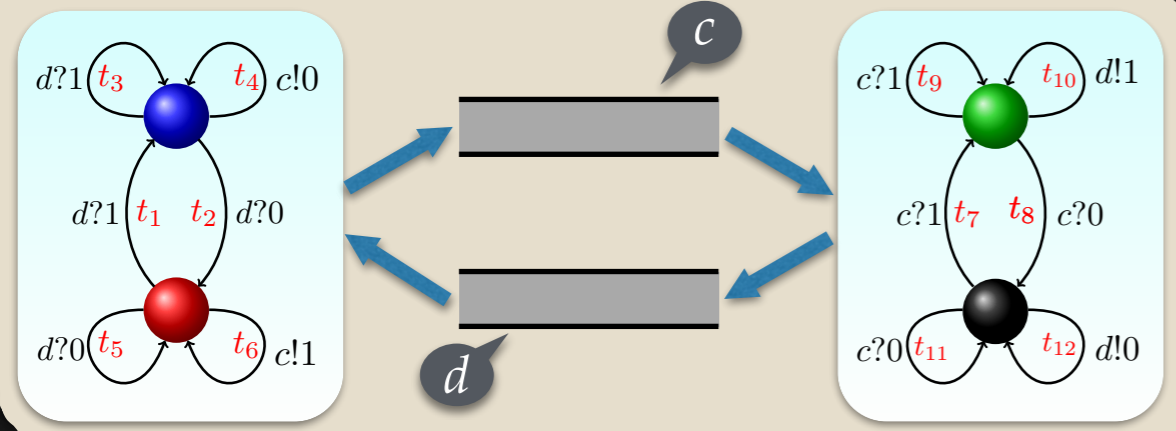


# Lossy Transitions



Lossy

# Transitions



Blue node, Green node, € €

$t_4$

Blue node, Green node, 0 €

$t_4$

Blue node, Green node, 00 €

$t_{10}$

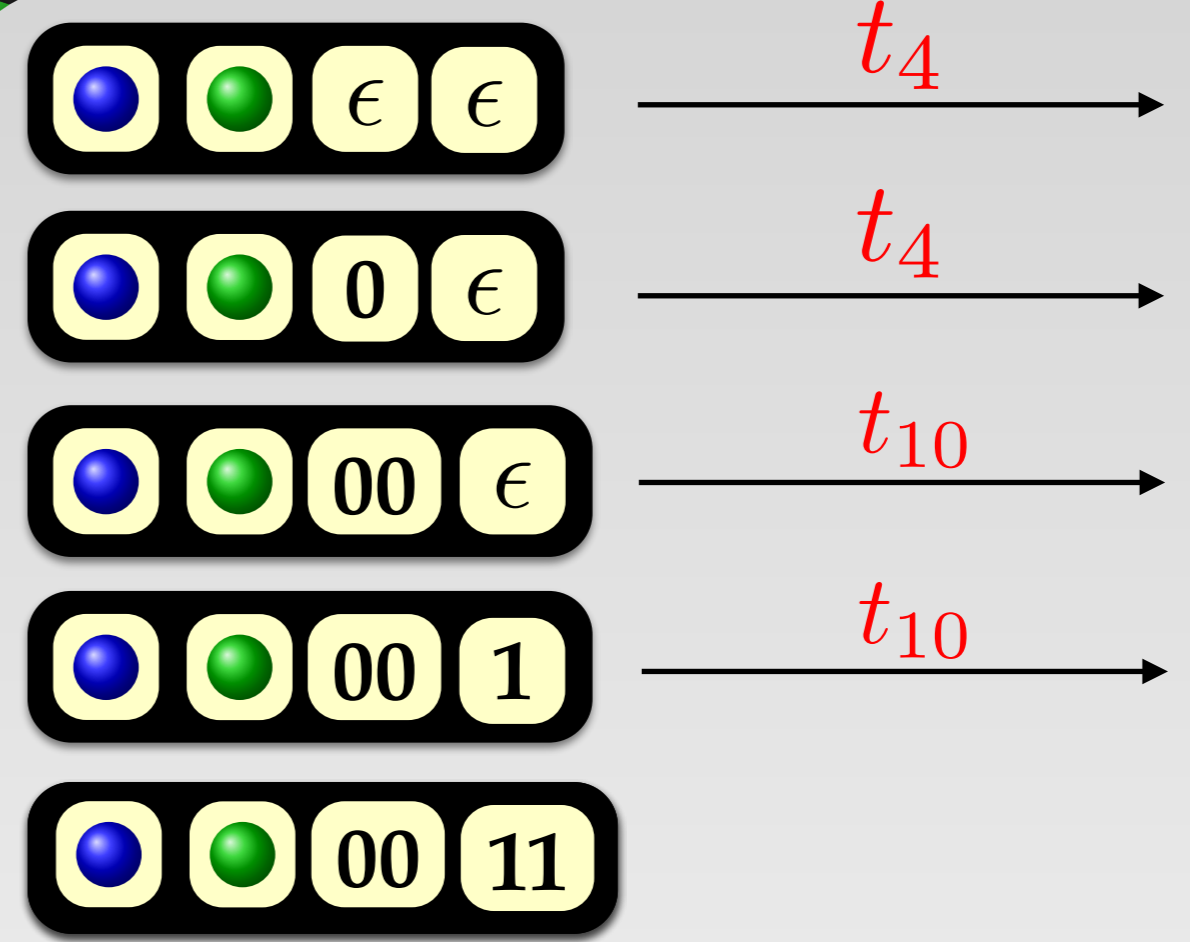
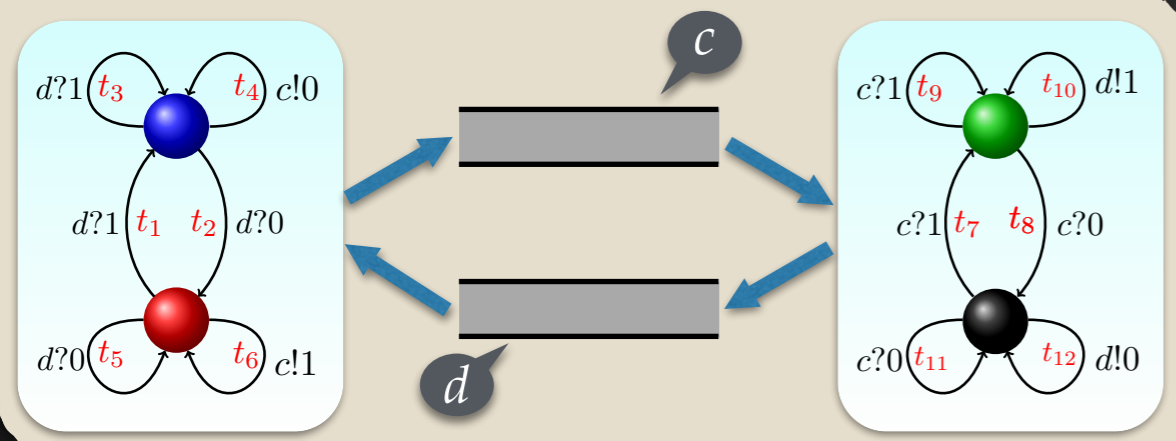
Blue node, Green node, 00 1

$t_{10}$

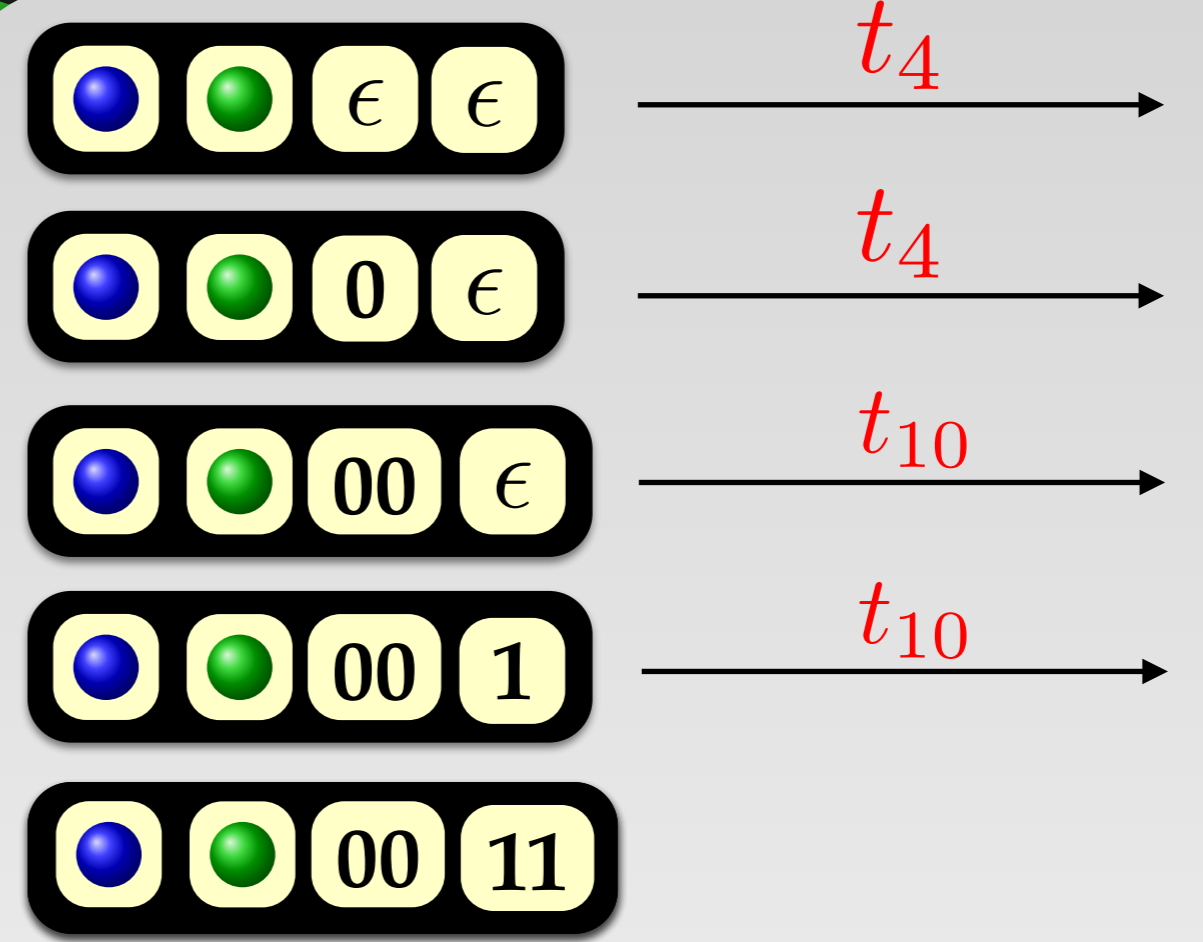
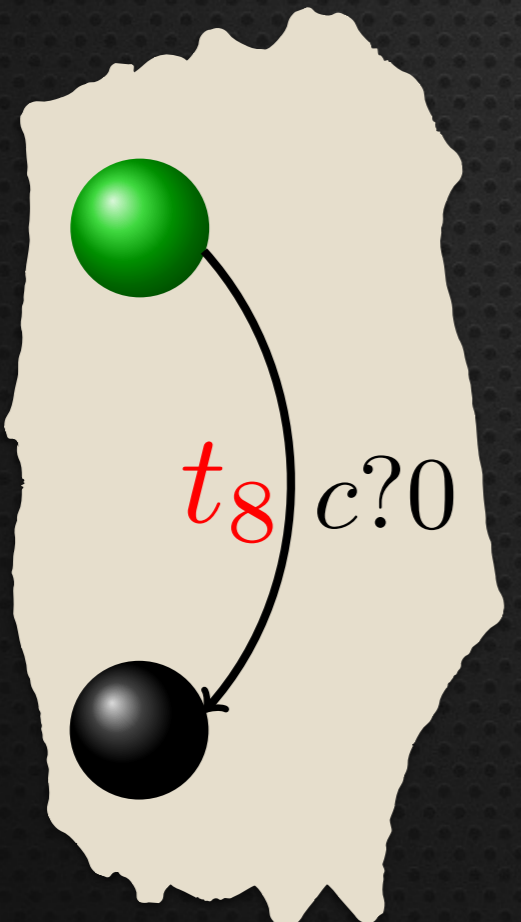
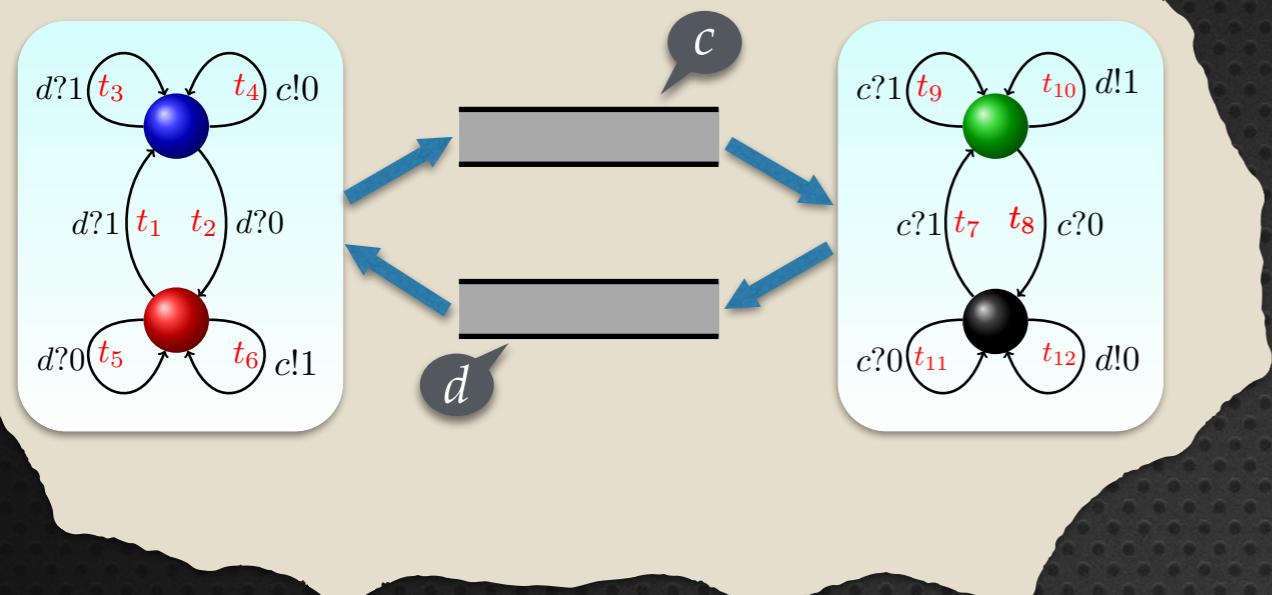
Blue node, Green node, 00 11



# Lossy Transitions

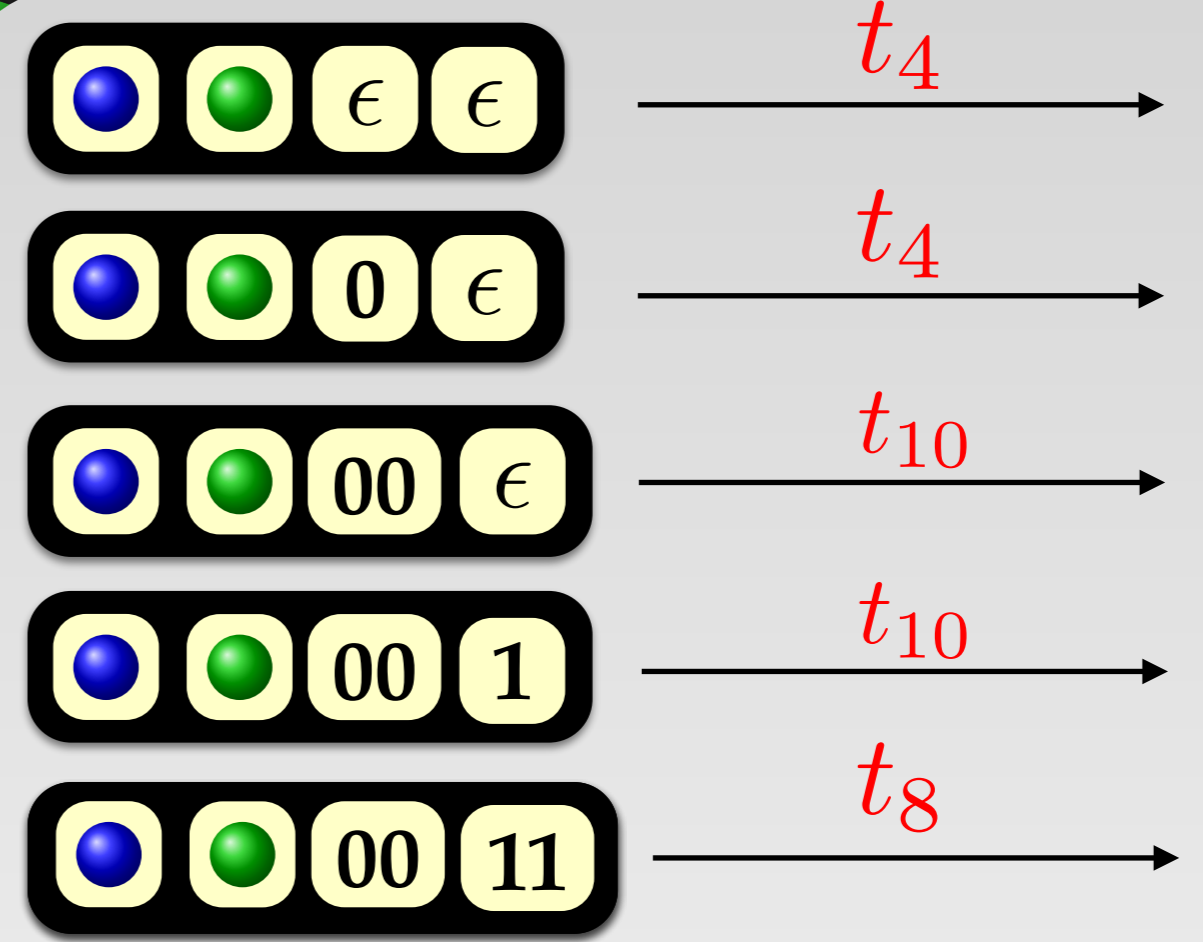
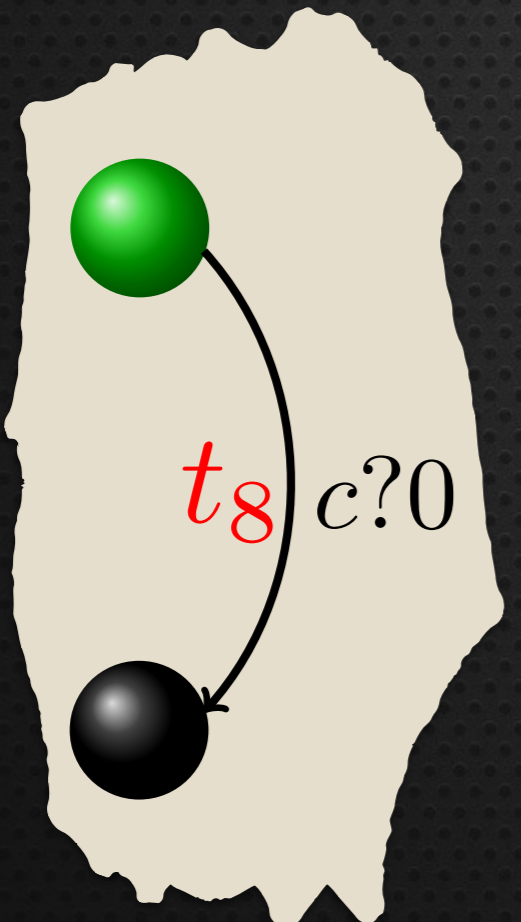
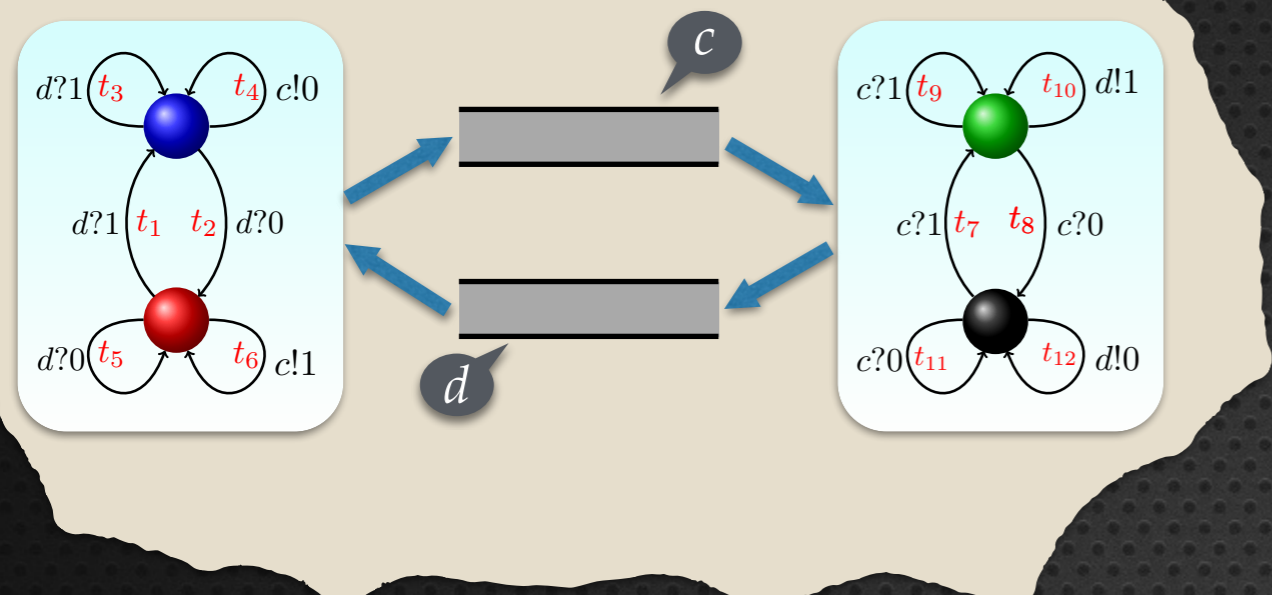


# Lossy Transitions

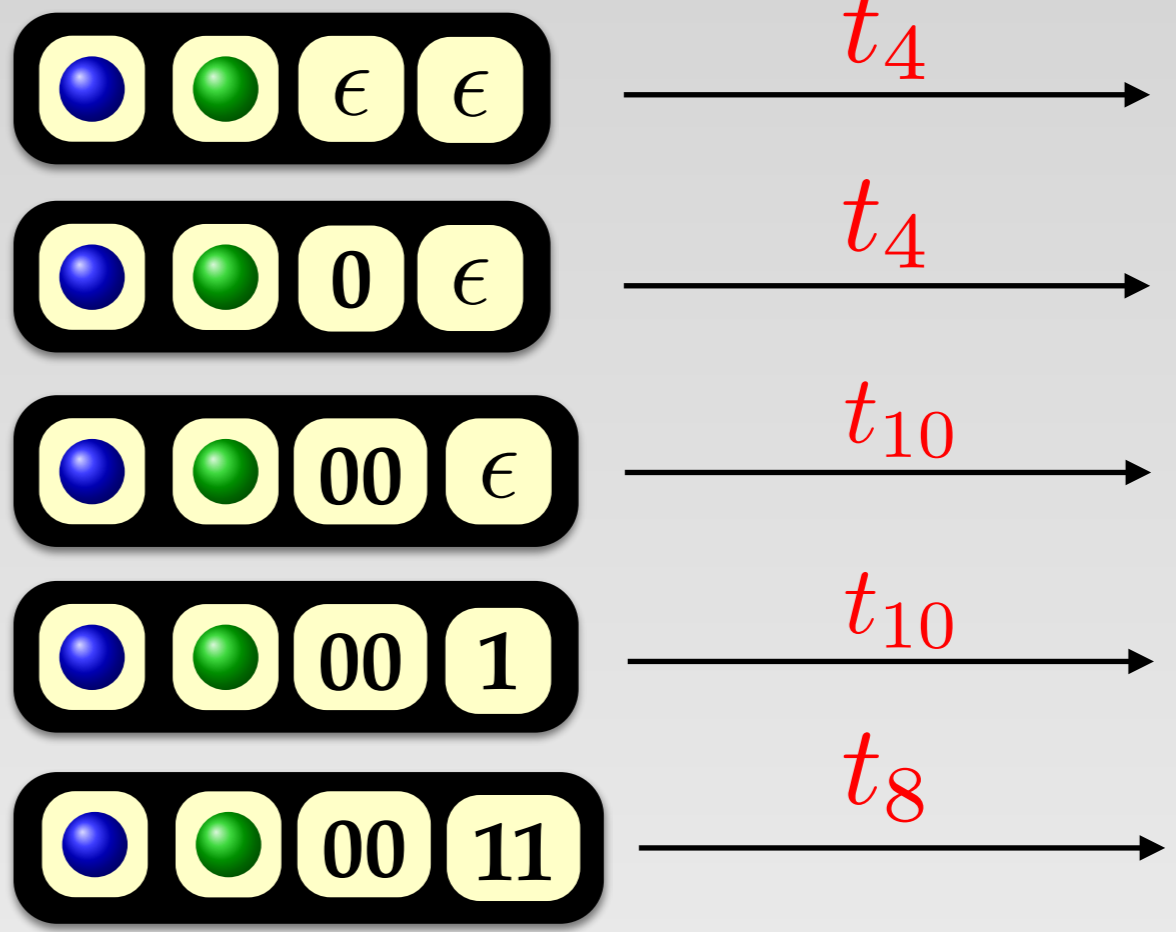
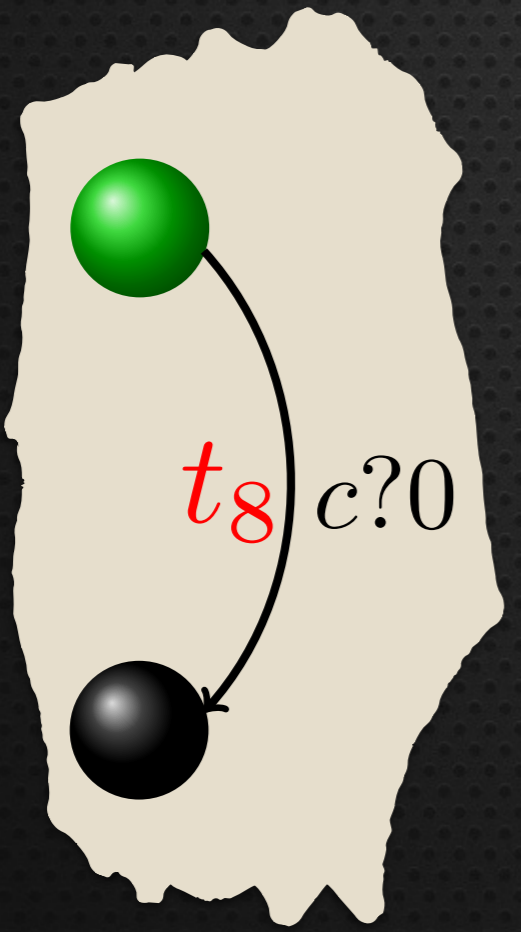
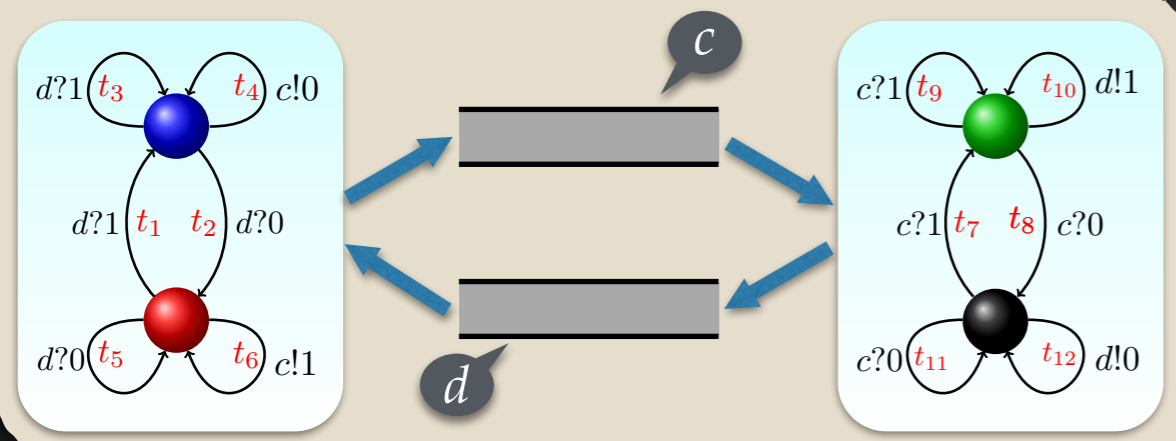




# Lossy Transitions

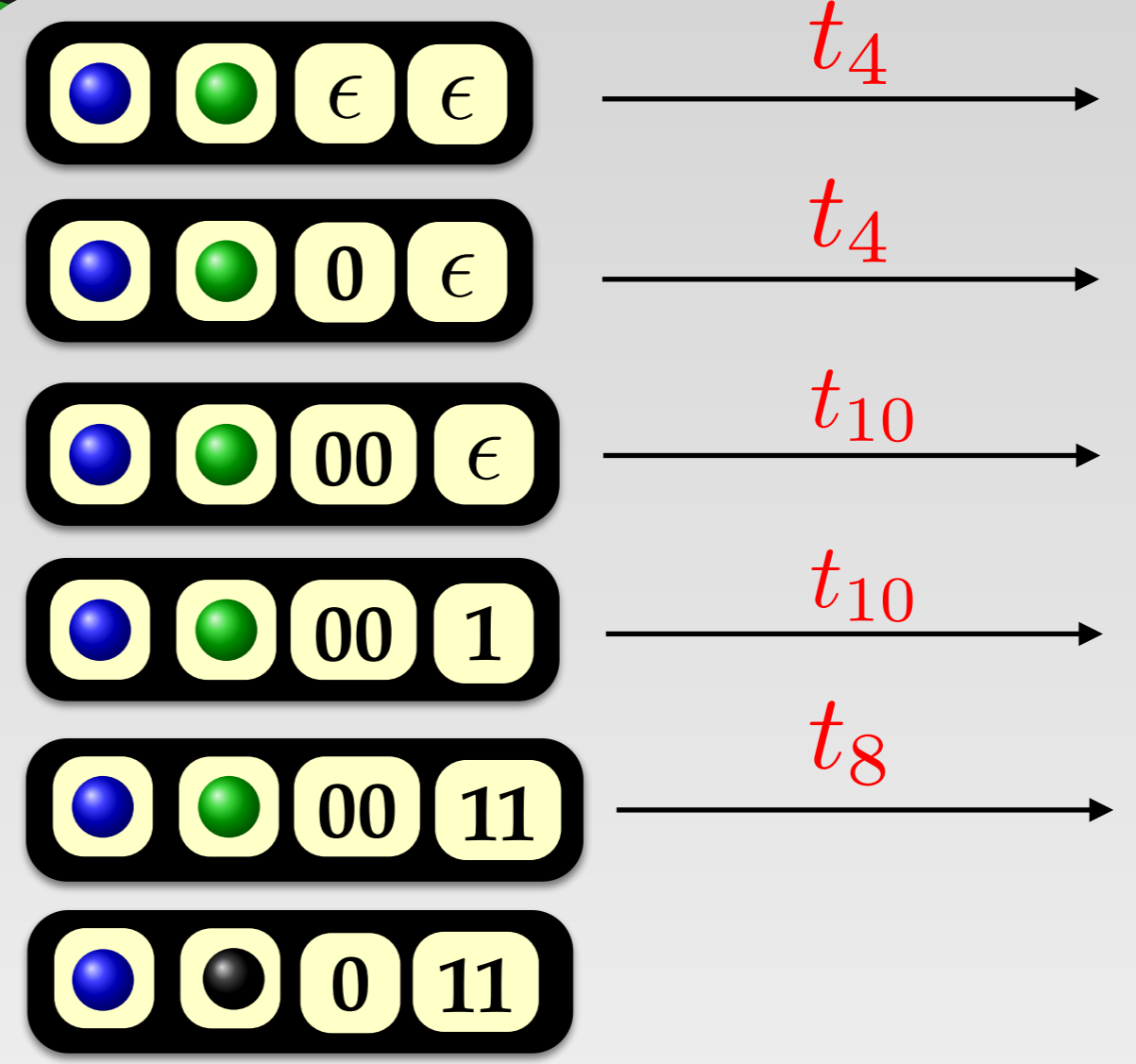
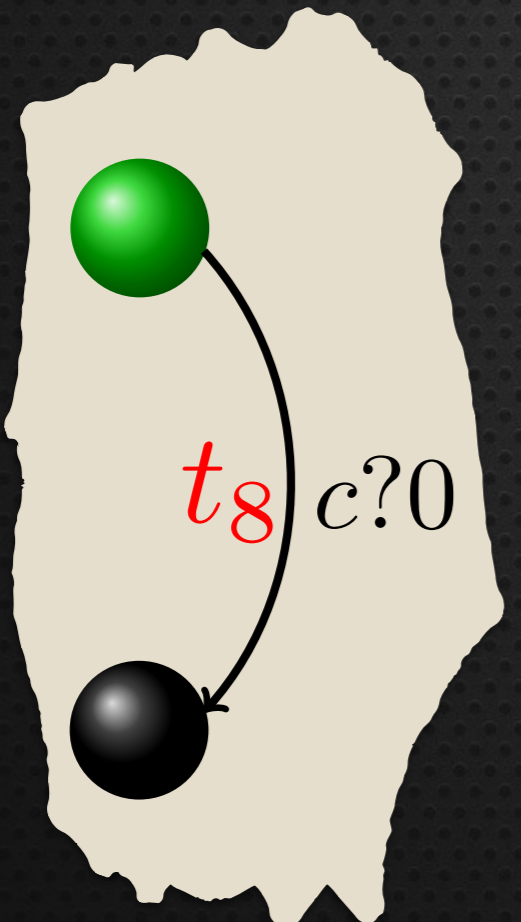
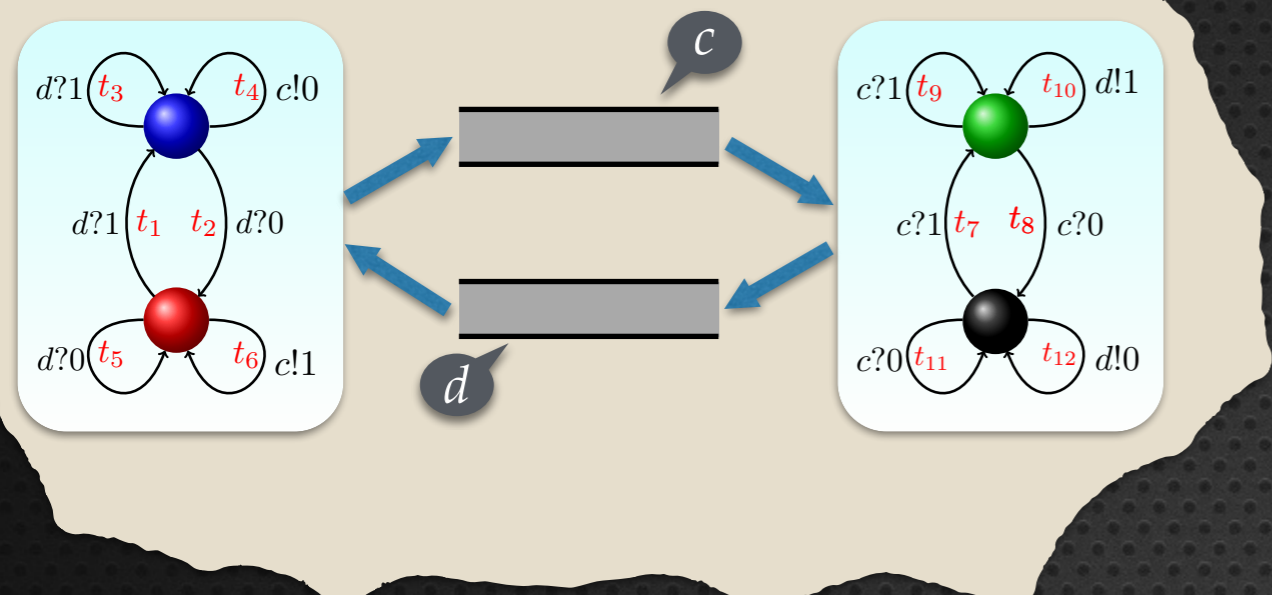


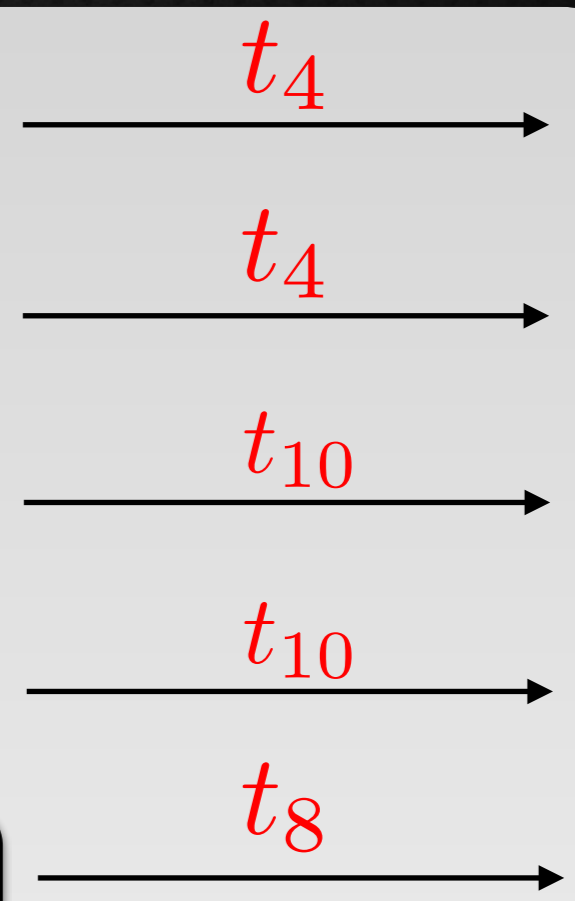
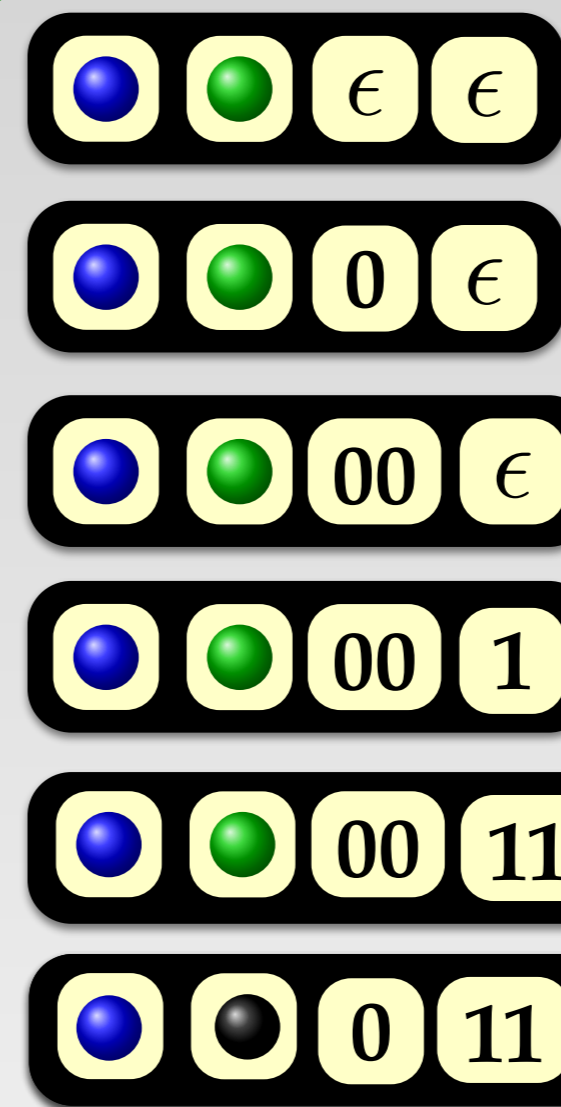
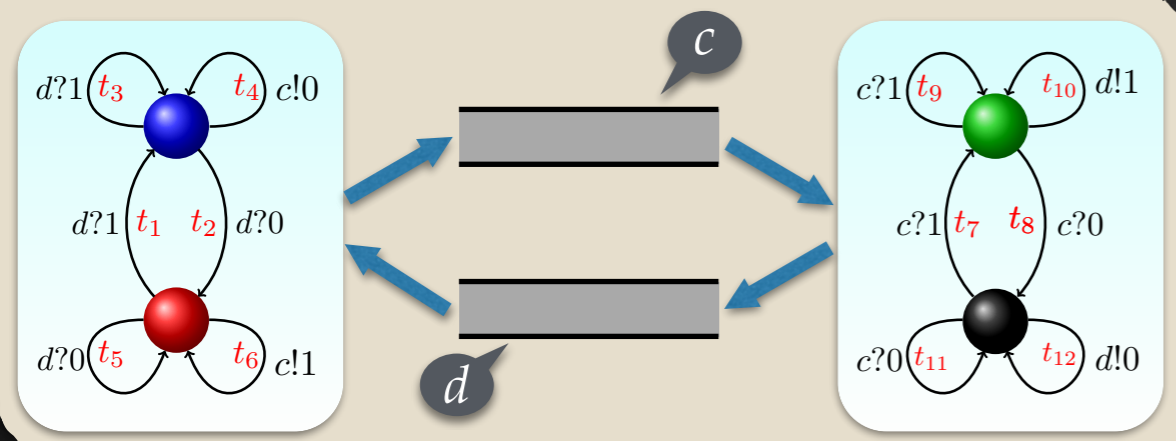
# Lossy Transitions



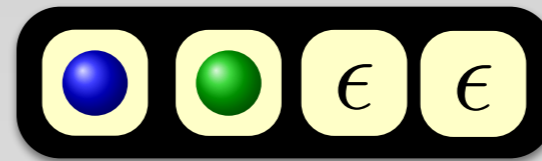
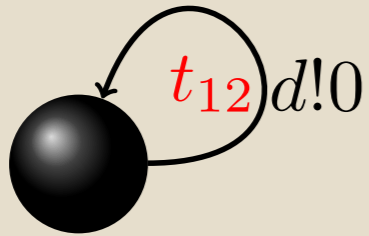
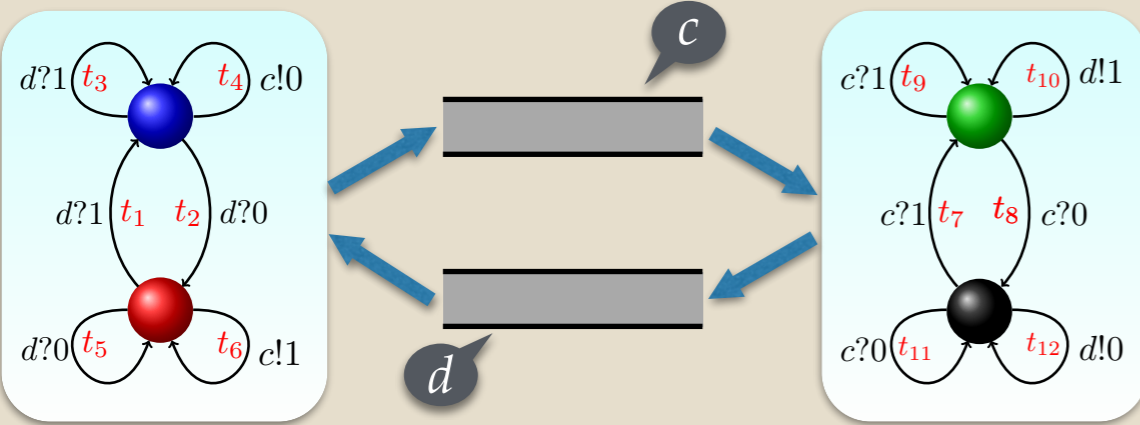


# Lossy Transitions

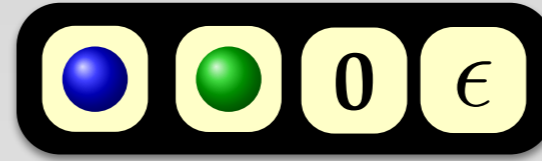




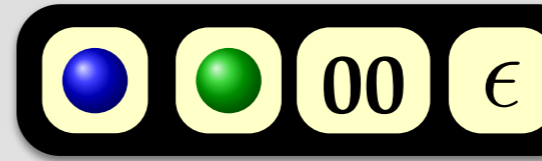




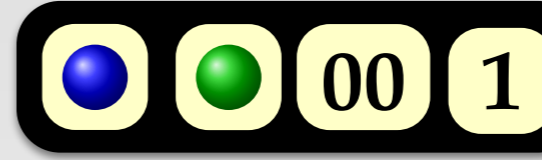
$t_4$



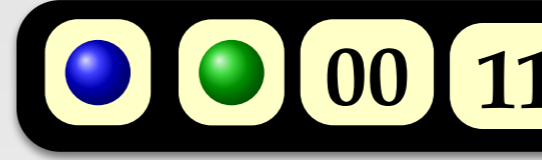
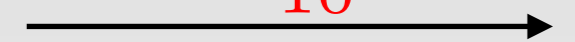
$t_4$



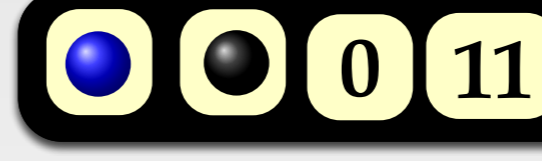
$t_{10}$

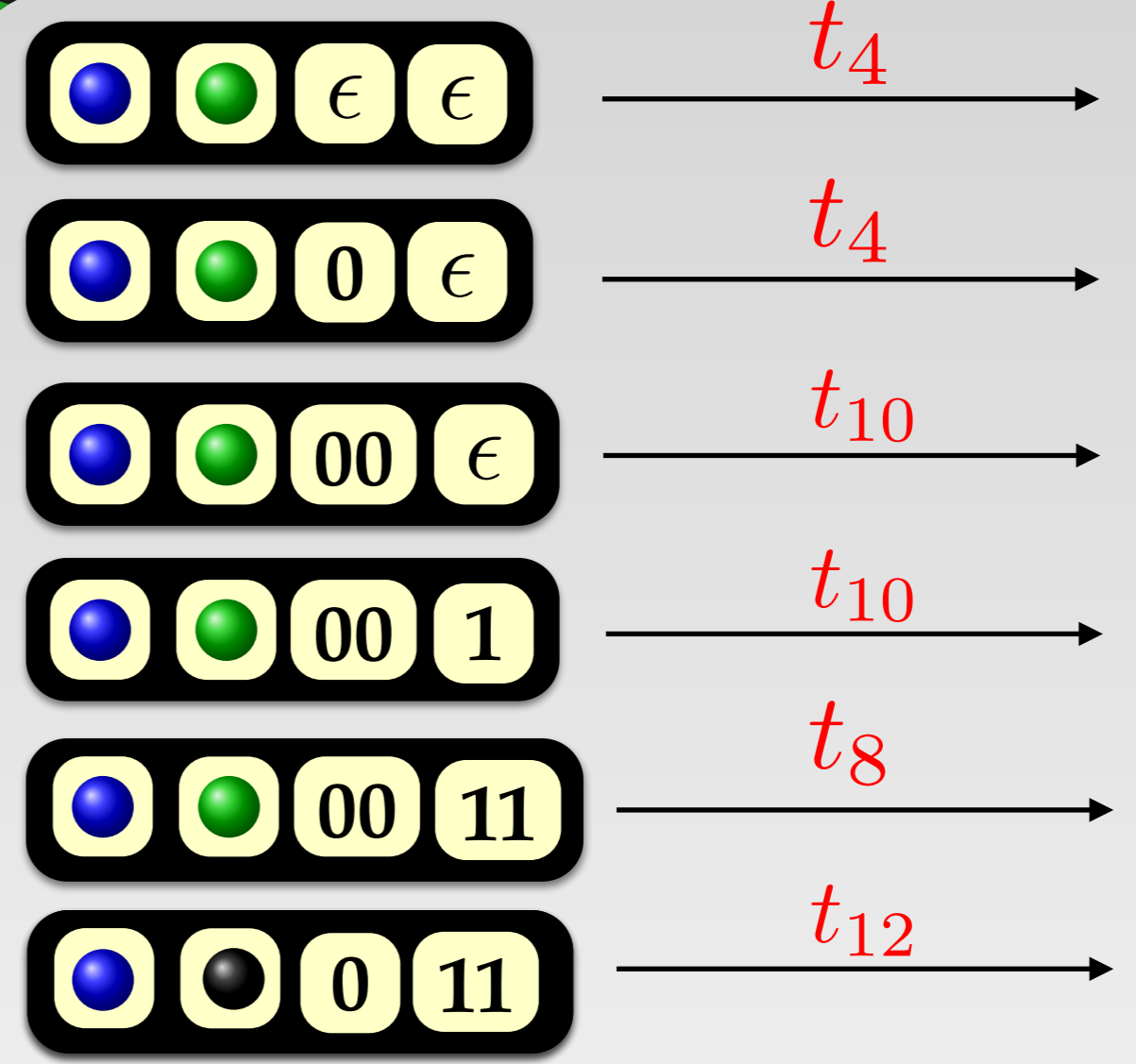
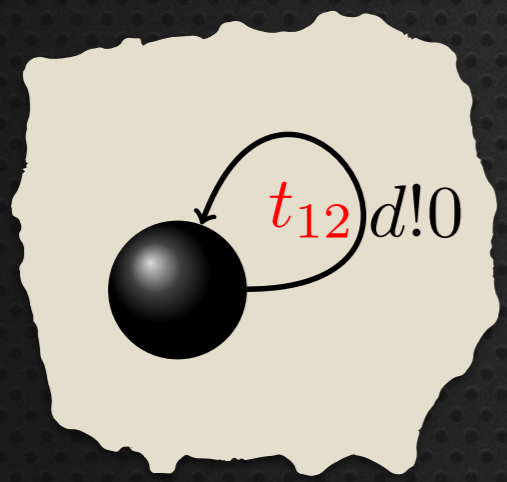
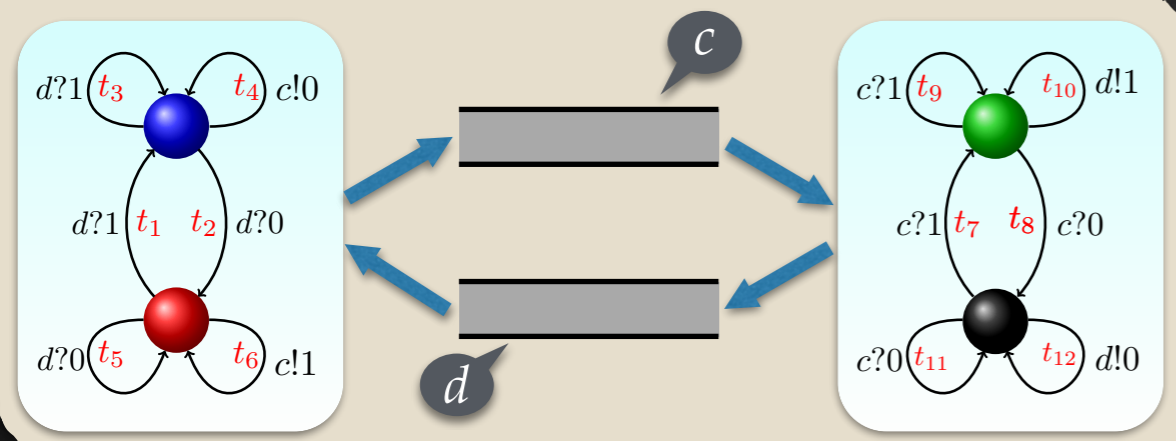


$t_{10}$

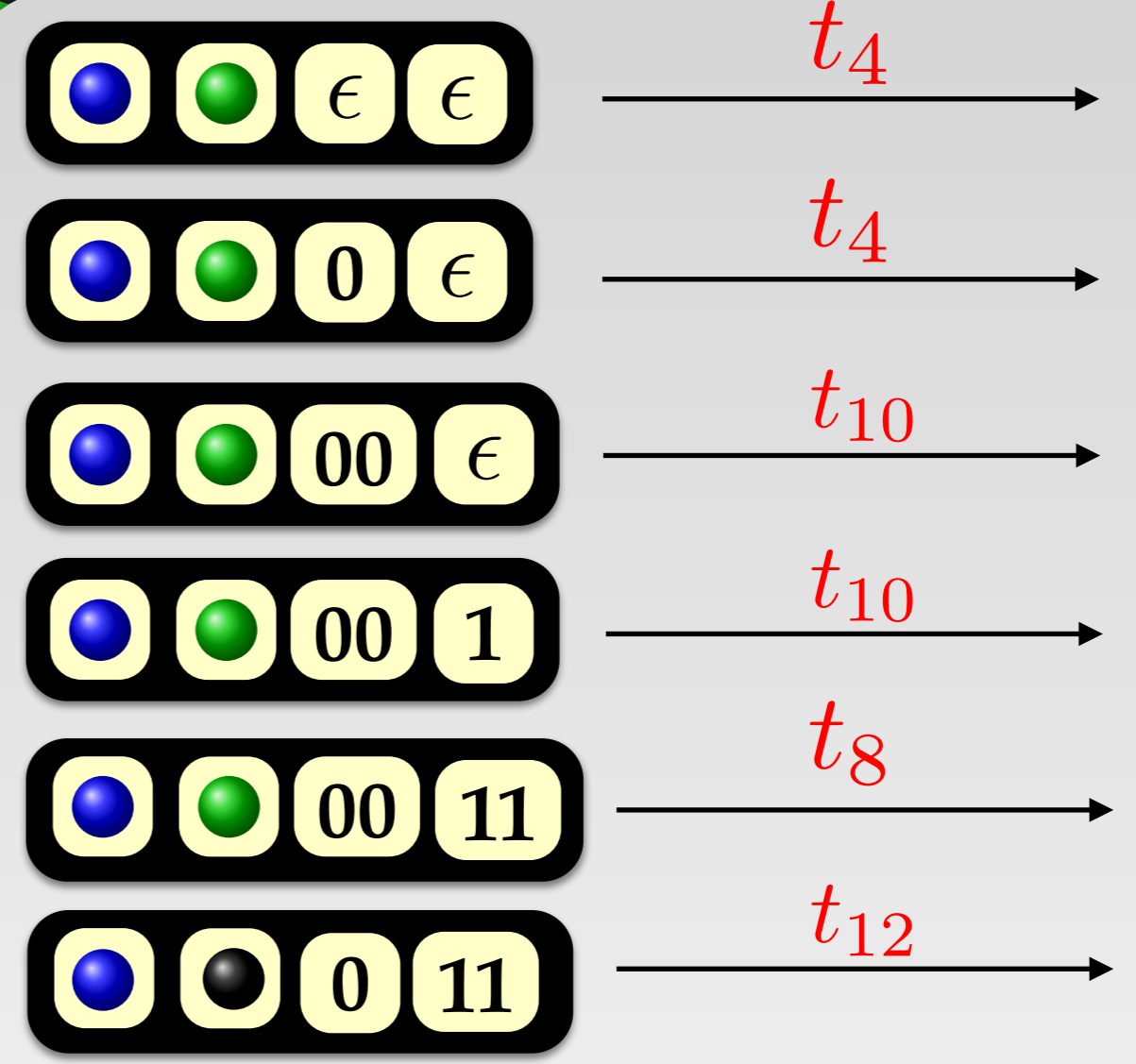
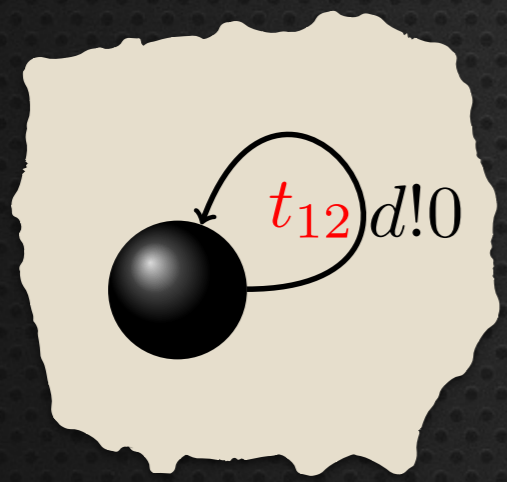
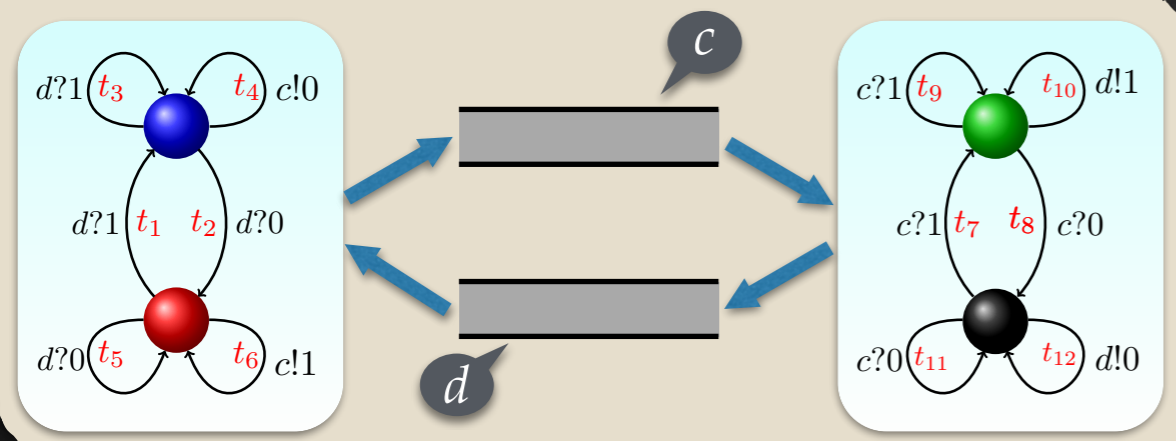


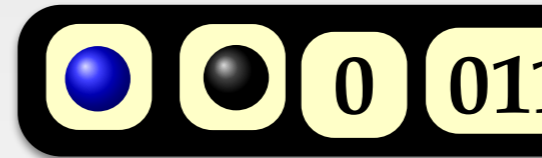
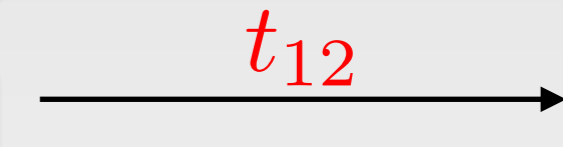
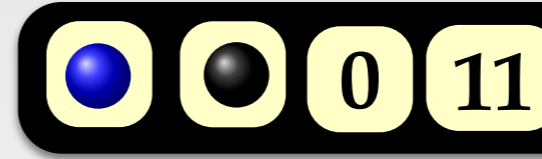
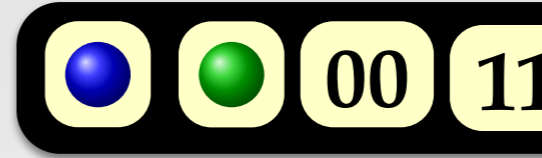
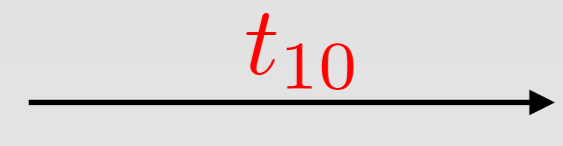
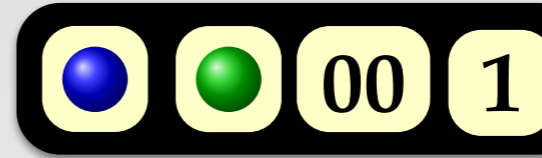
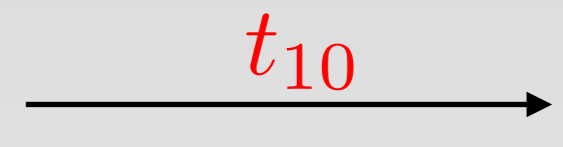
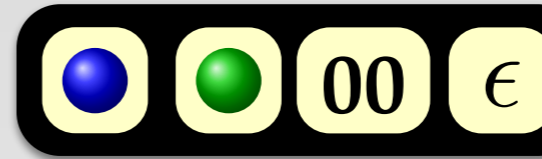
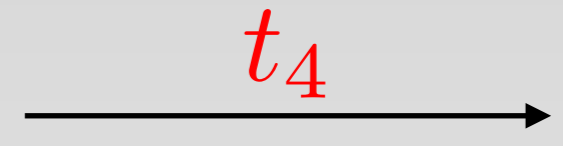
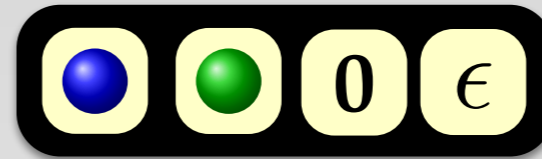
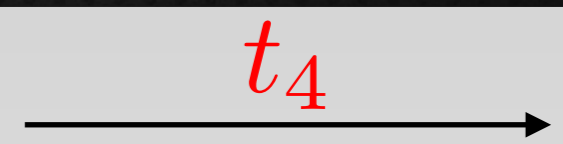
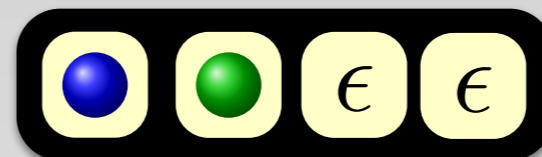
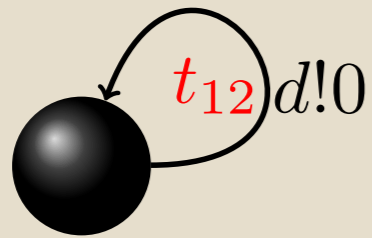
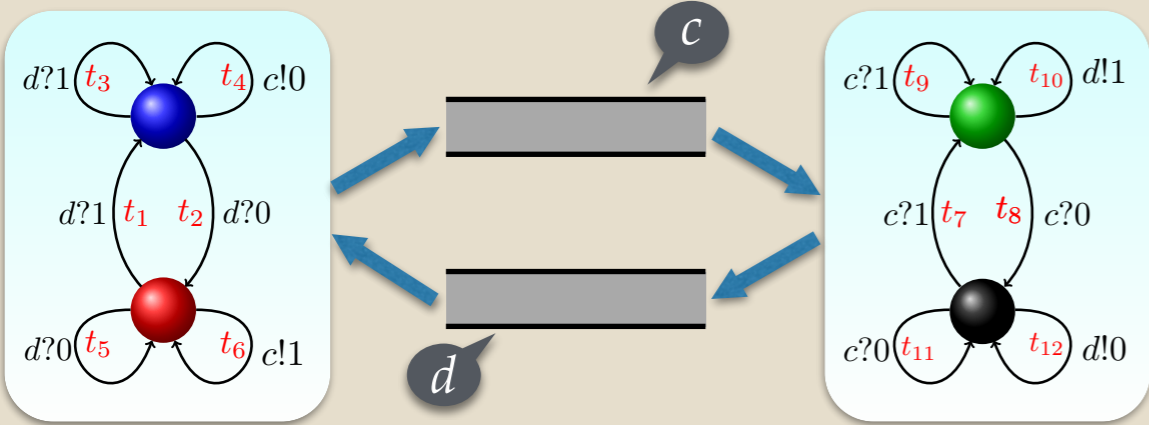
$t_8$



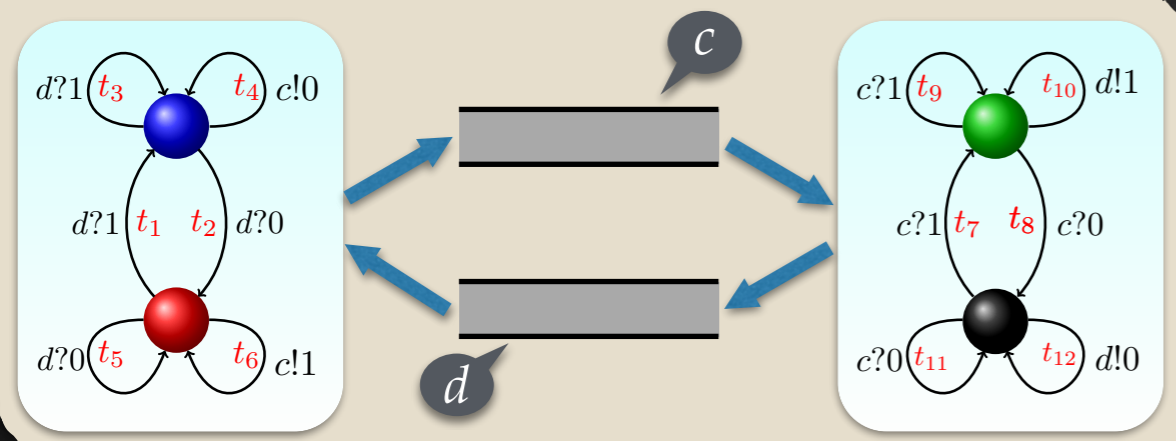












Blue circle, Green circle, € €

$t_4$

Blue circle, Green circle, 0 €

$t_4$

Blue circle, Green circle, 00 €

$t_{10}$

Blue circle, Green circle, 00 1

$t_{10}$

Blue circle, Green circle, 00 11

$t_8$

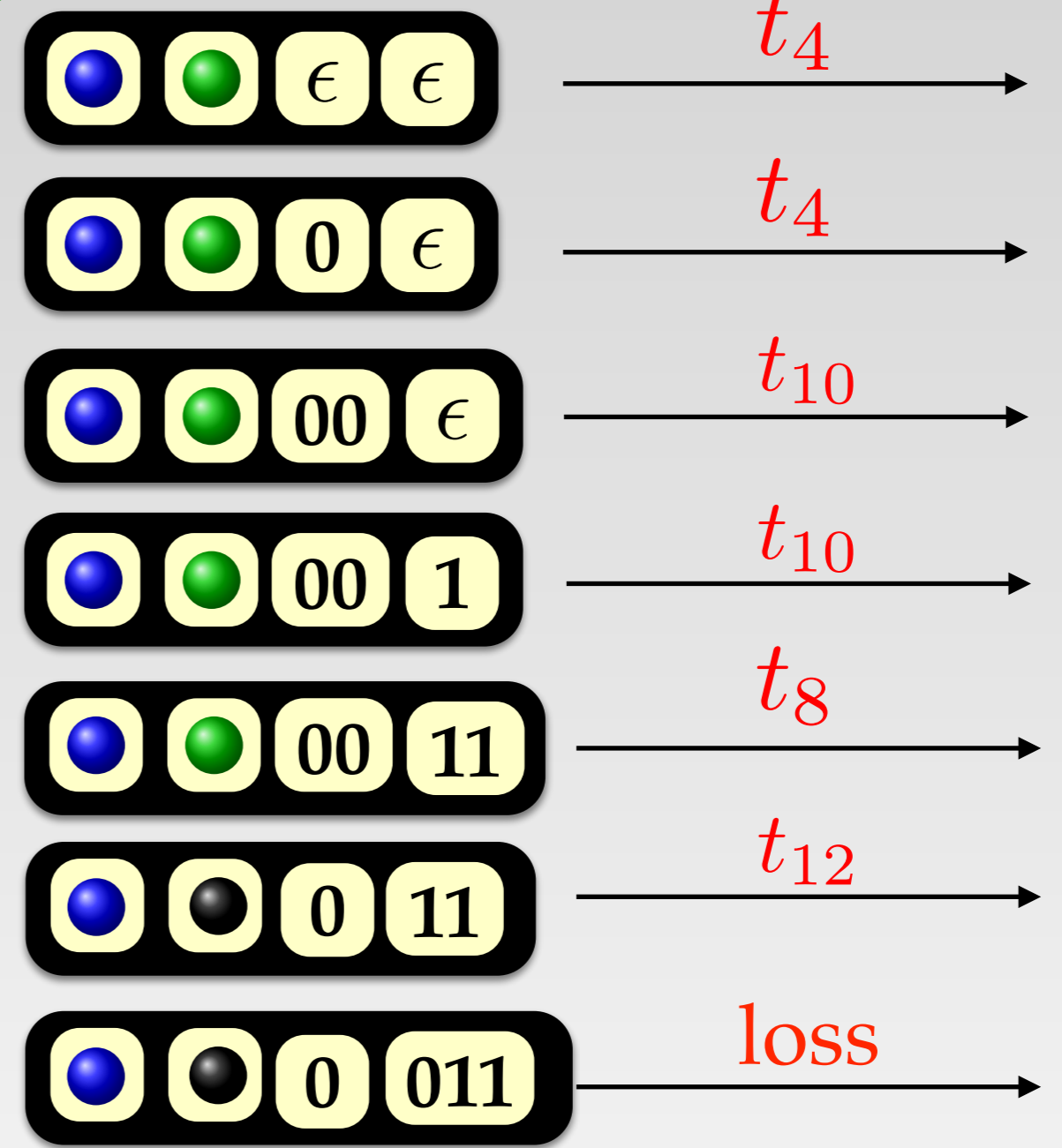
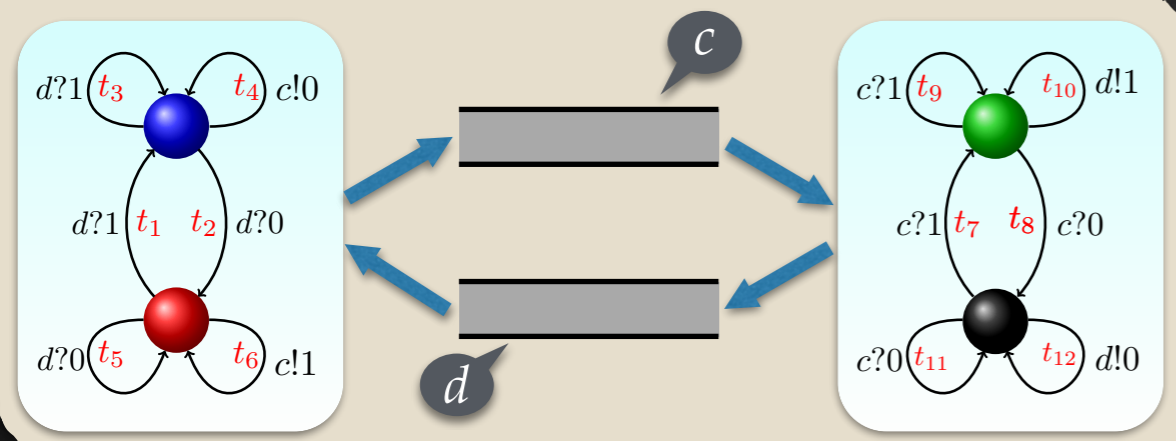
Blue circle, Black circle, 0 11

$t_{12}$

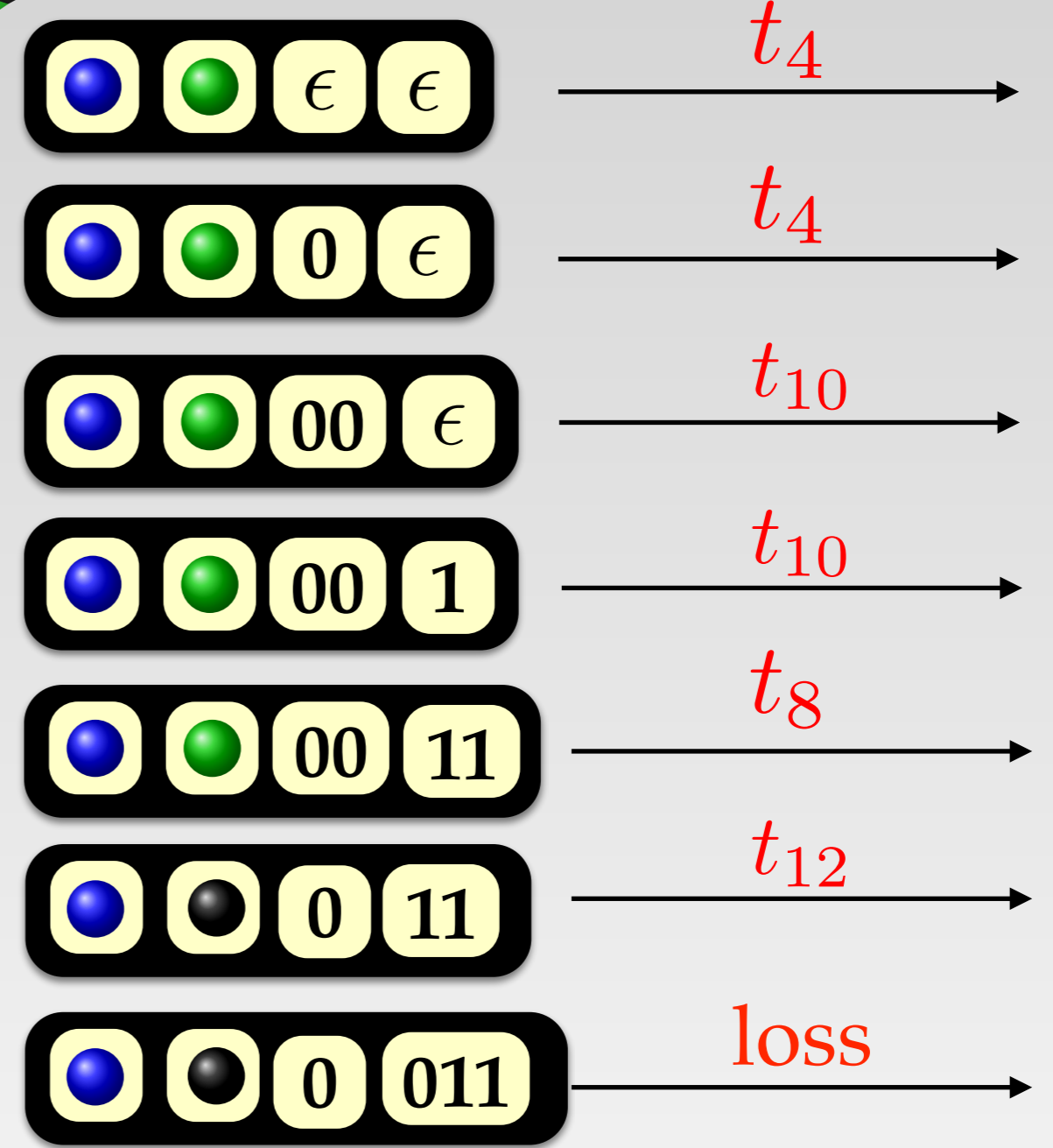
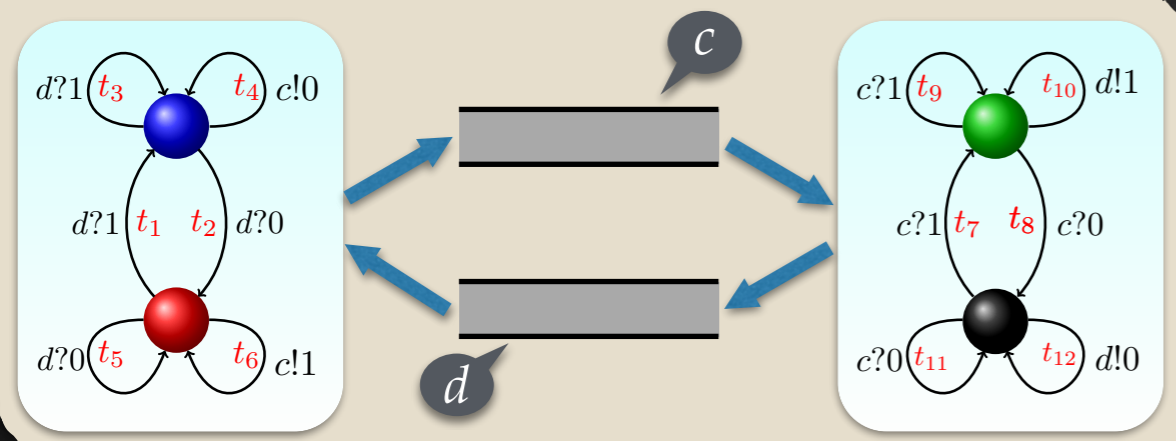
Blue circle, Black circle, 0 011

Lossy

# Transitions

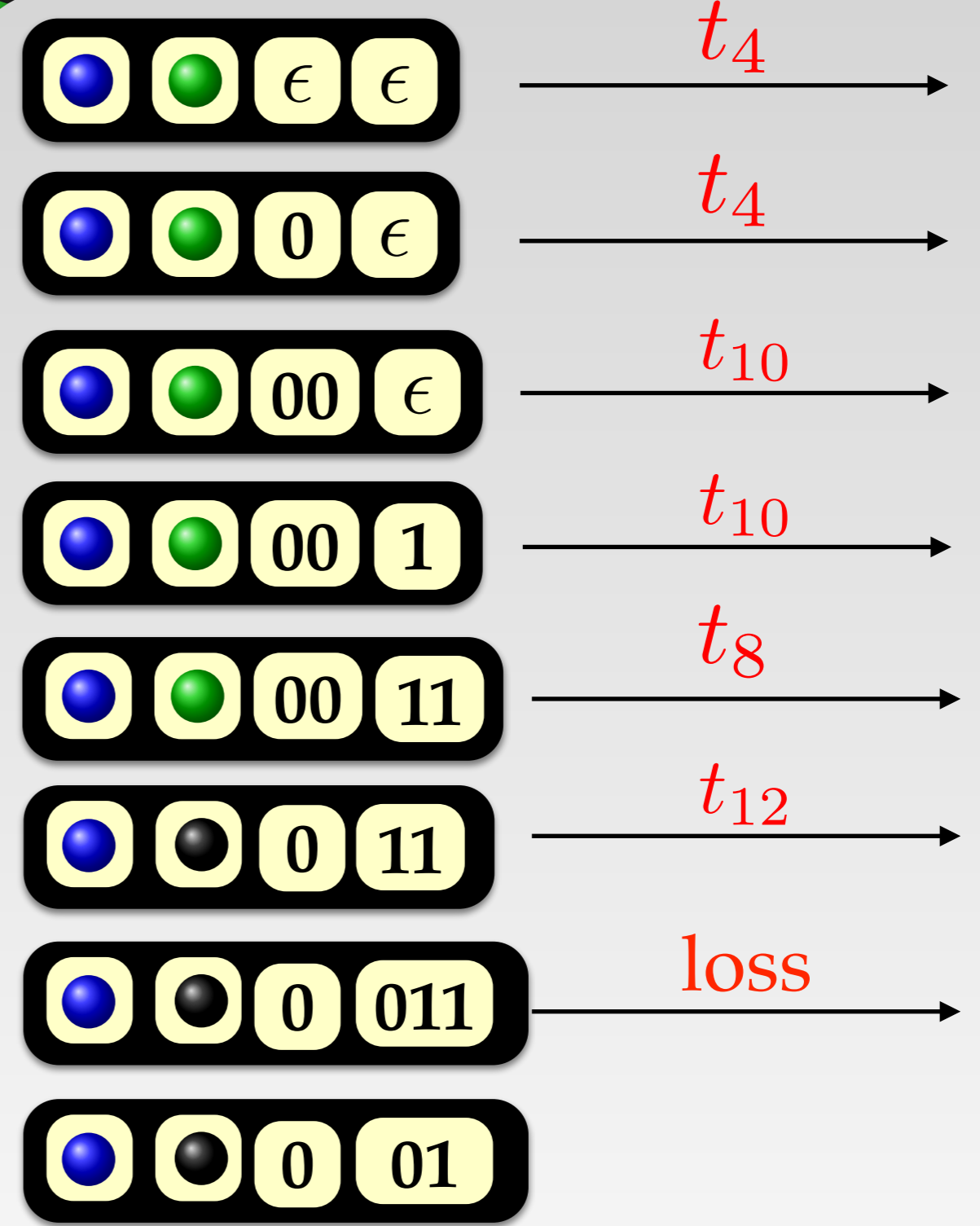
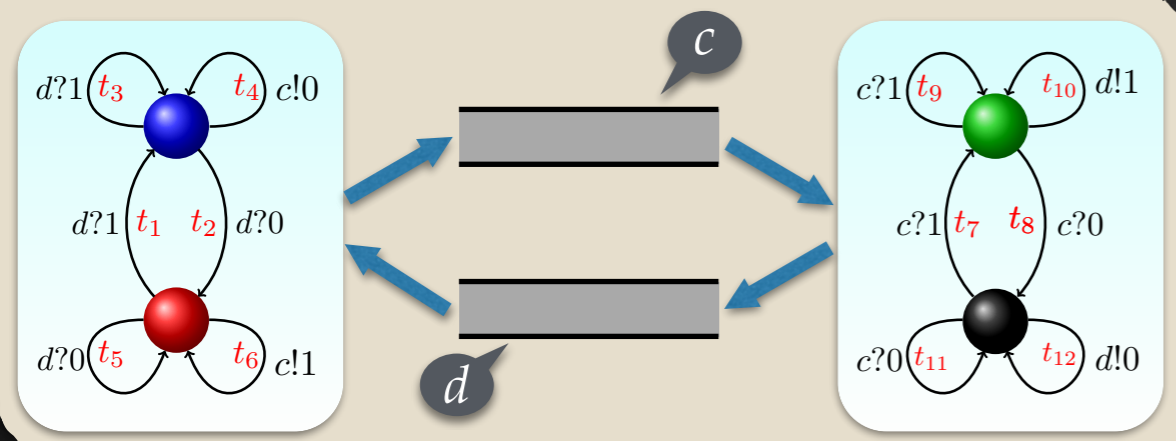






Lossy

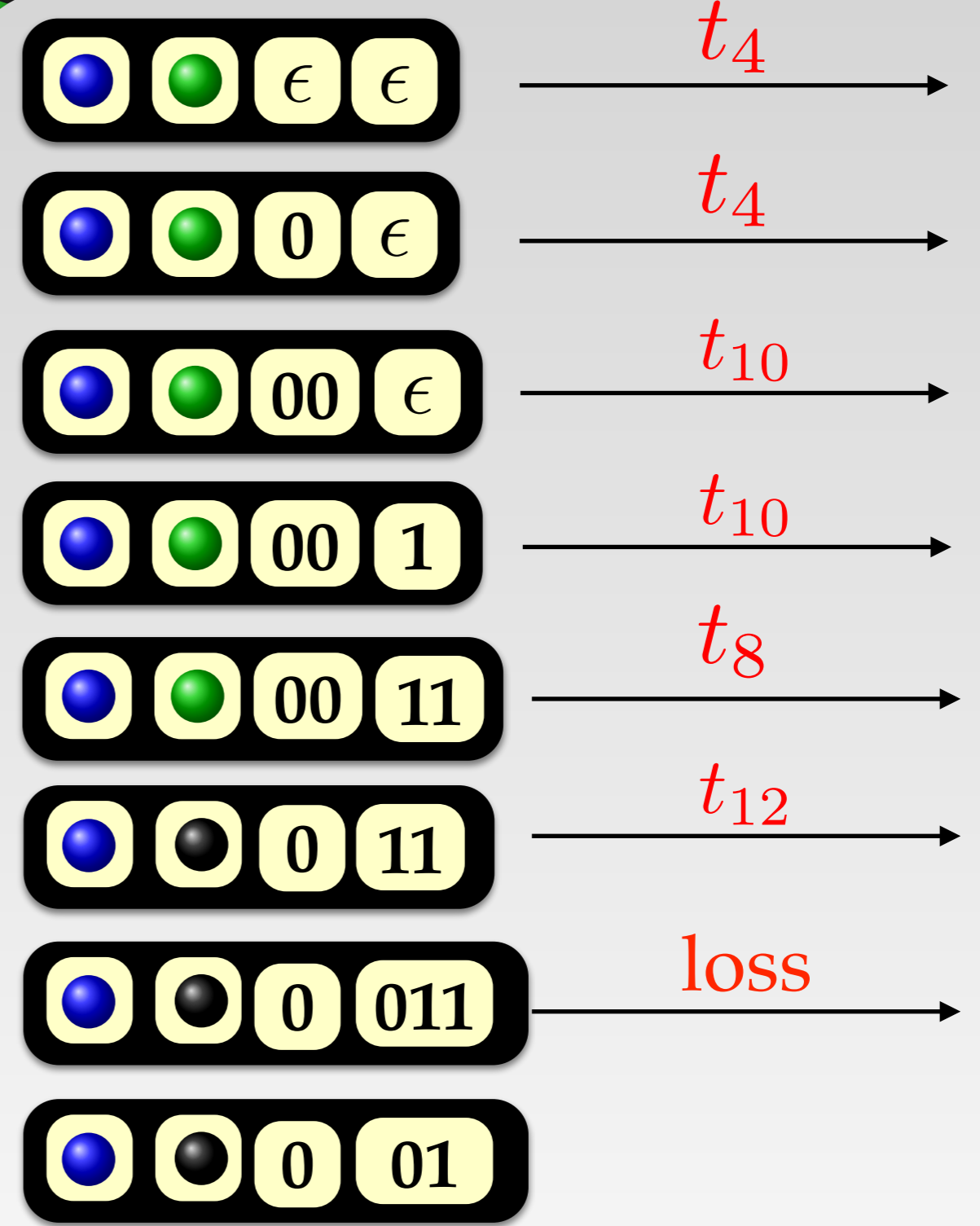
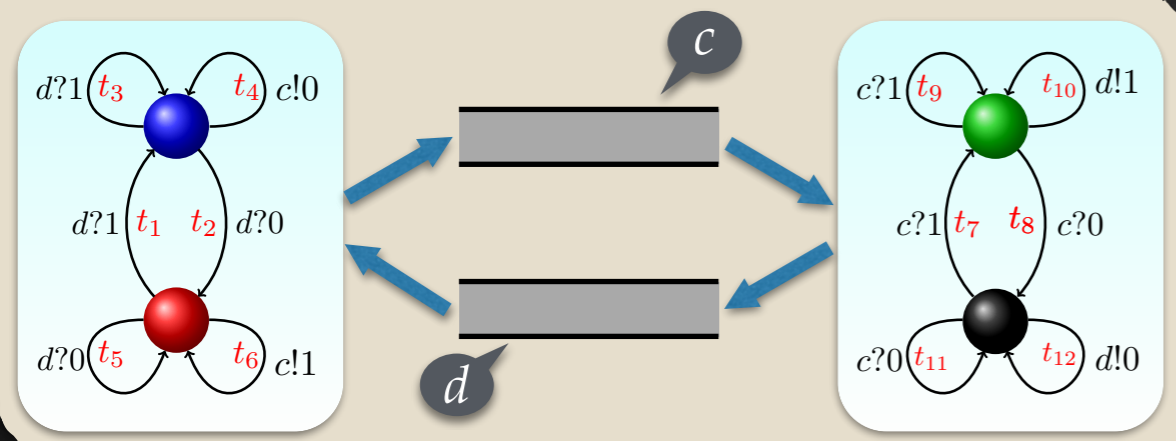
# Transitions





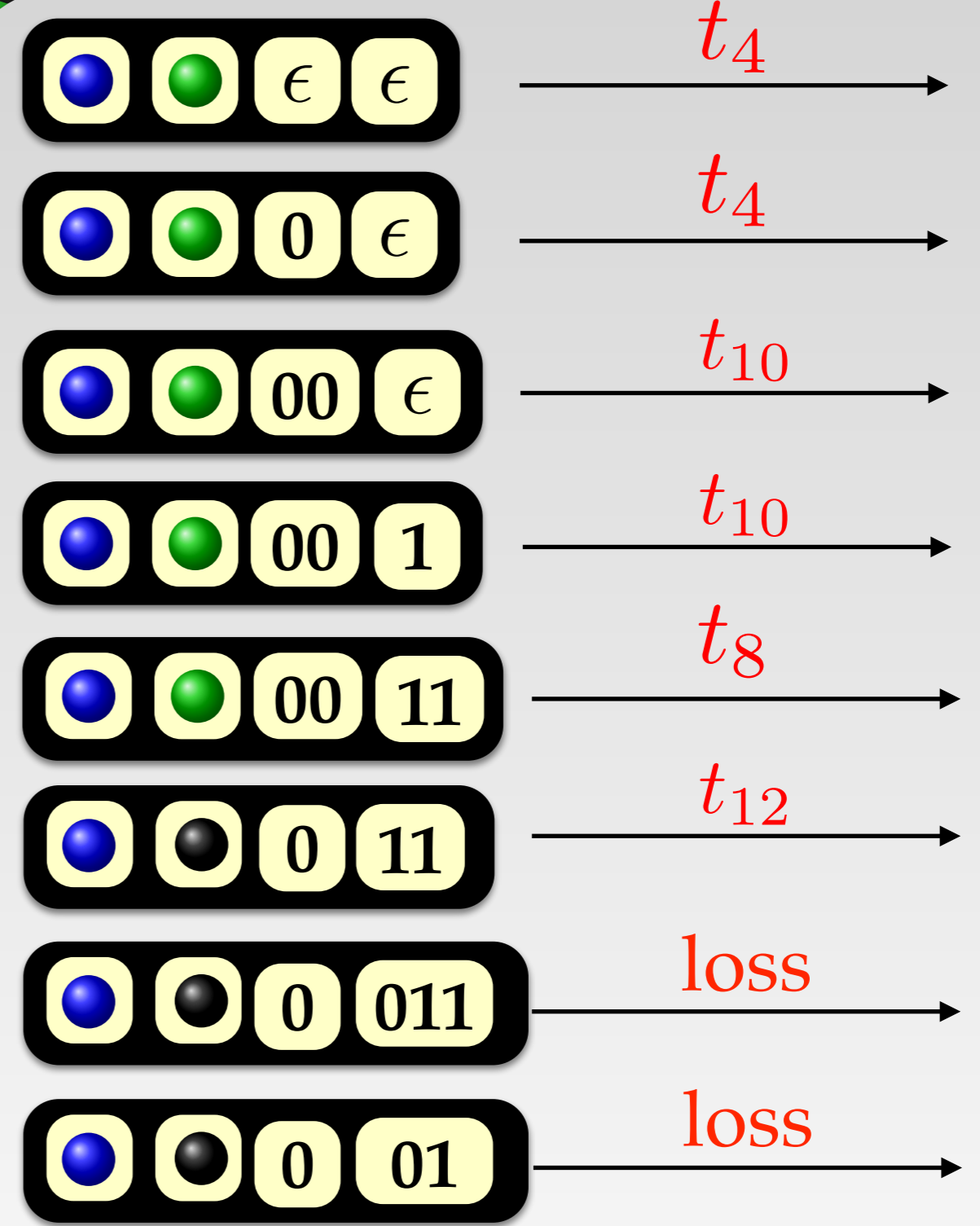
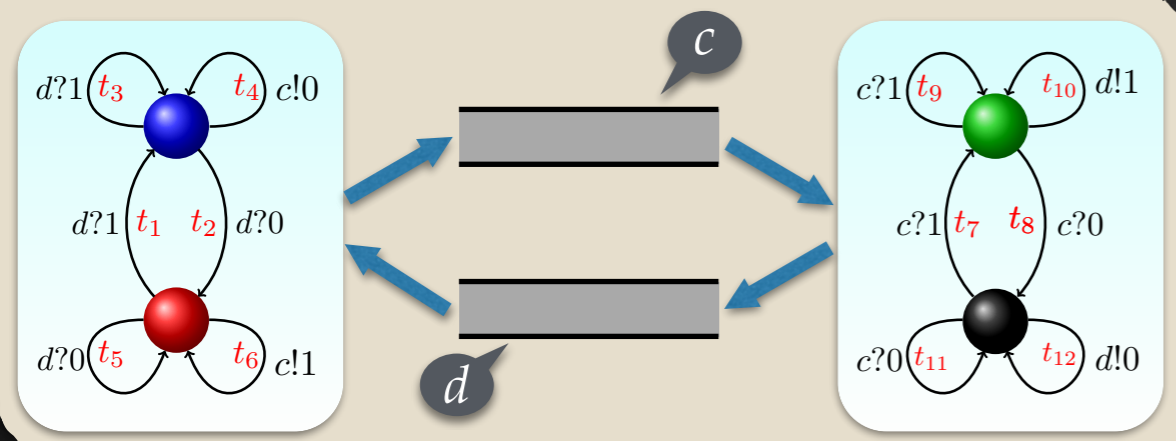
Lossy

# Transitions

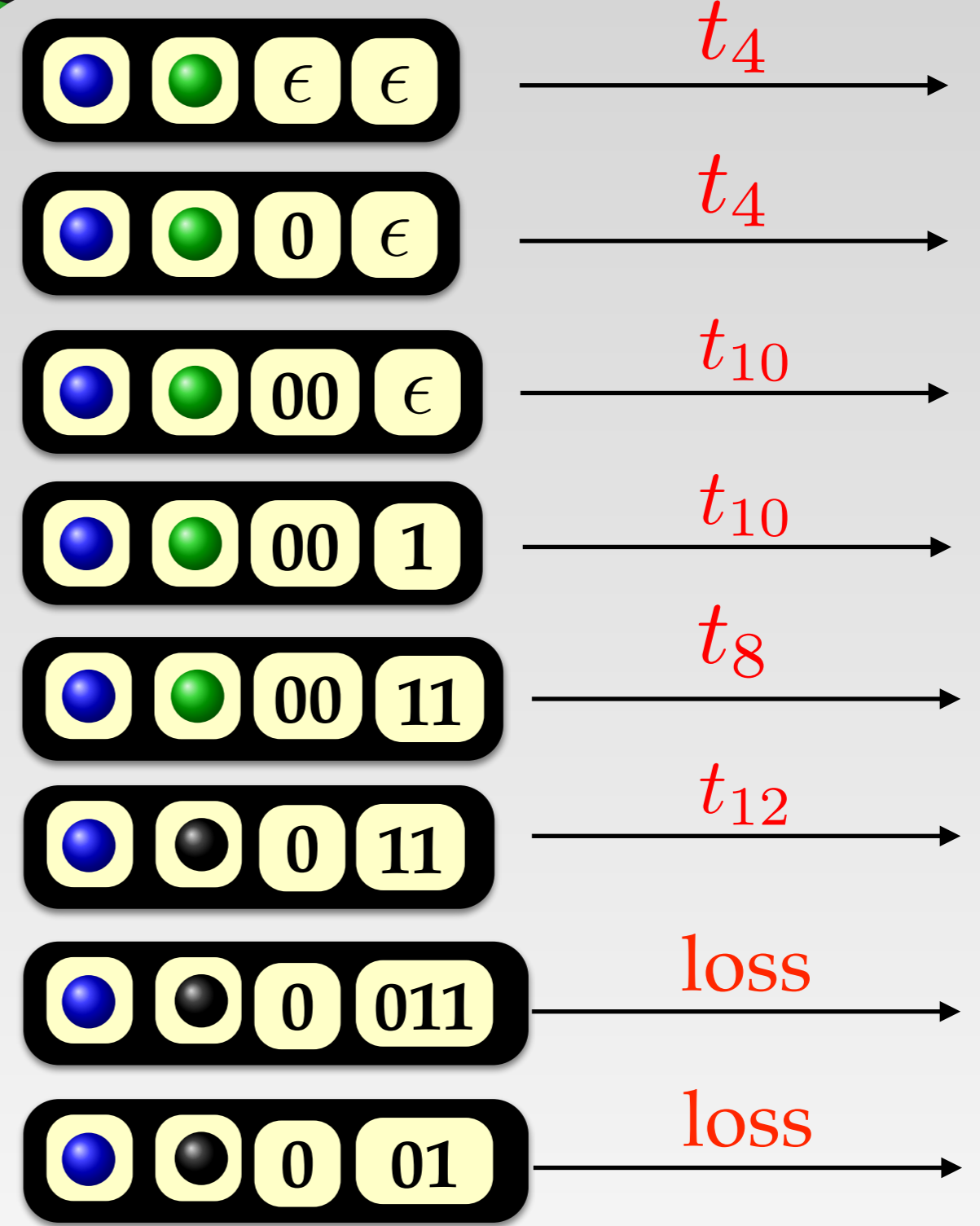
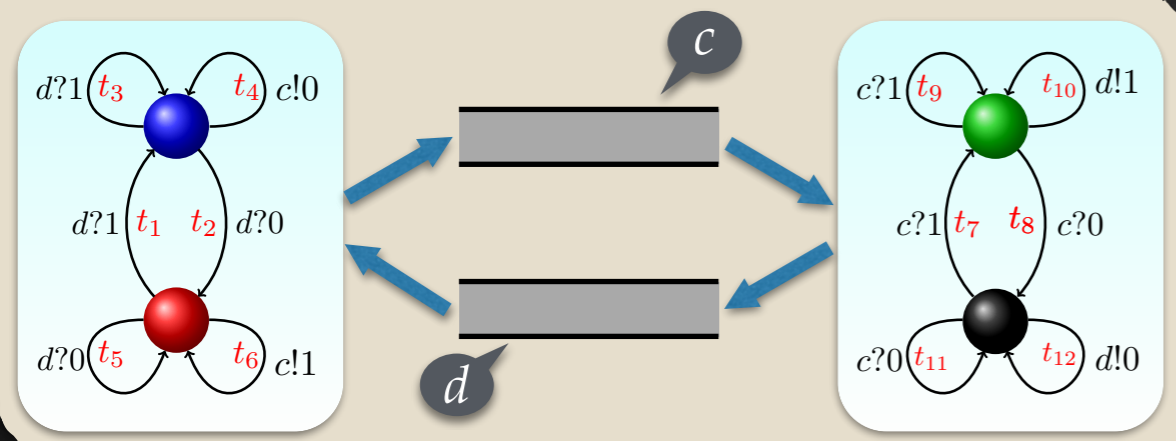


Lossy

# Transitions

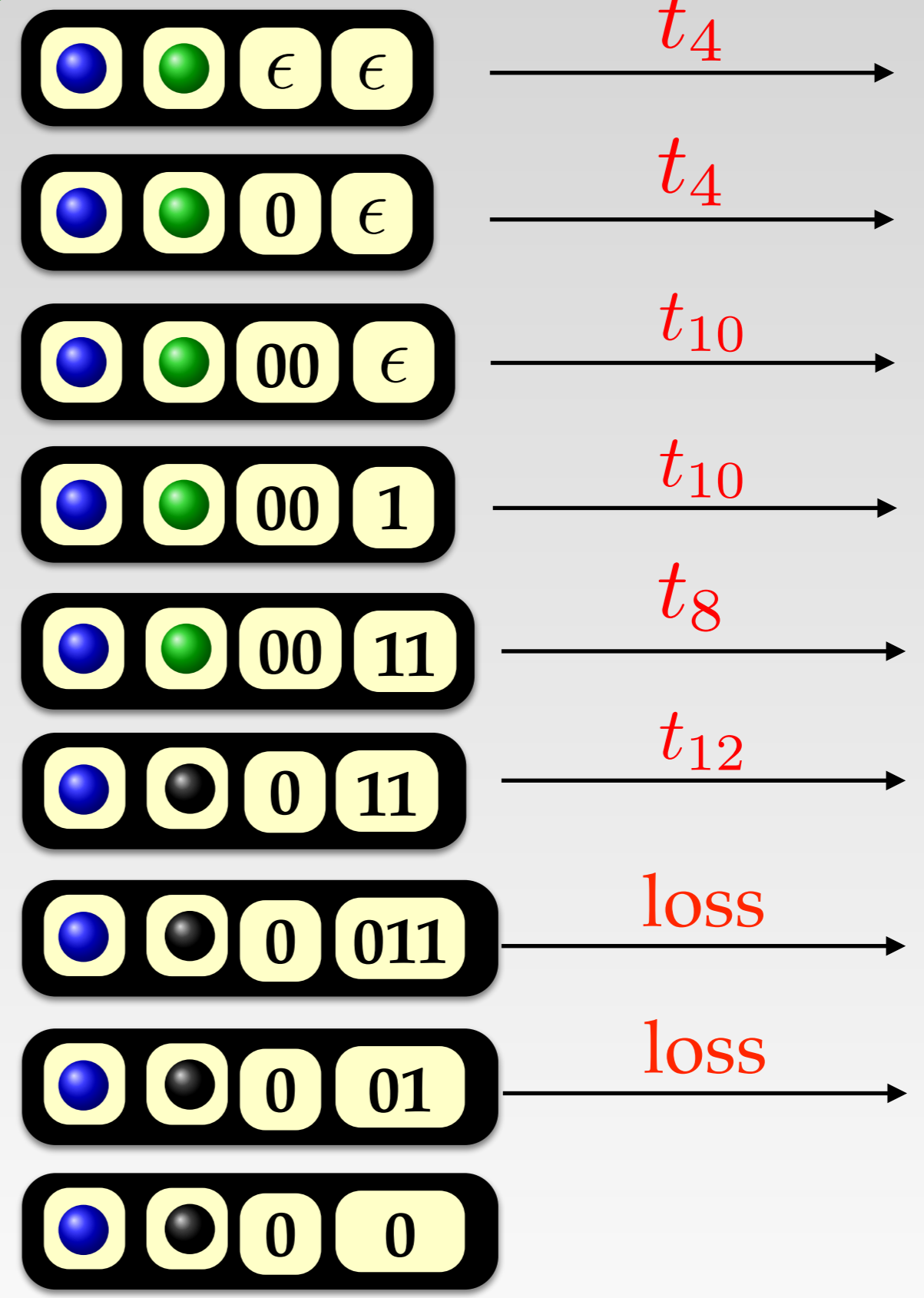
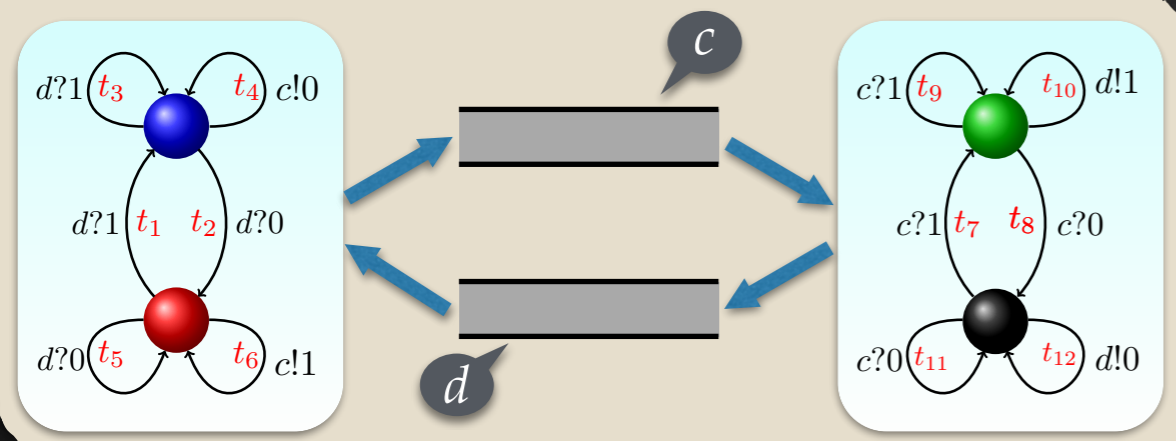




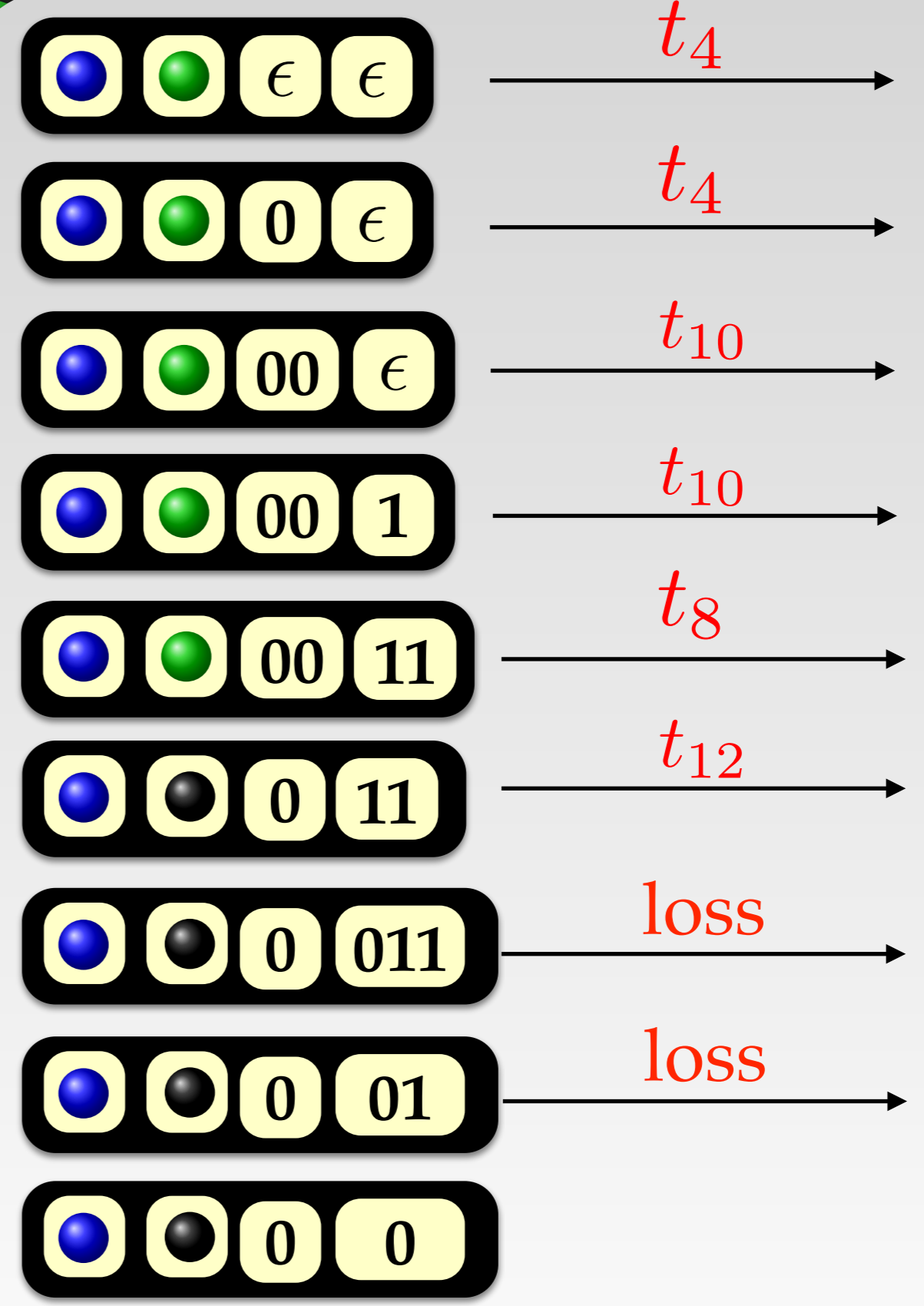
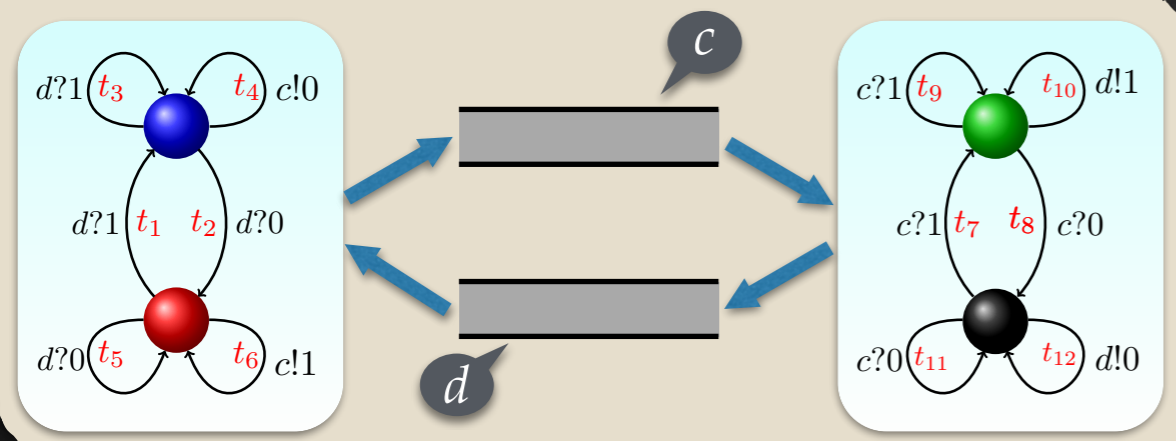


Lossy

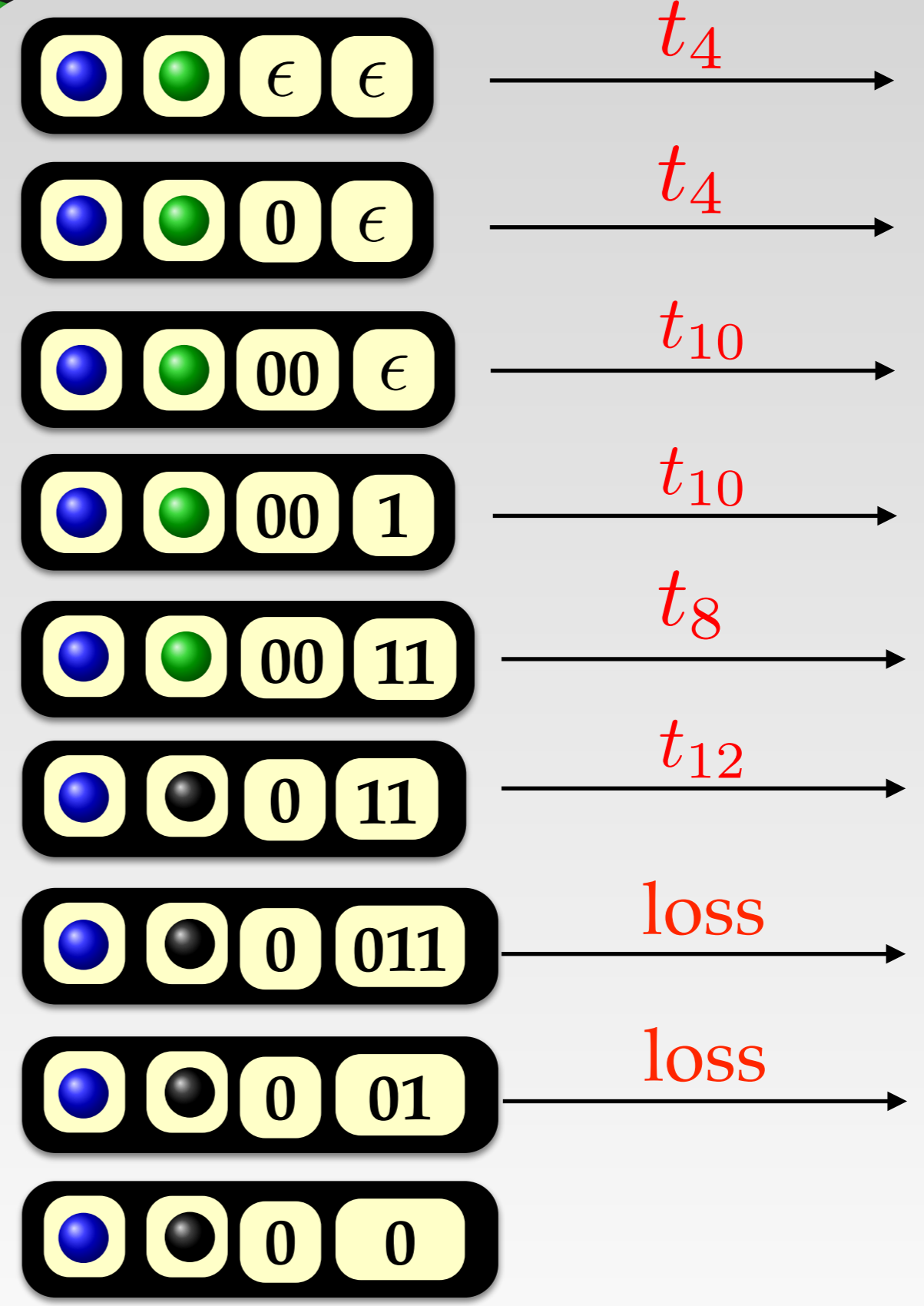
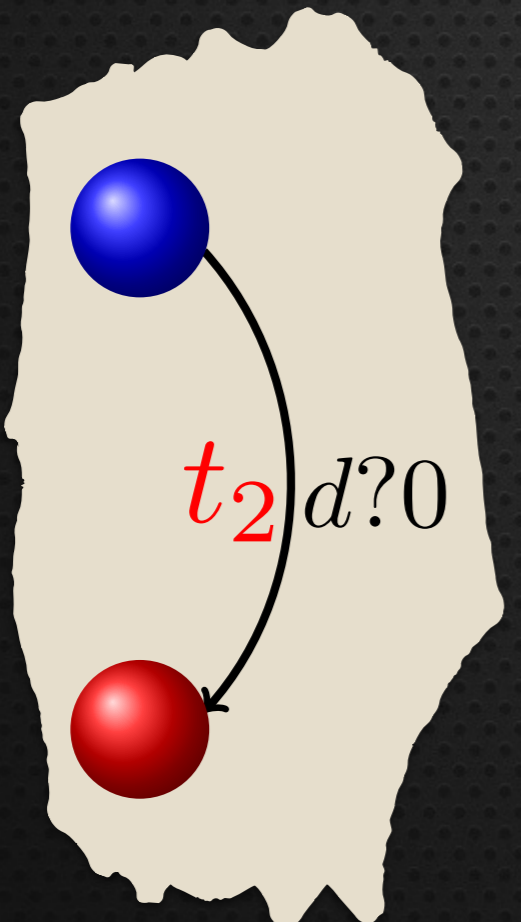
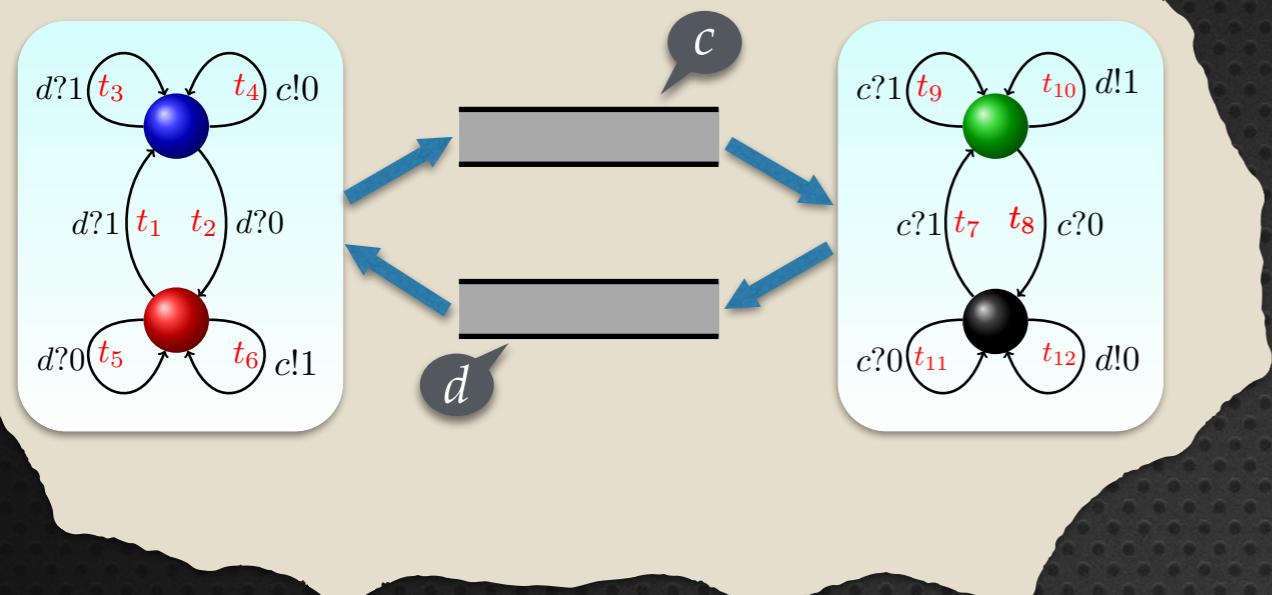
# Transitions





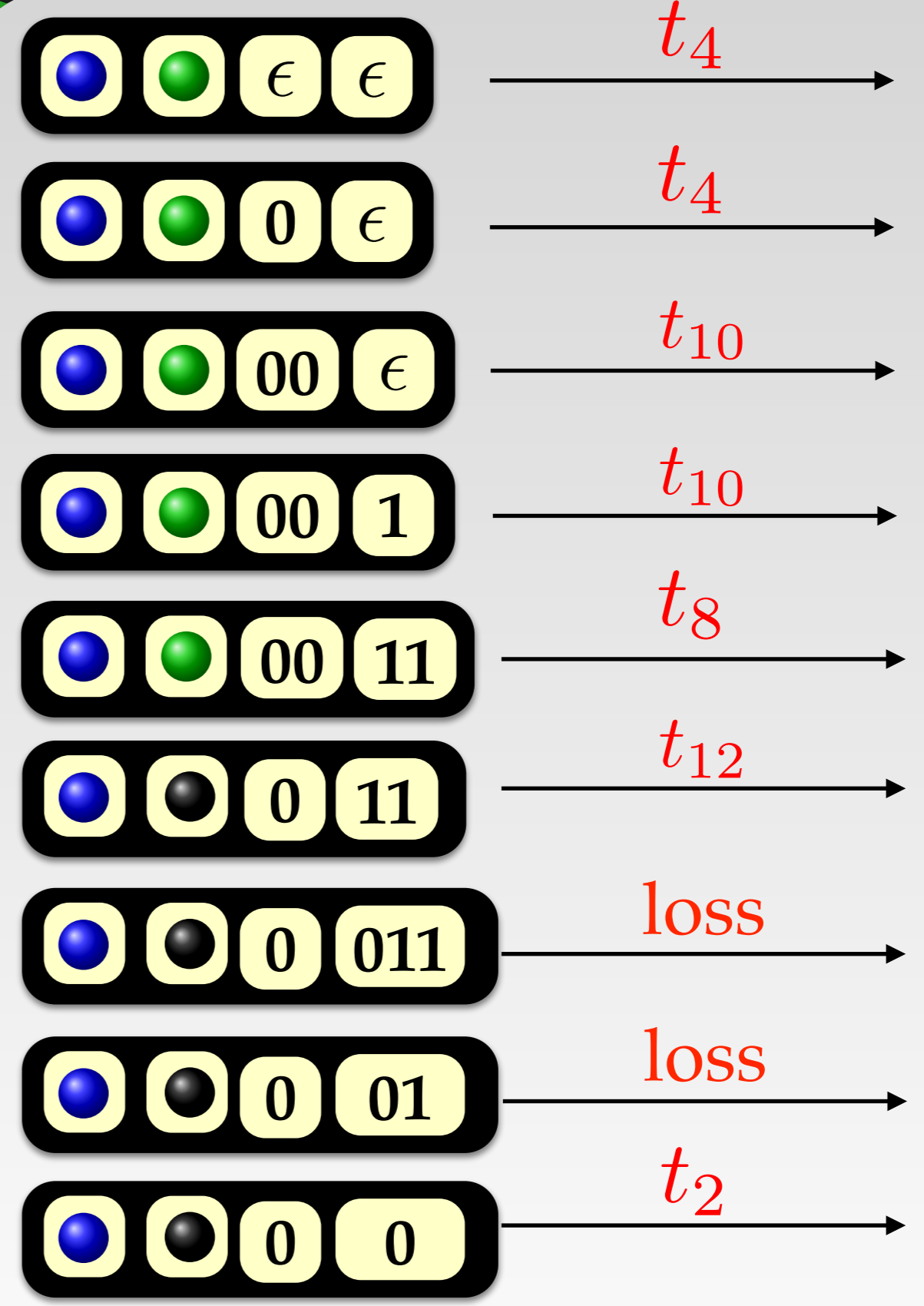
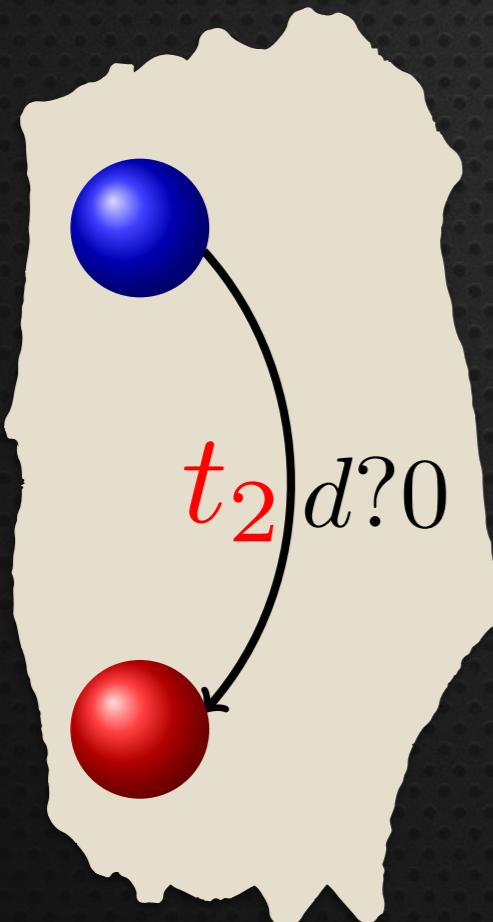
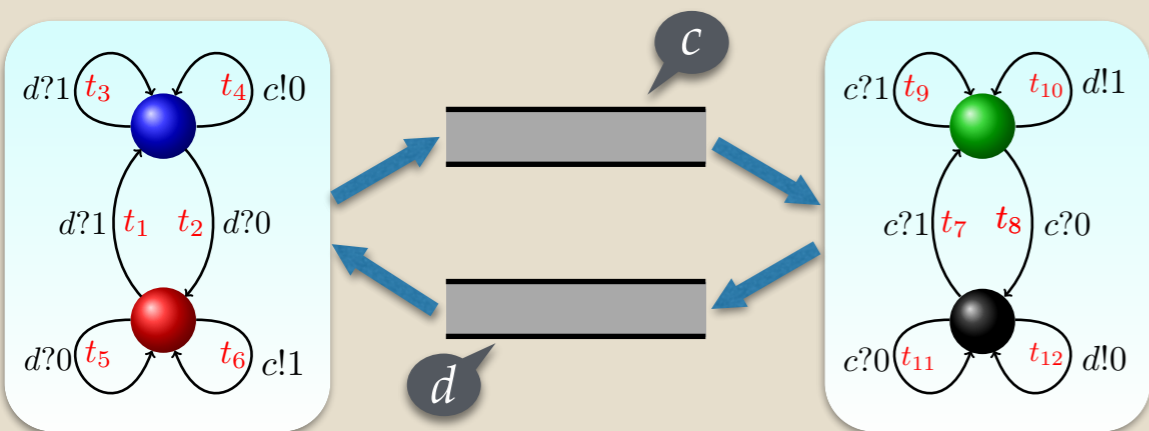


# Lossy Transitions

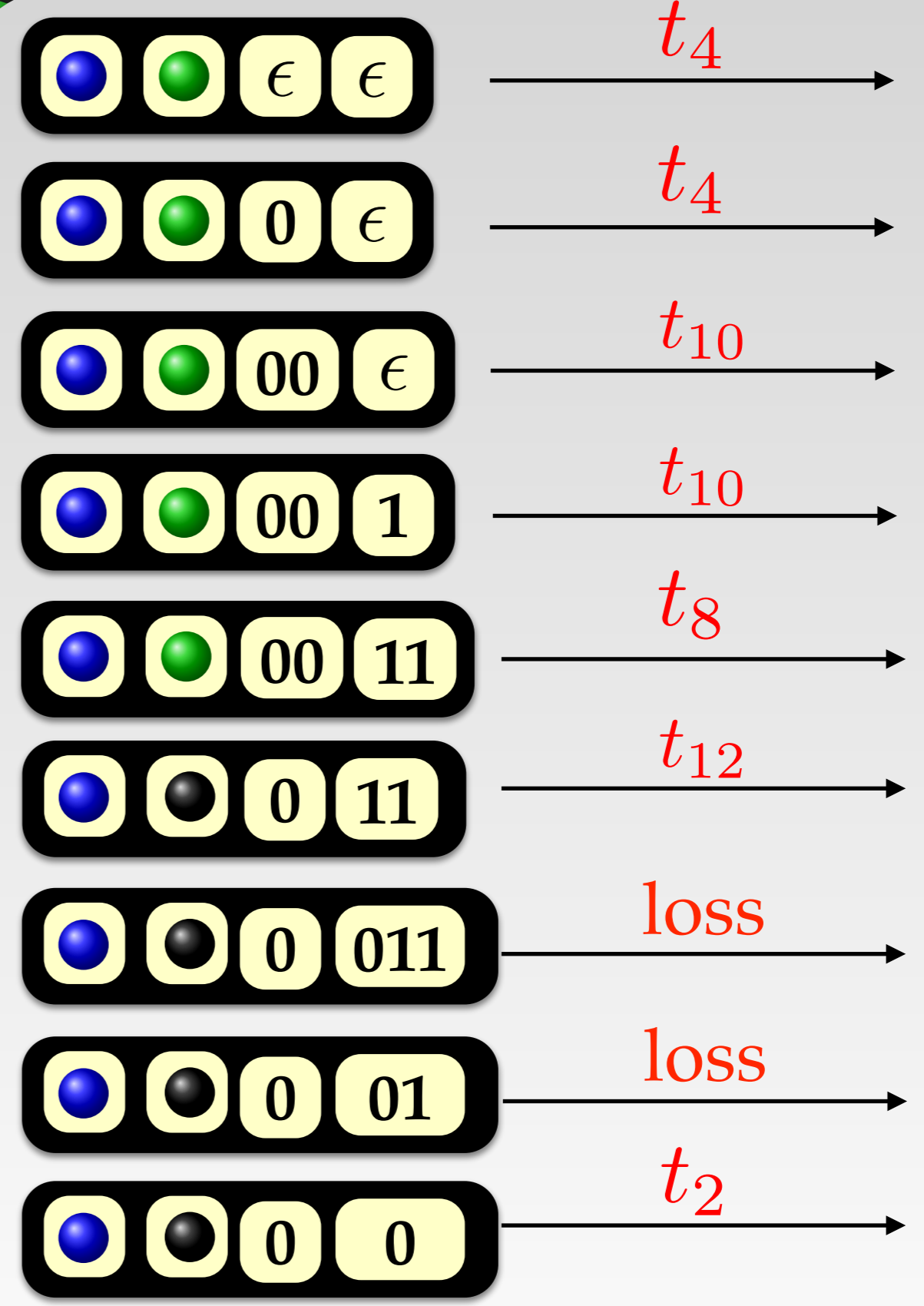
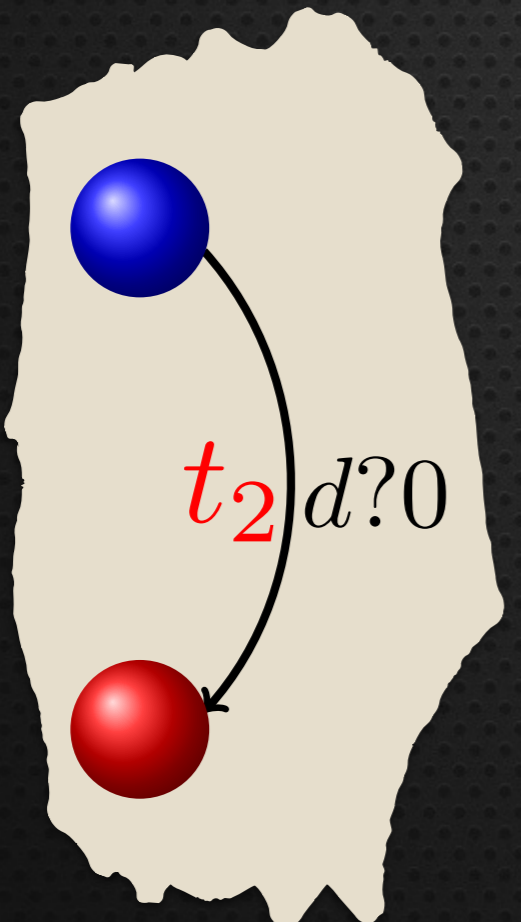
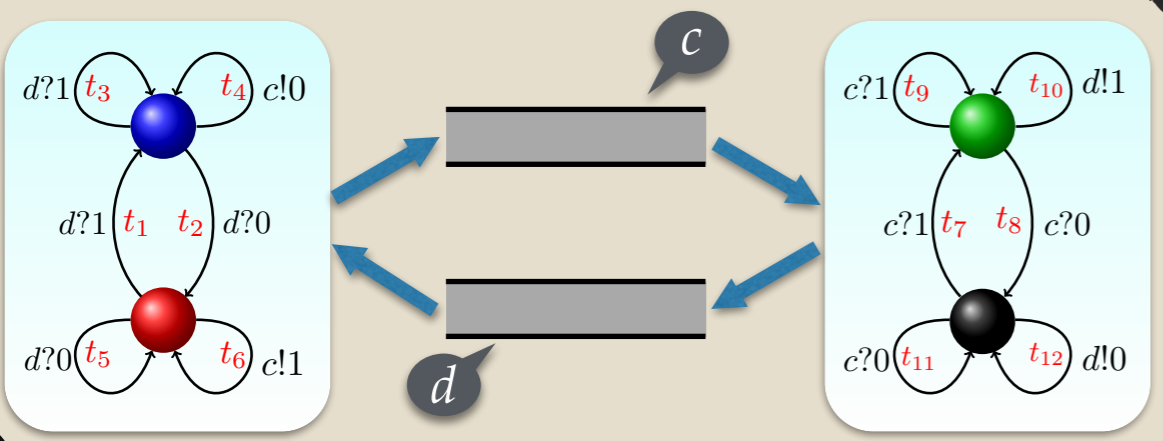




# Lossy Transitions



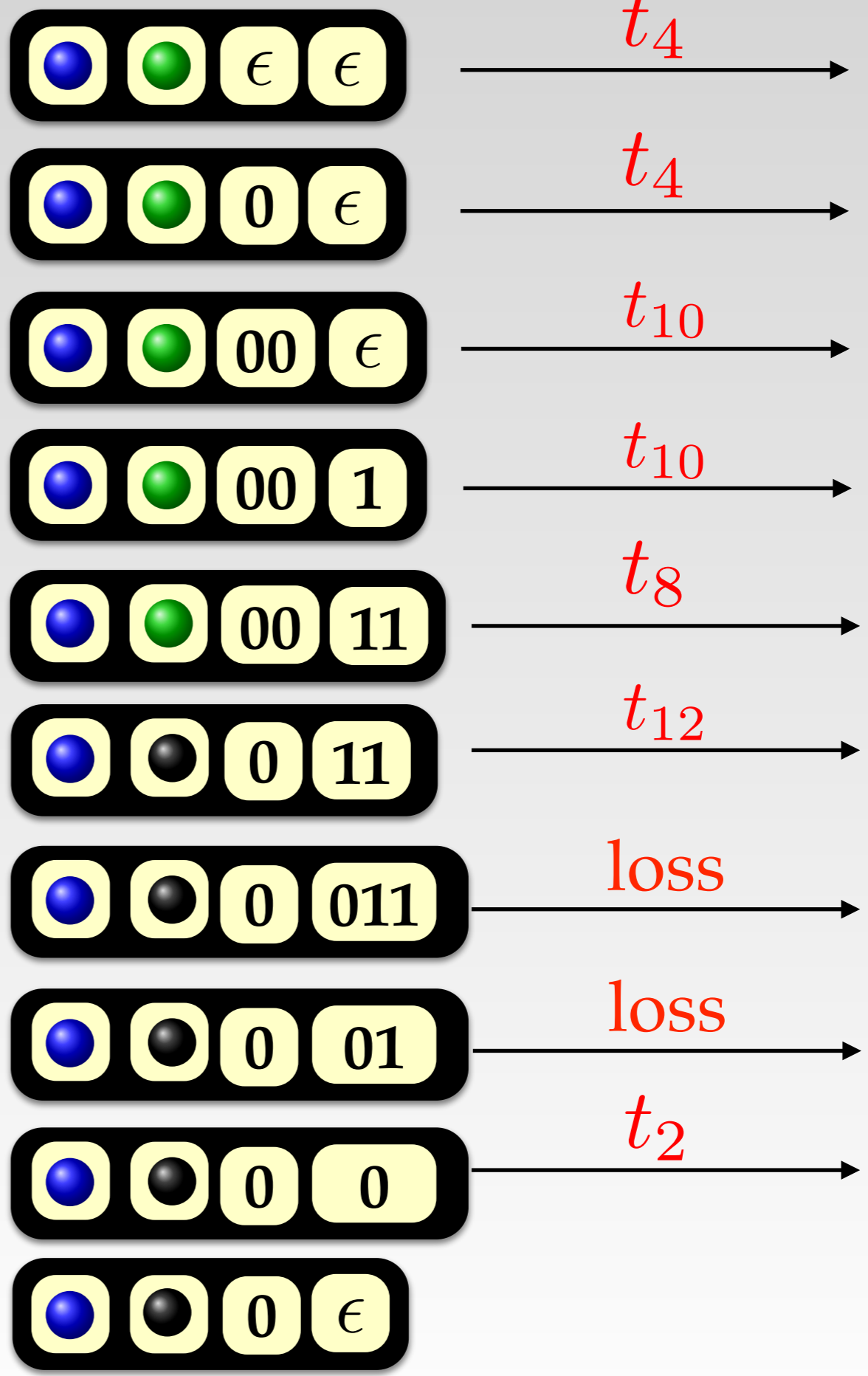
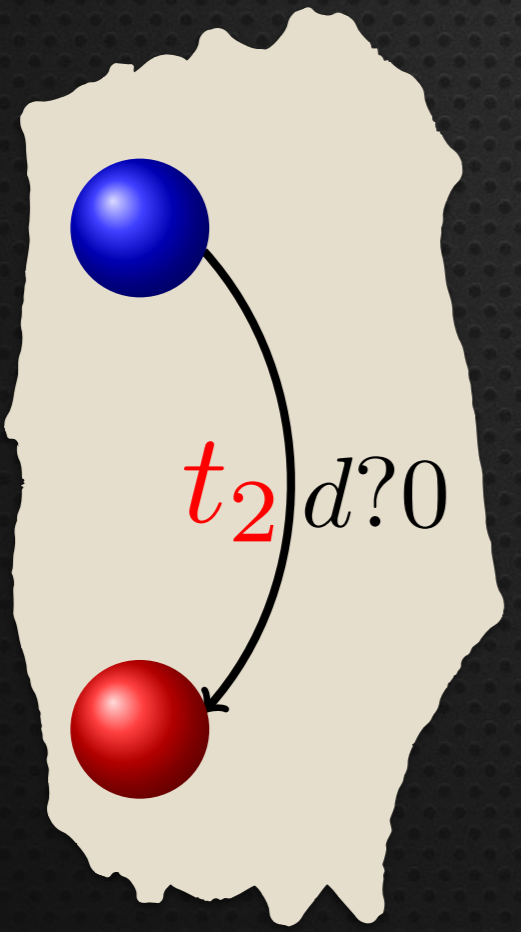
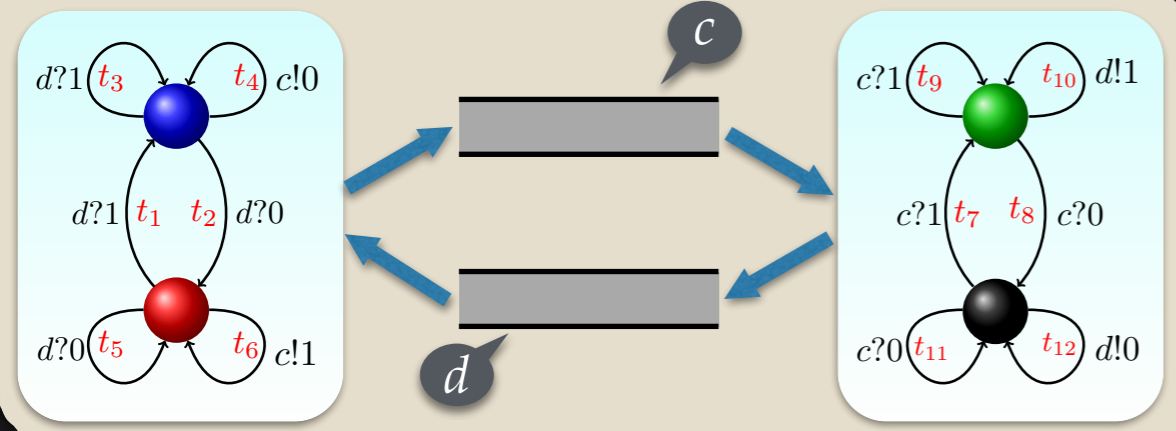
# Lossy Transitions



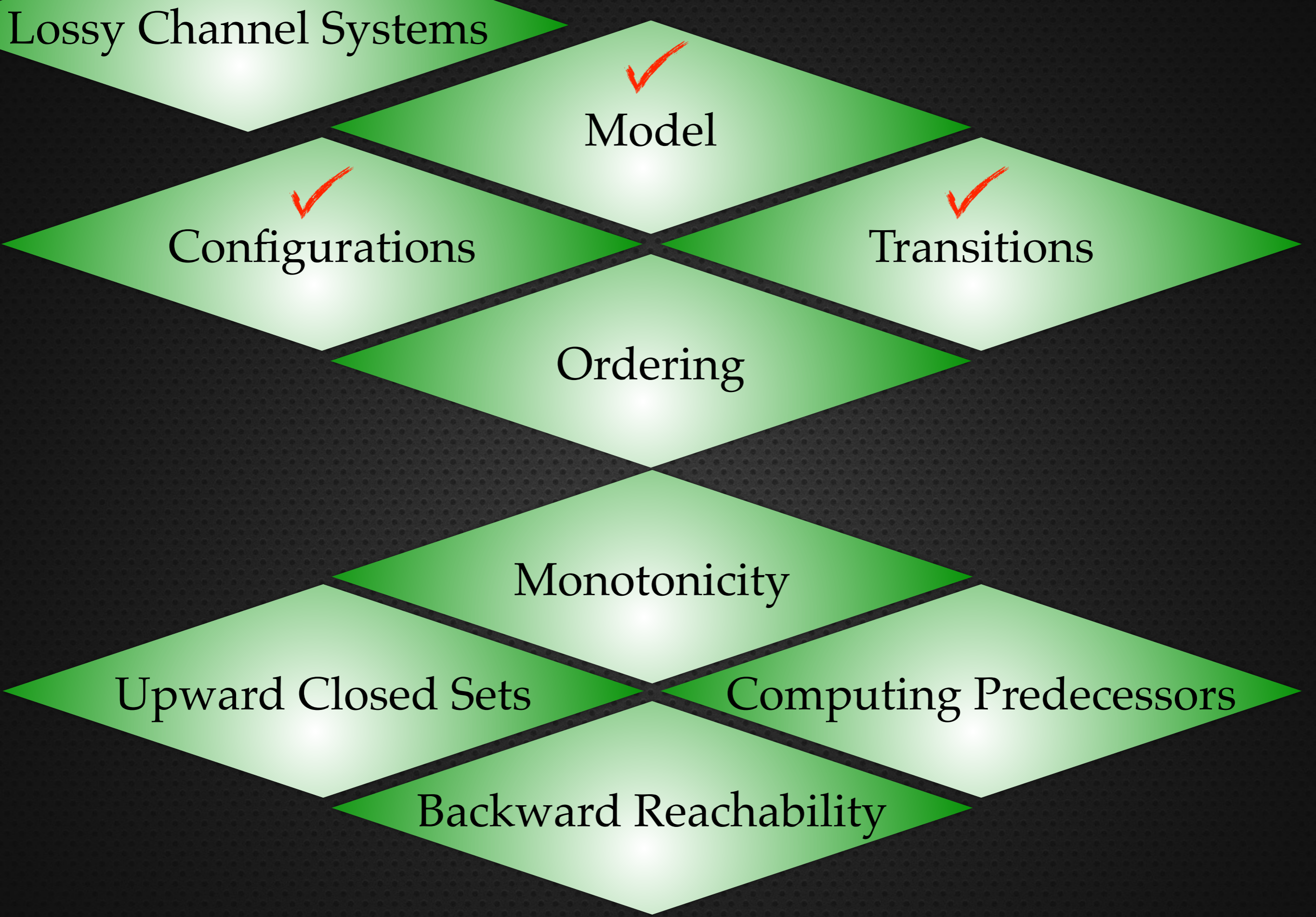


Lossy

# Transitions

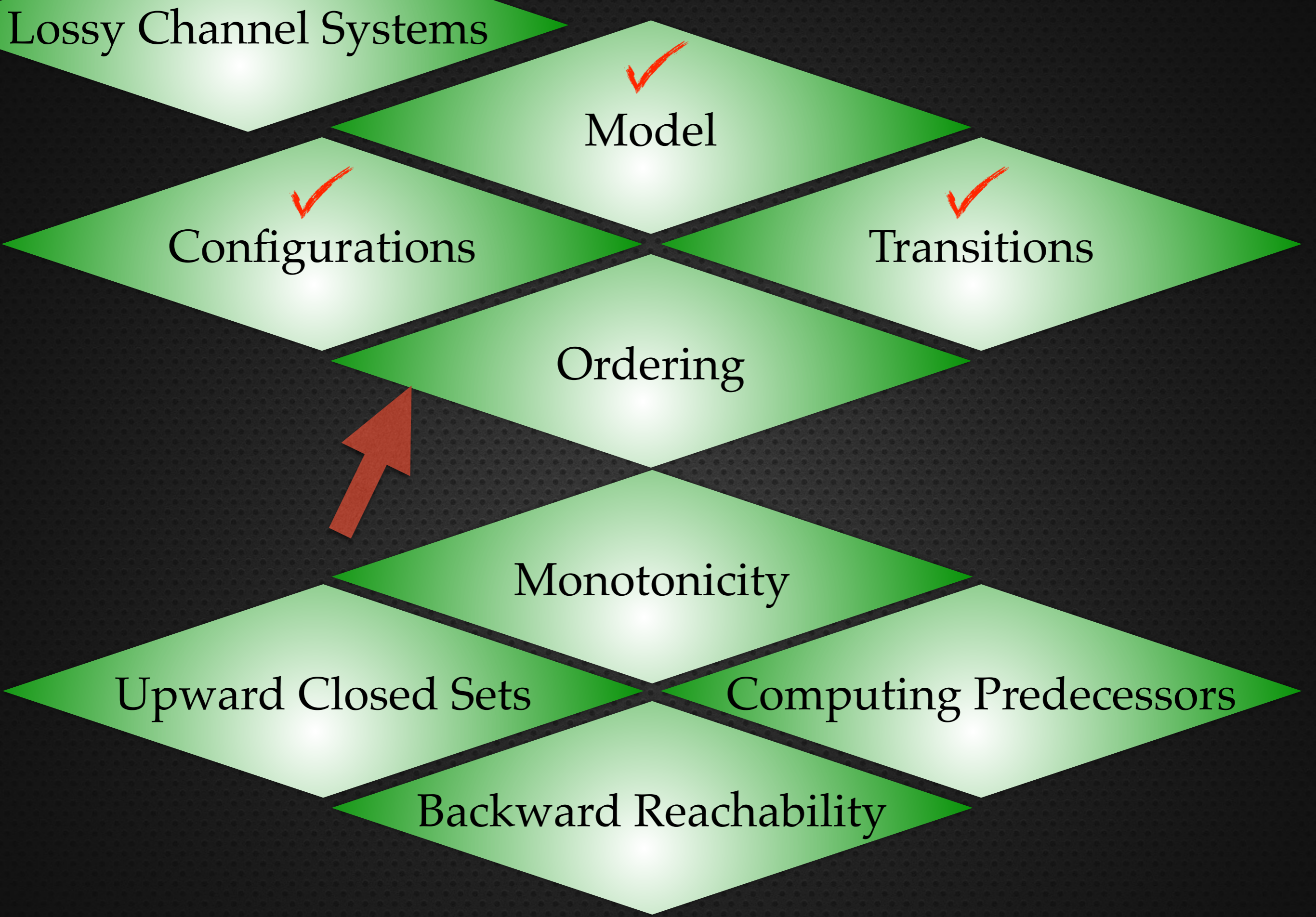


# Lossy Channel Systems





# Lossy Channel Systems



Model ✓

Configurations ✓

Transitions ✓

Ordering

Monotonicity

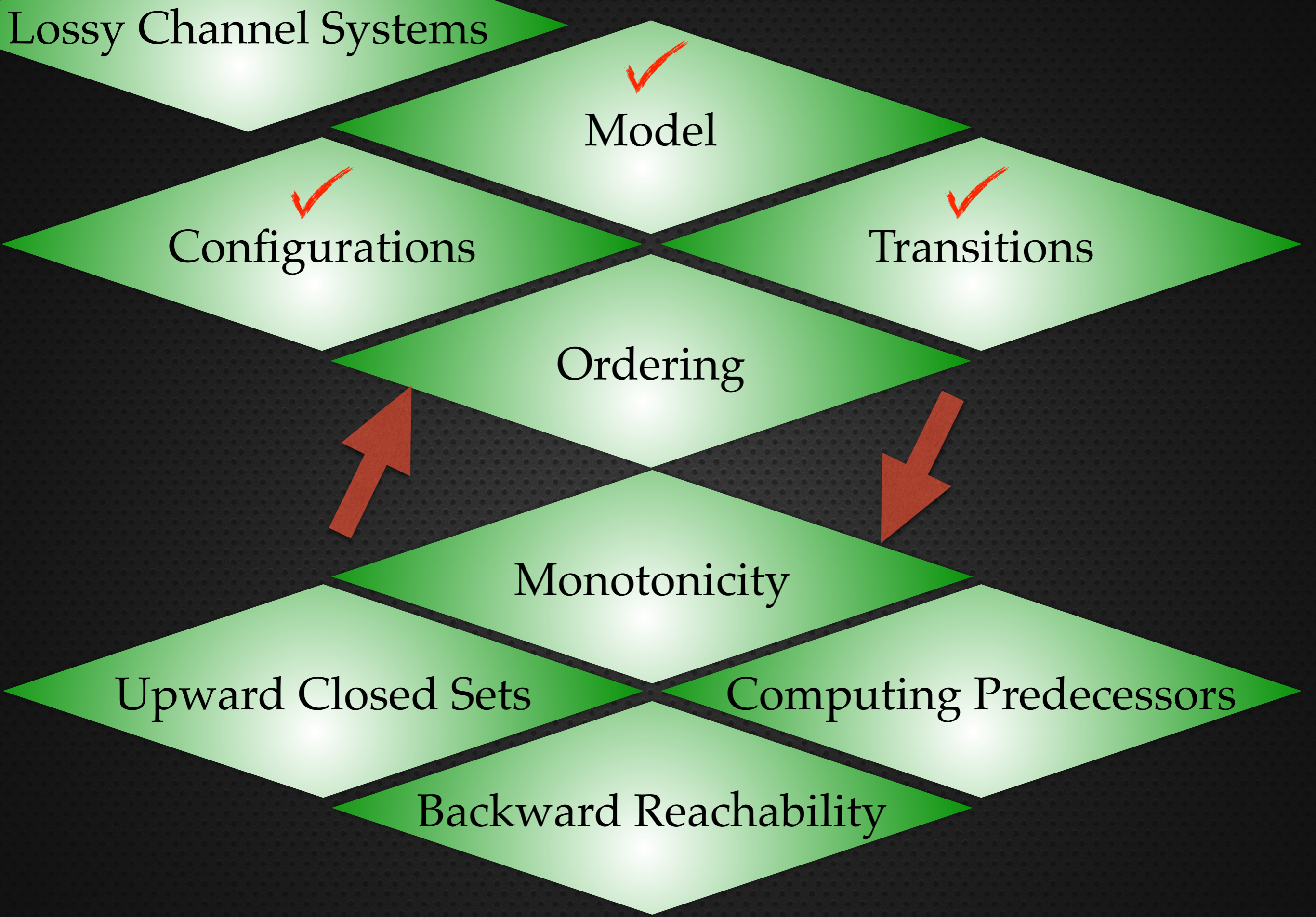
Upward Closed Sets

Computing Predecessors

Backward Reachability

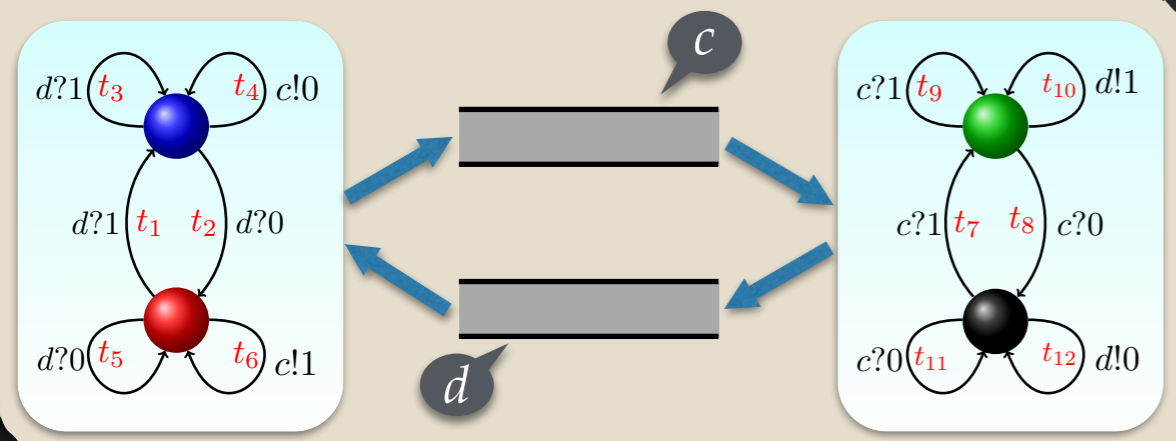


# Lossy Channel Systems



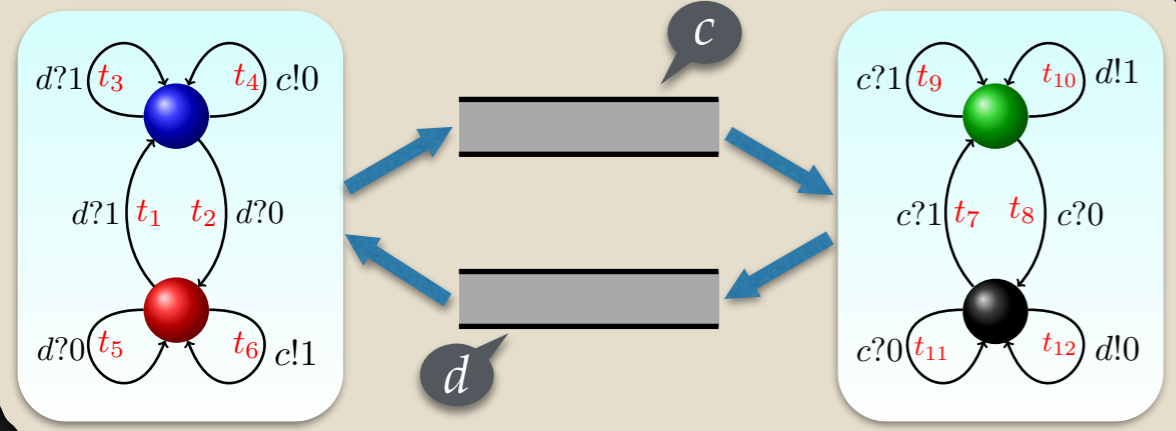


# Lossy Ordering





# Lossy Ordering

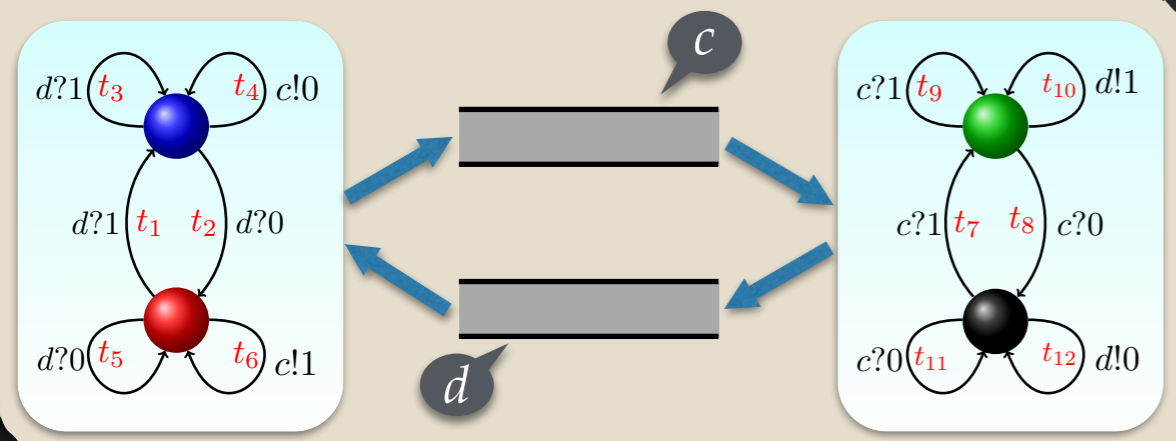


Subword Relation

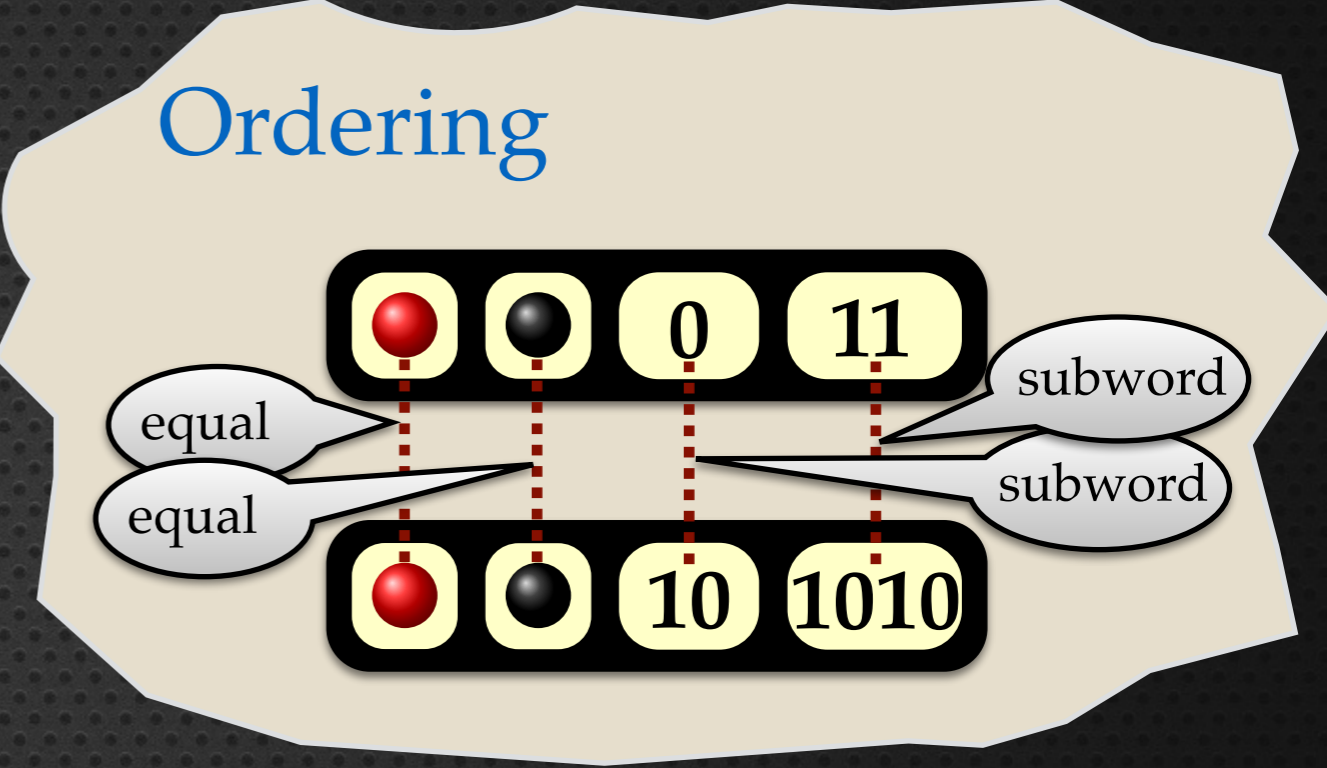
$ab \sqsubseteq xaybz$



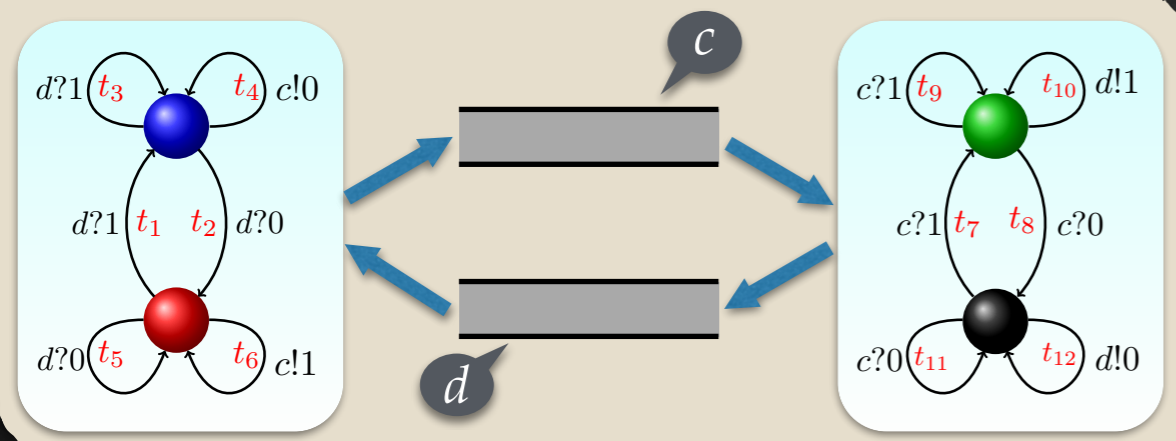
# Lossy Ordering



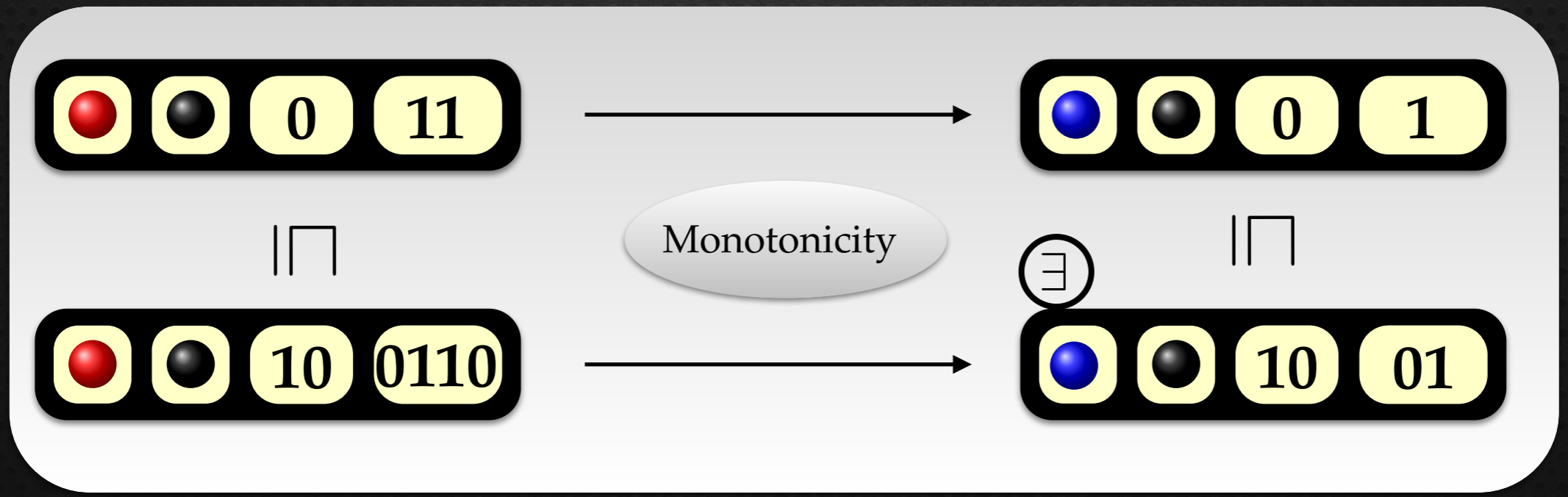
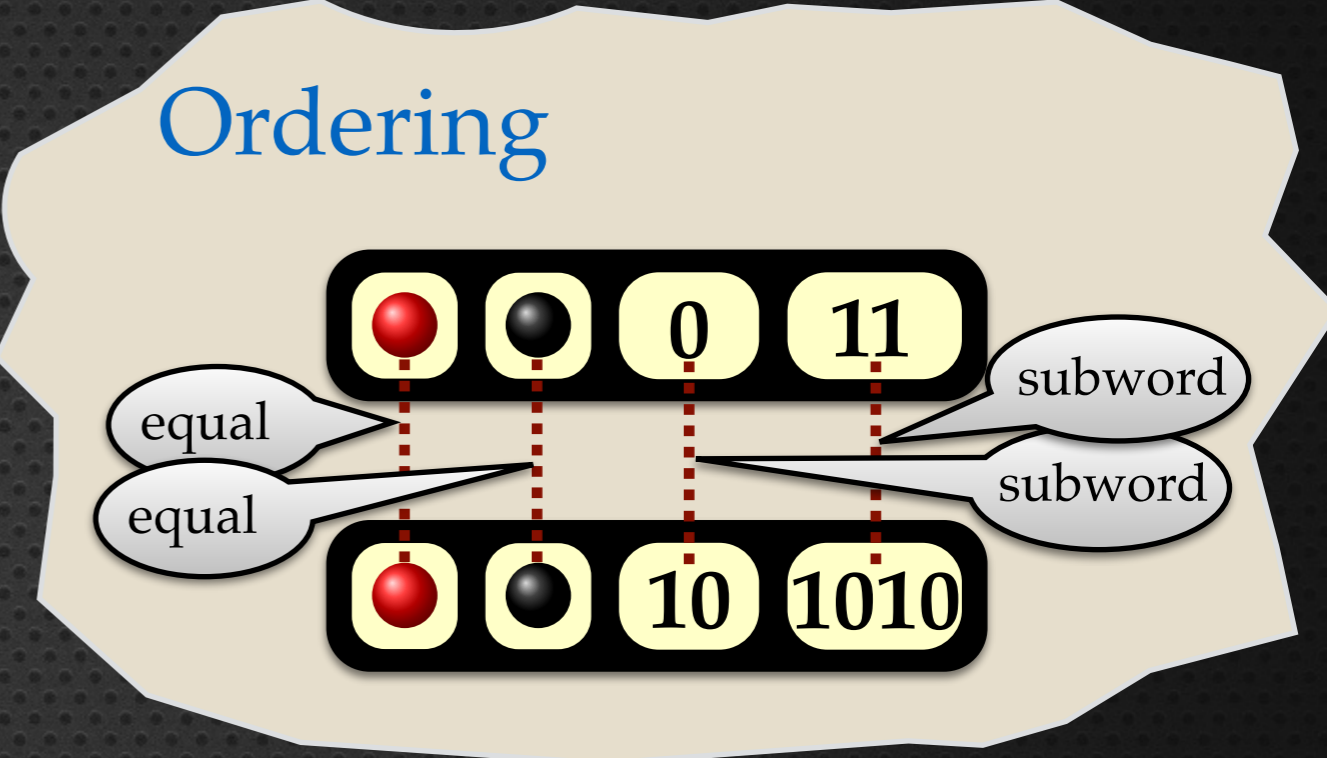
Subword Relation  
 $ab \sqsubseteq xaybz$



# Lossy Ordering

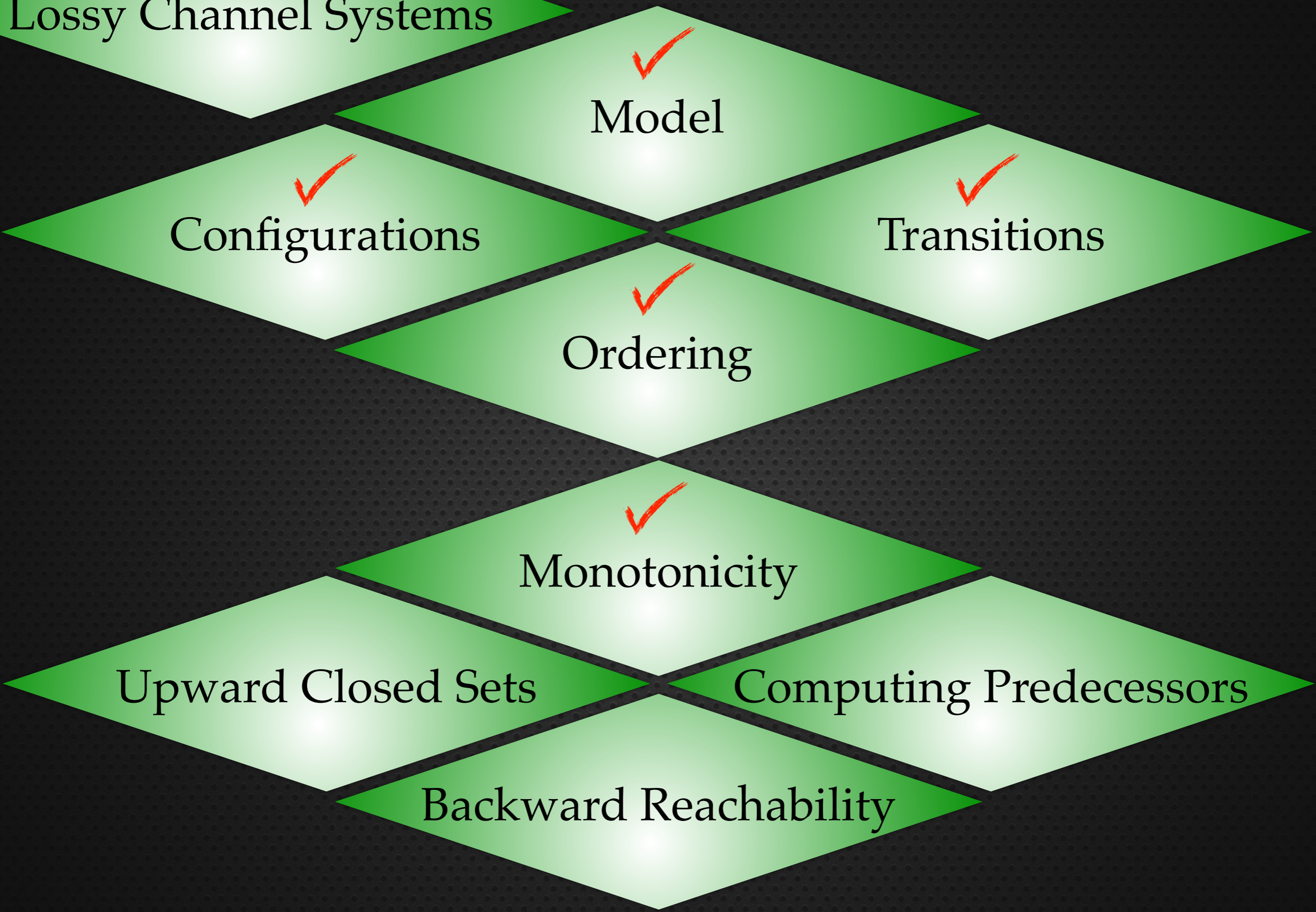


Subword Relation  
 $ab \sqsubseteq xaybz$



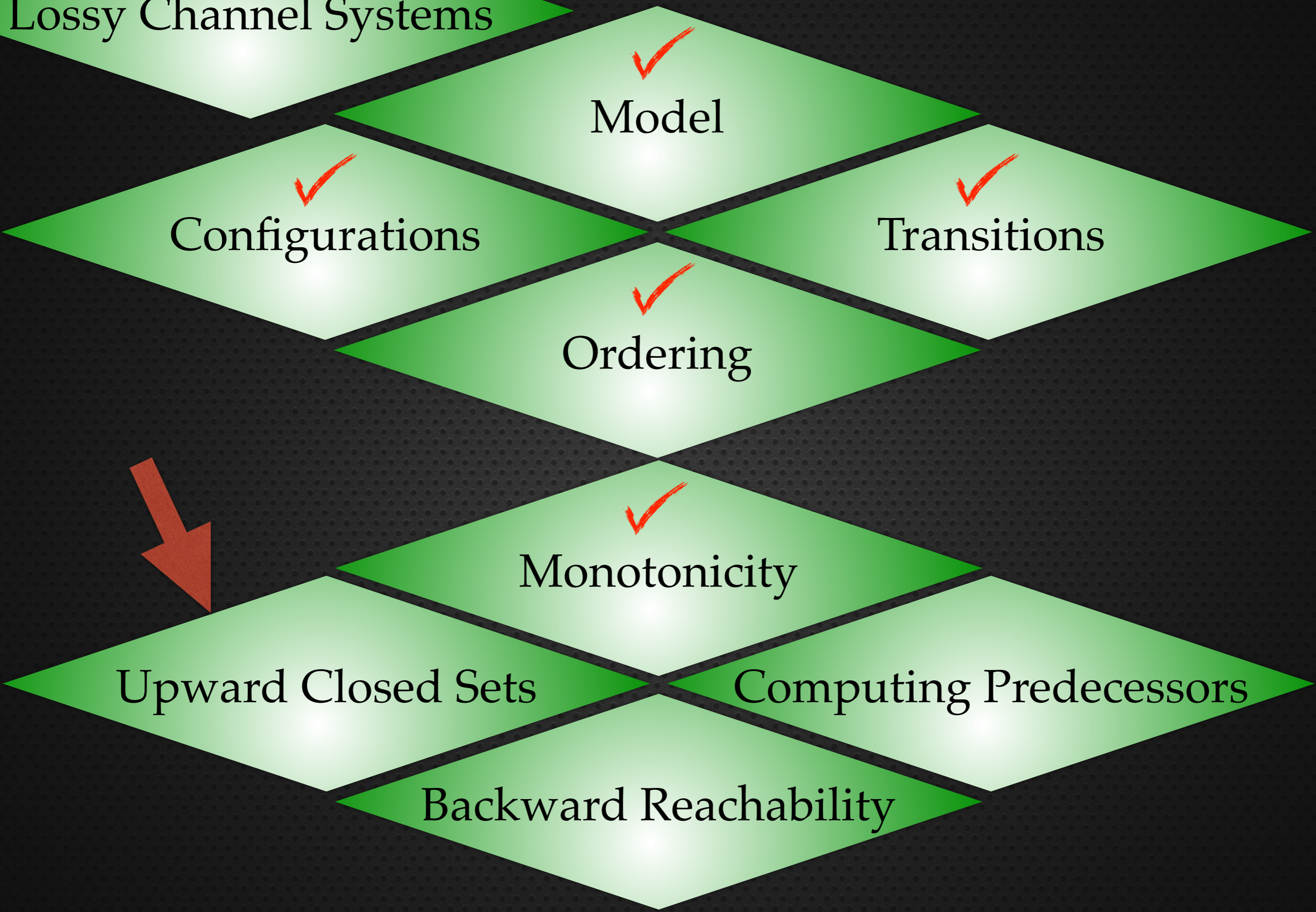


# Lossy Channel Systems



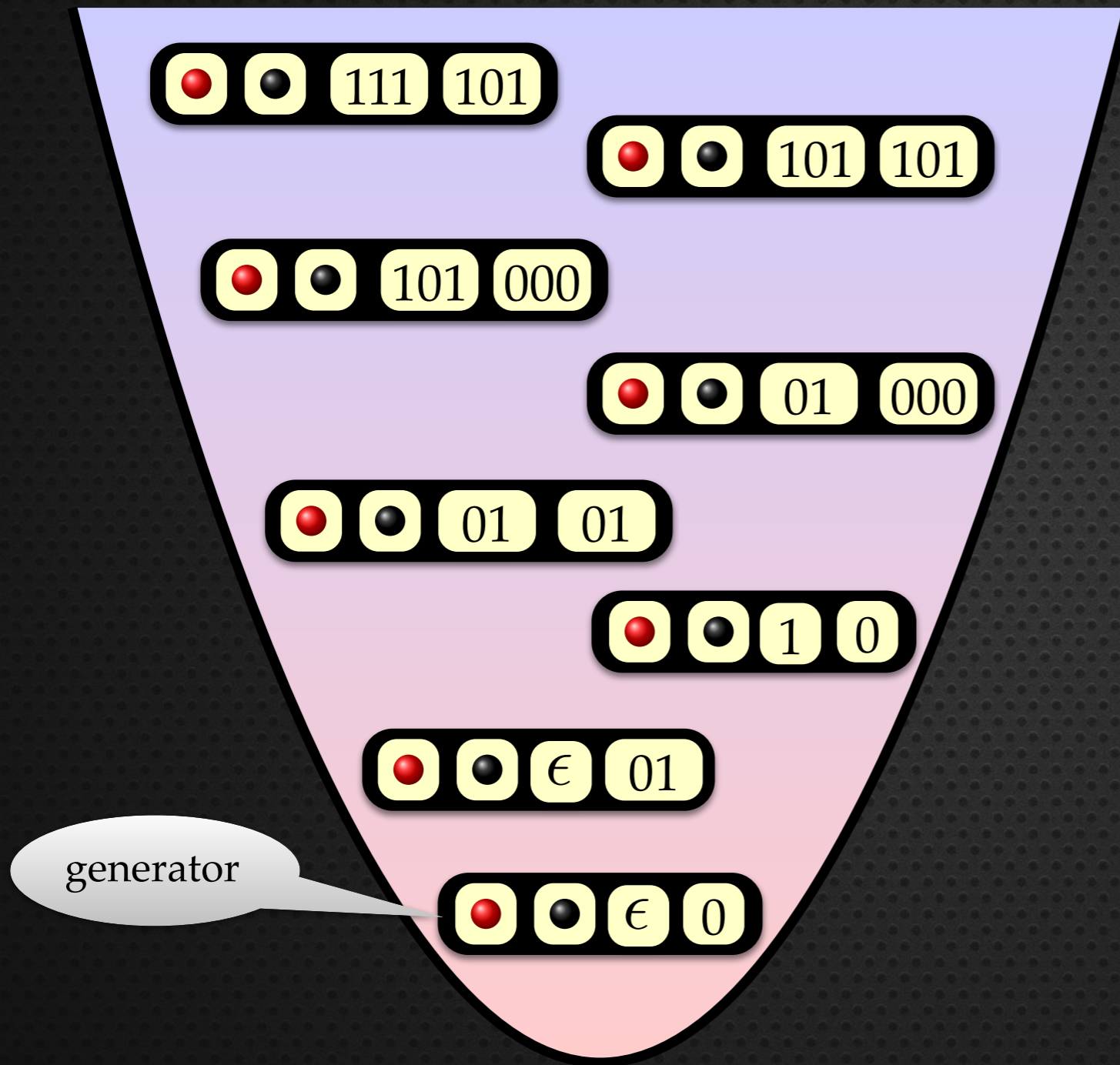


# Lossy Channel Systems



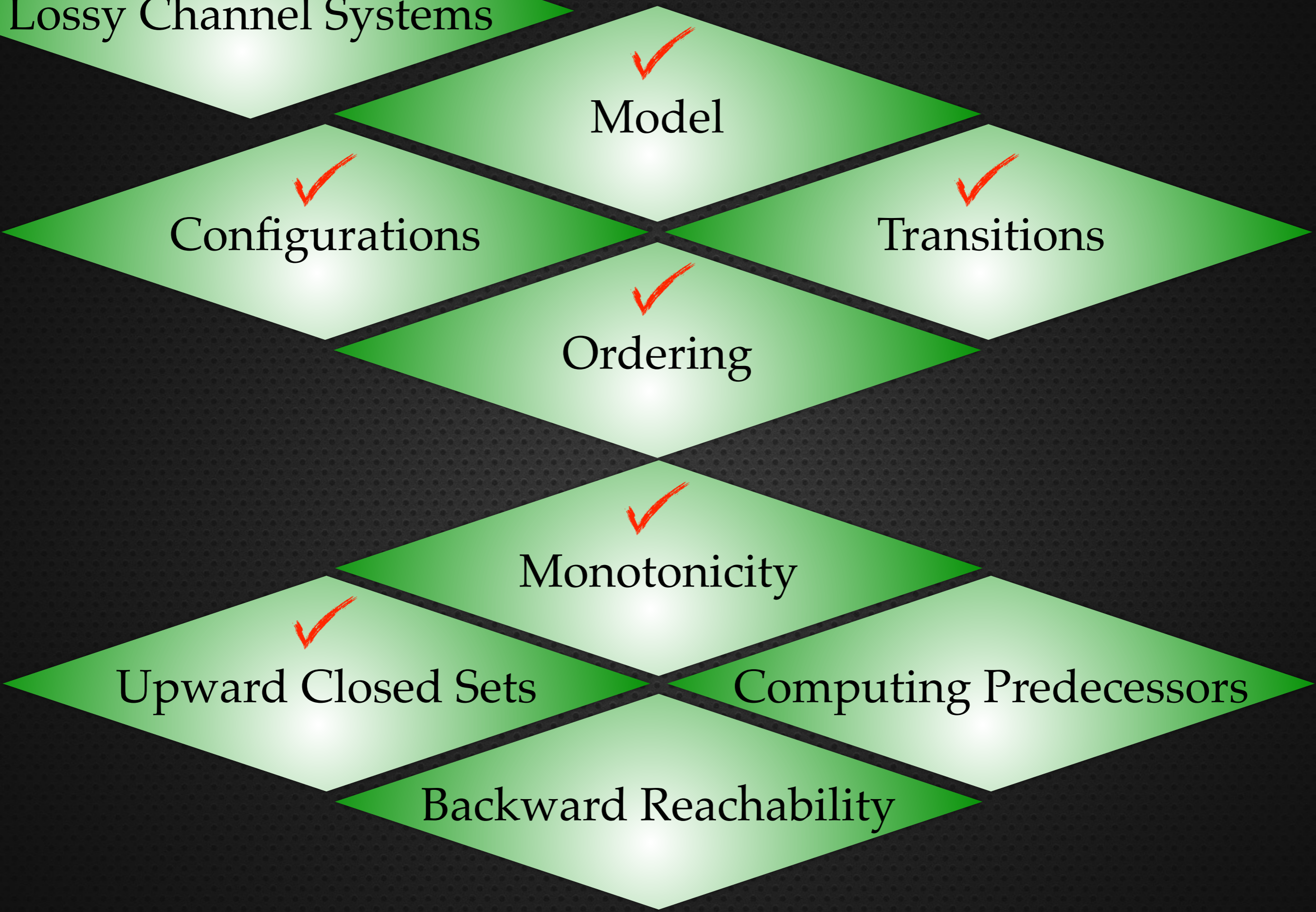


# Lossy Upward-Closed Sets





# Lossy Channel Systems



Model

Configurations

Transitions

Ordering

Monotonicity

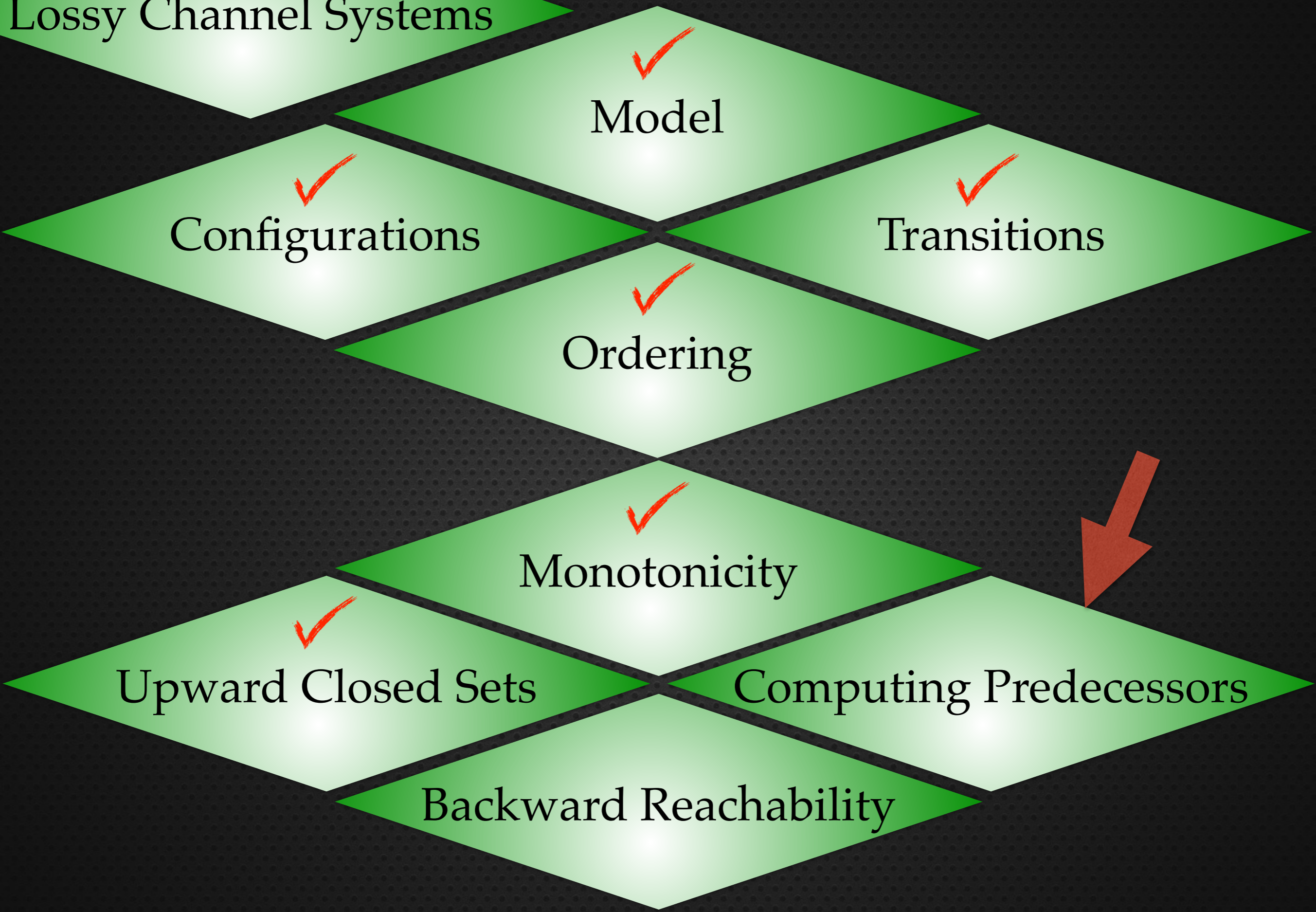
Upward Closed Sets

Computing Predecessors

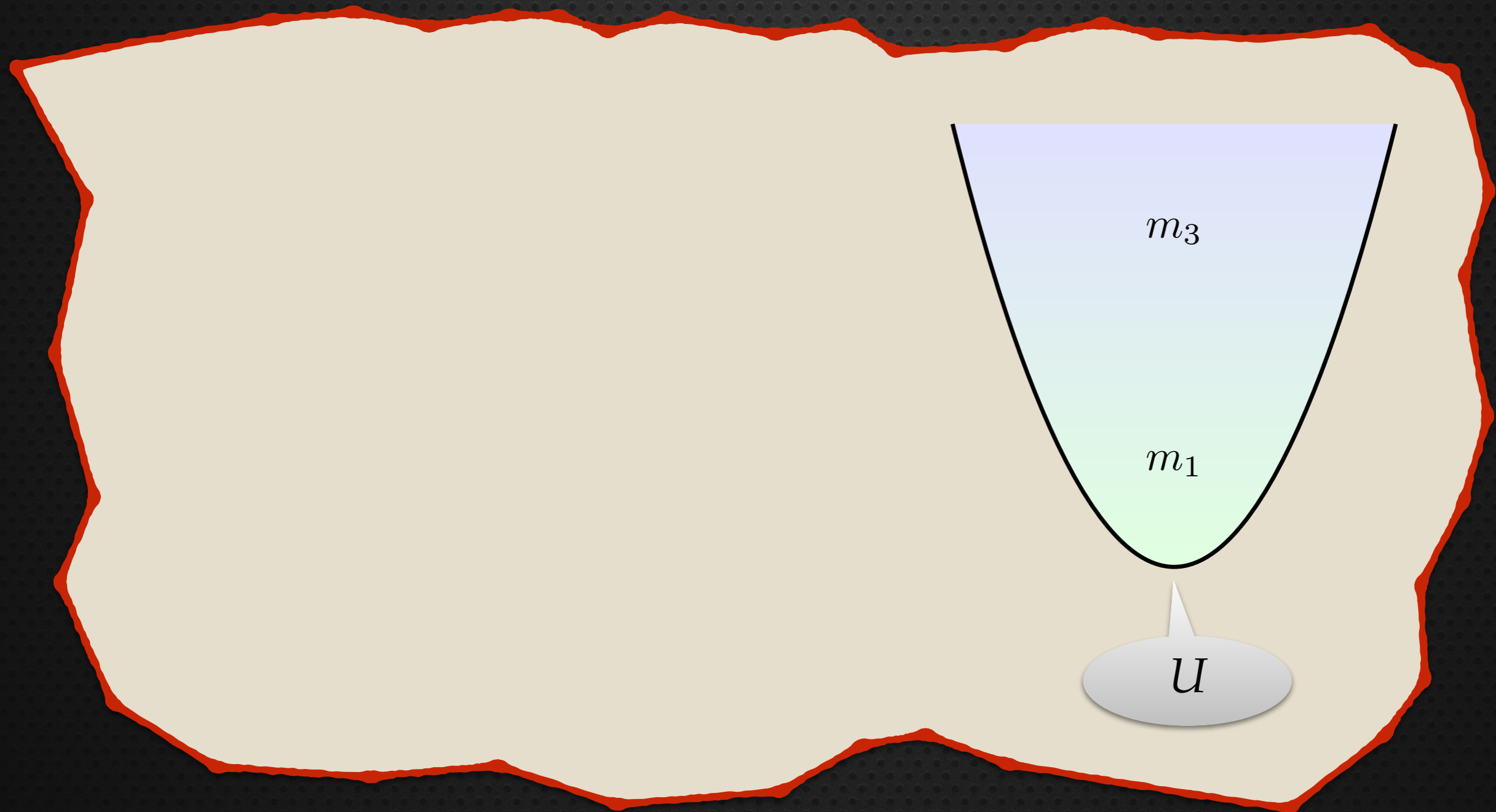
Backward Reachability



# Lossy Channel Systems

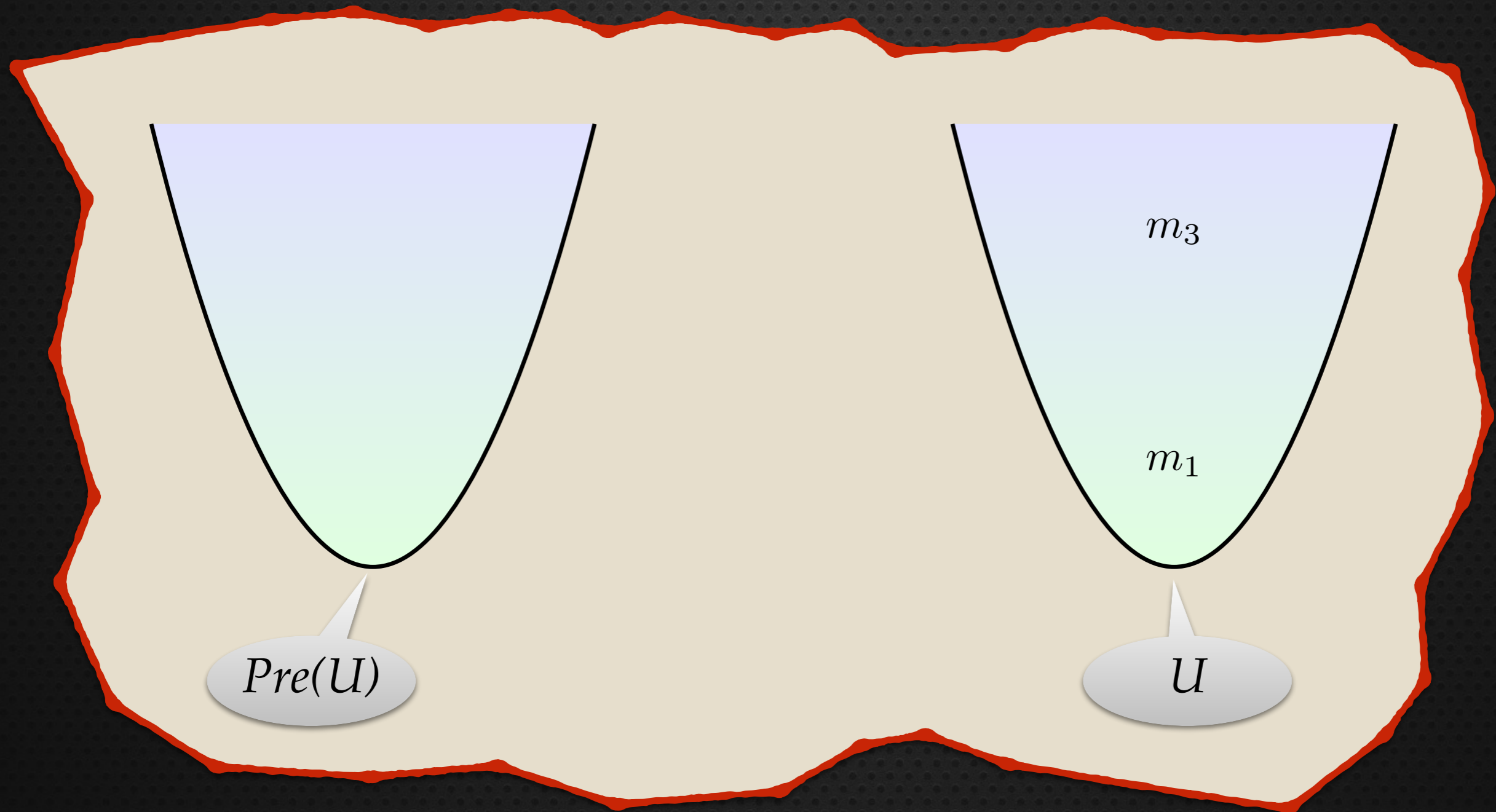


# Lossy Predecessors

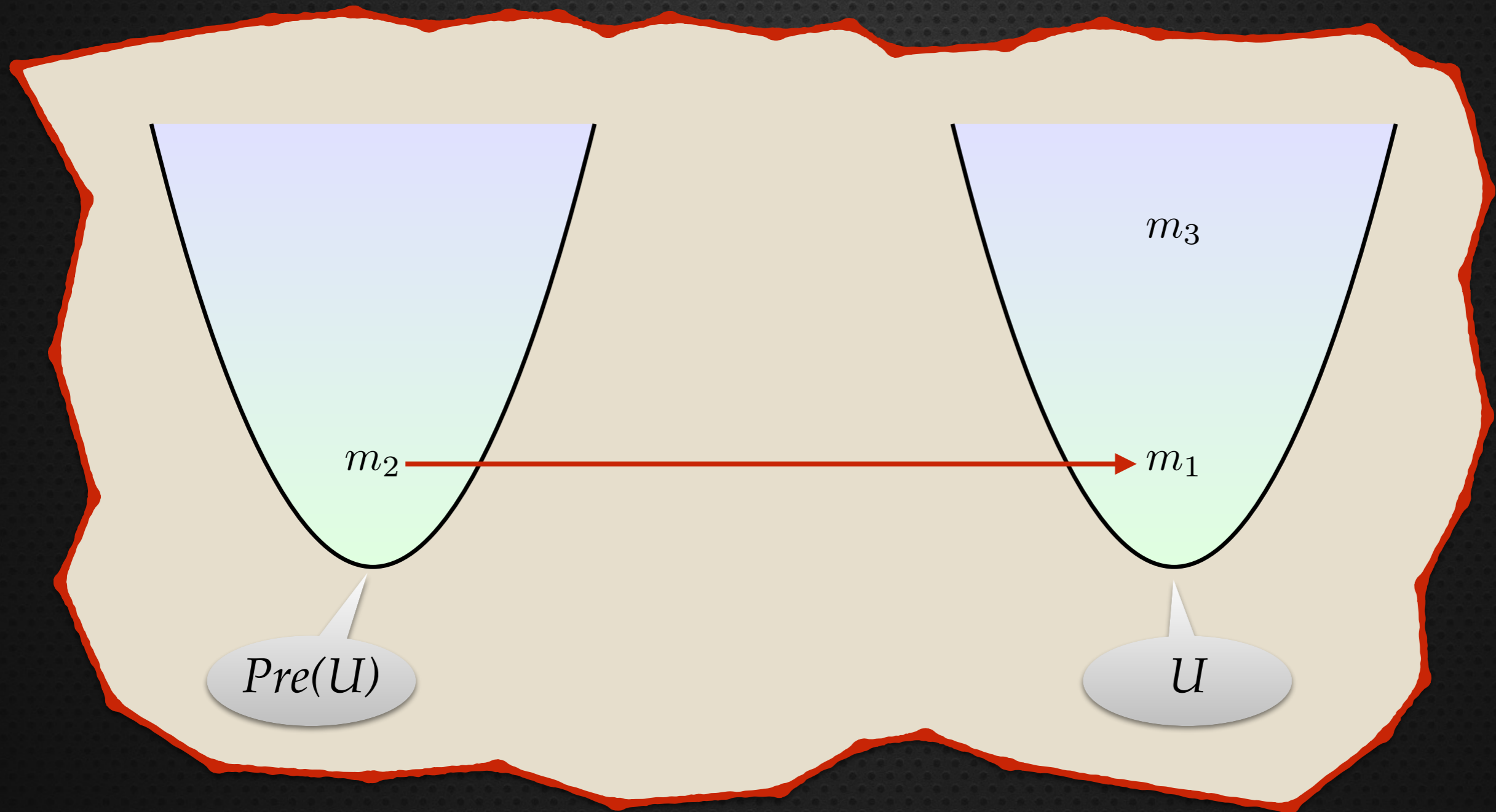




# Lossy Predecessors

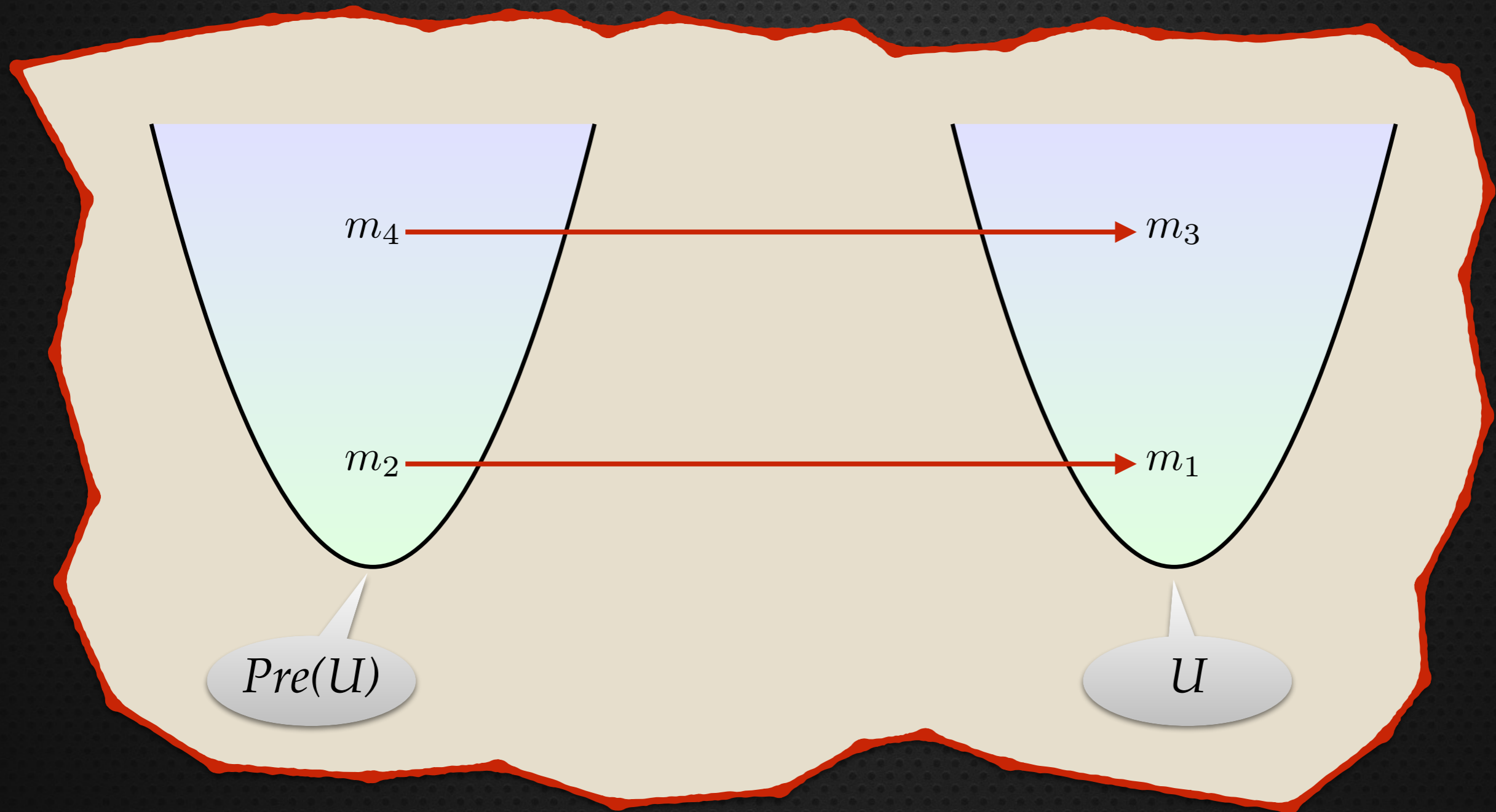


# Lossy Predecessors

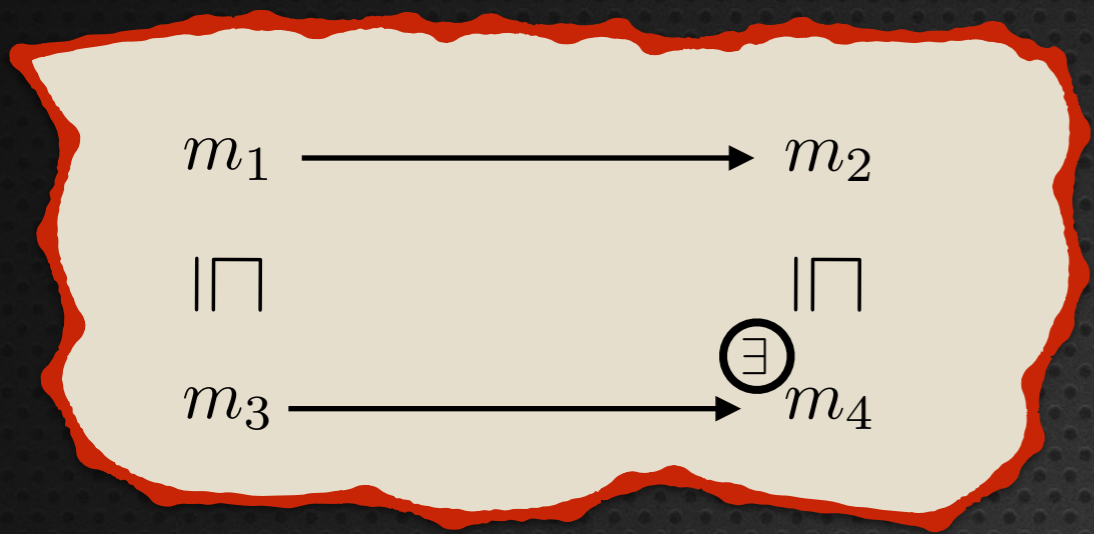




# Lossy Predecessors



# Lossy Predecessors

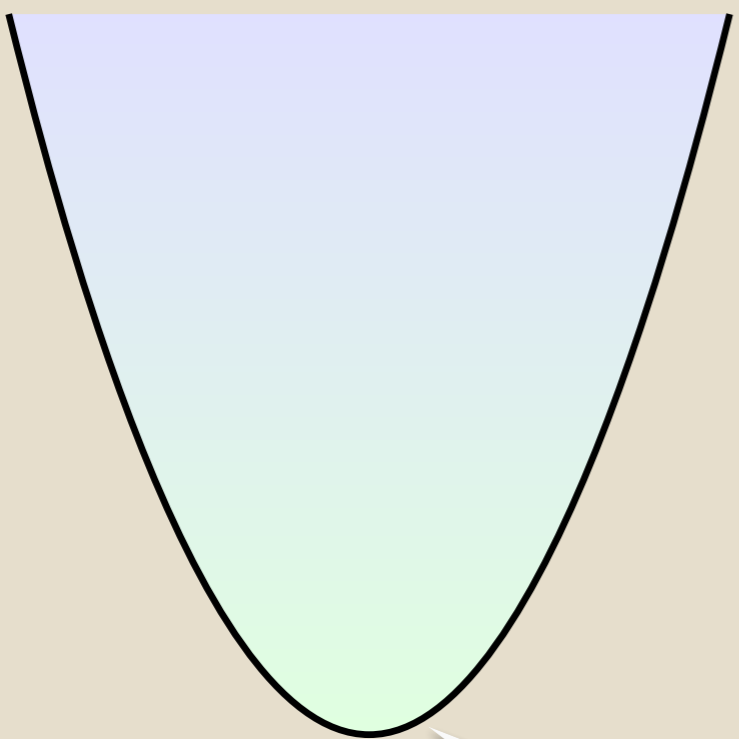
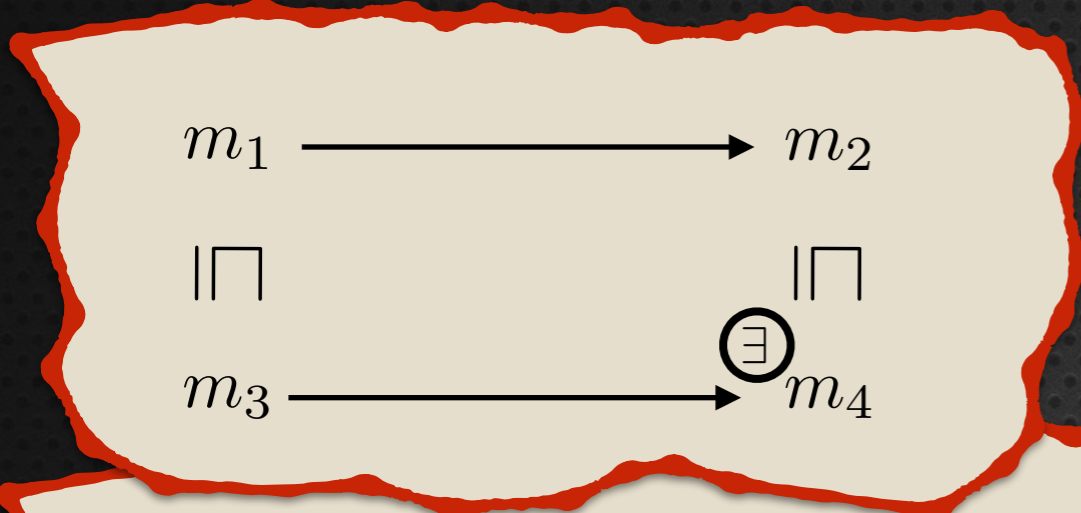


Monotonicity: UC persevered by *Pre*

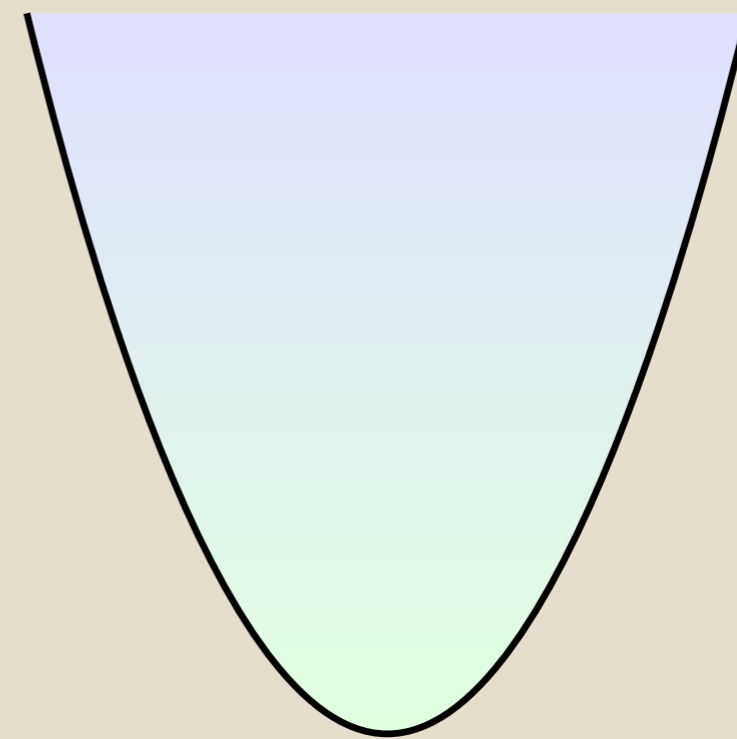


# Lossy Predecessors

Monotonicity: UC persevered by *Pre*



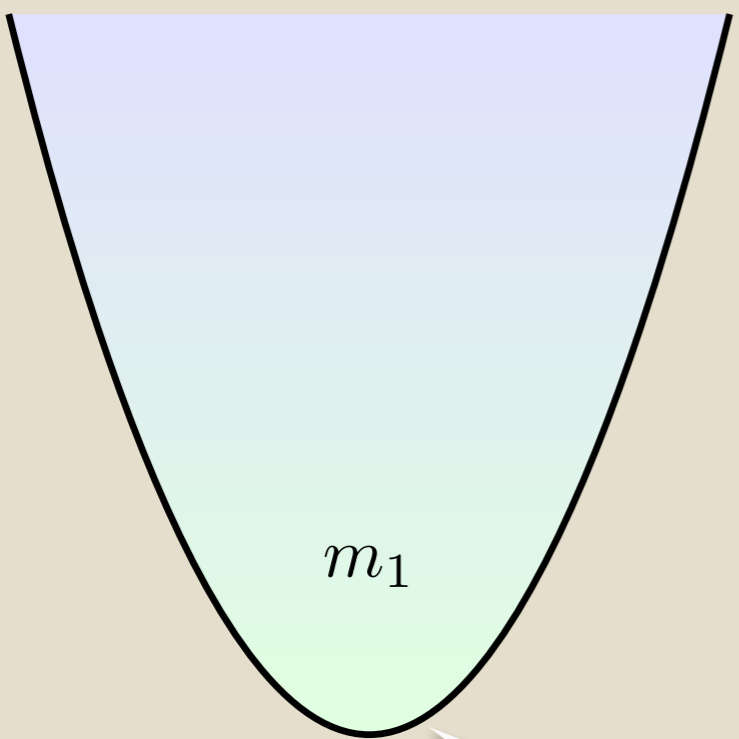
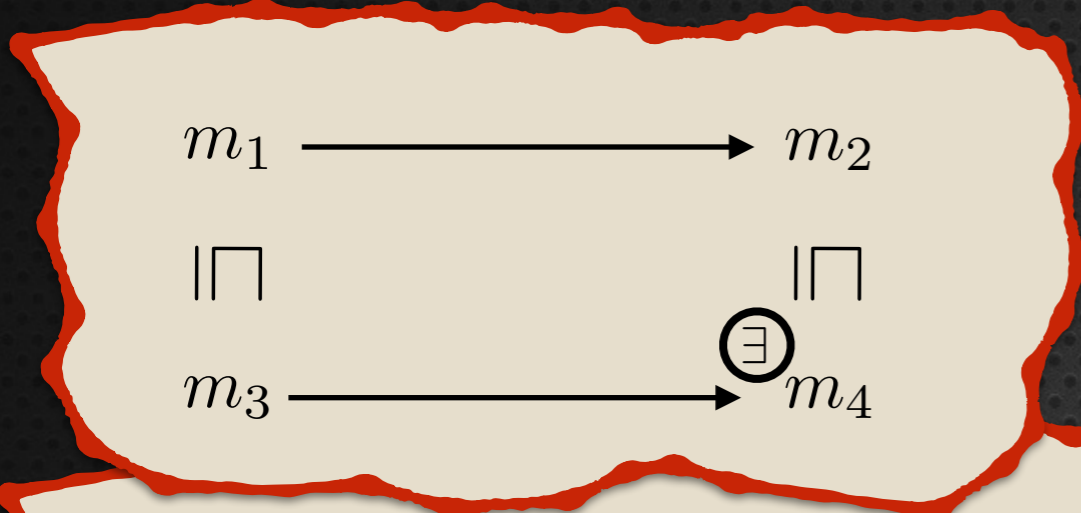
upward closed?



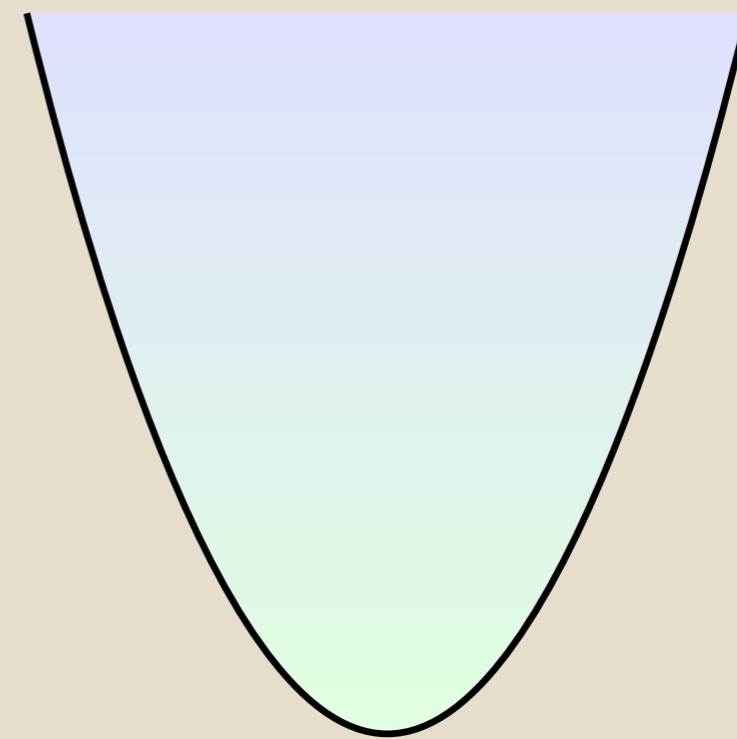
upward closed

# Lossy Predecessors

Monotonicity: UC persevered by *Pre*



*Pre(U)* upward closed?

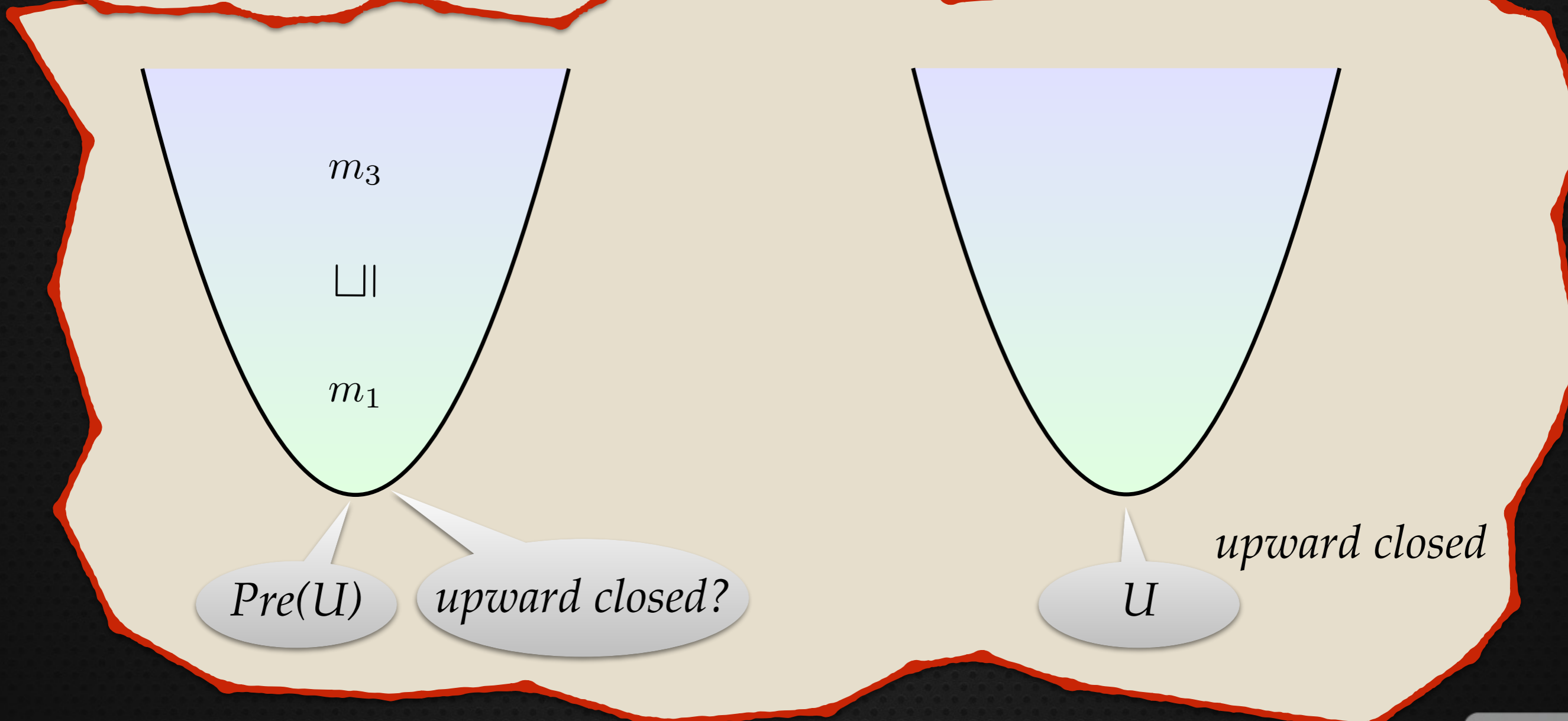
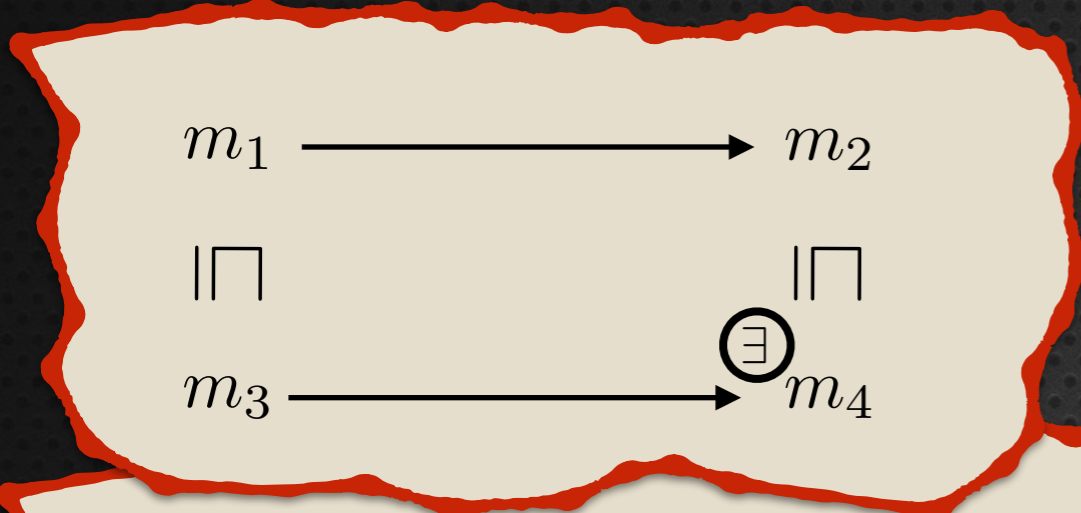


*U* upward closed



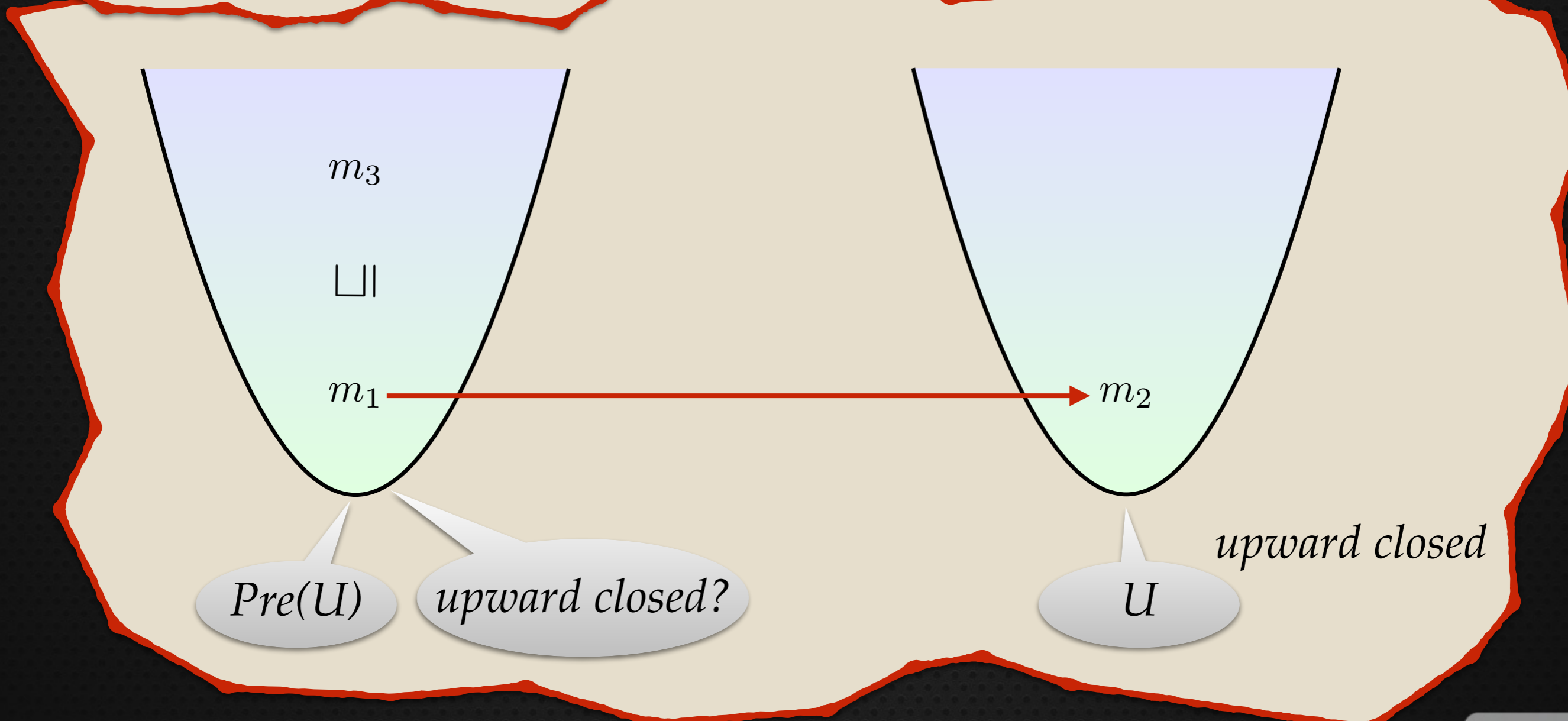
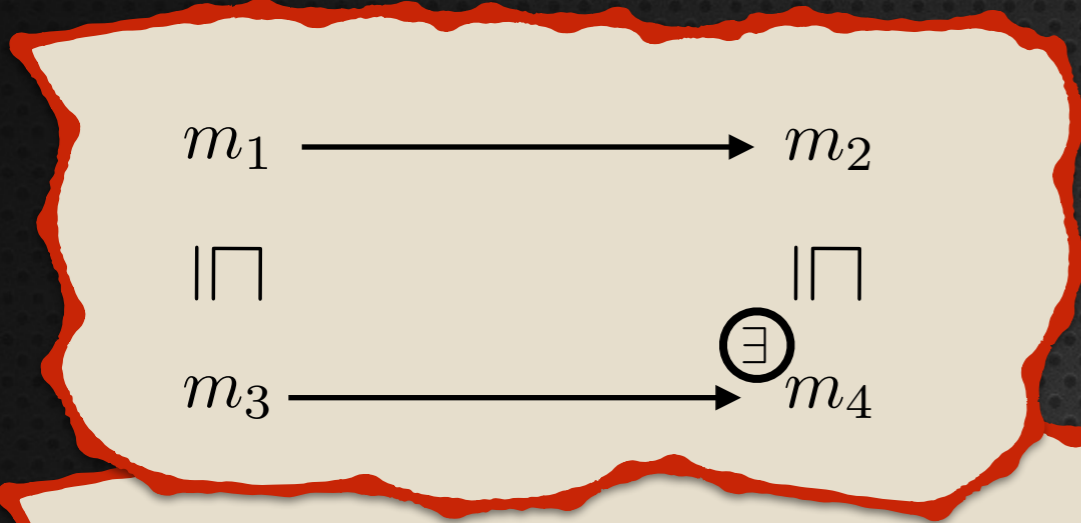
# Lossy Predecessors

Monotonicity: UC persevered by *Pre*



# Lossy Predecessors

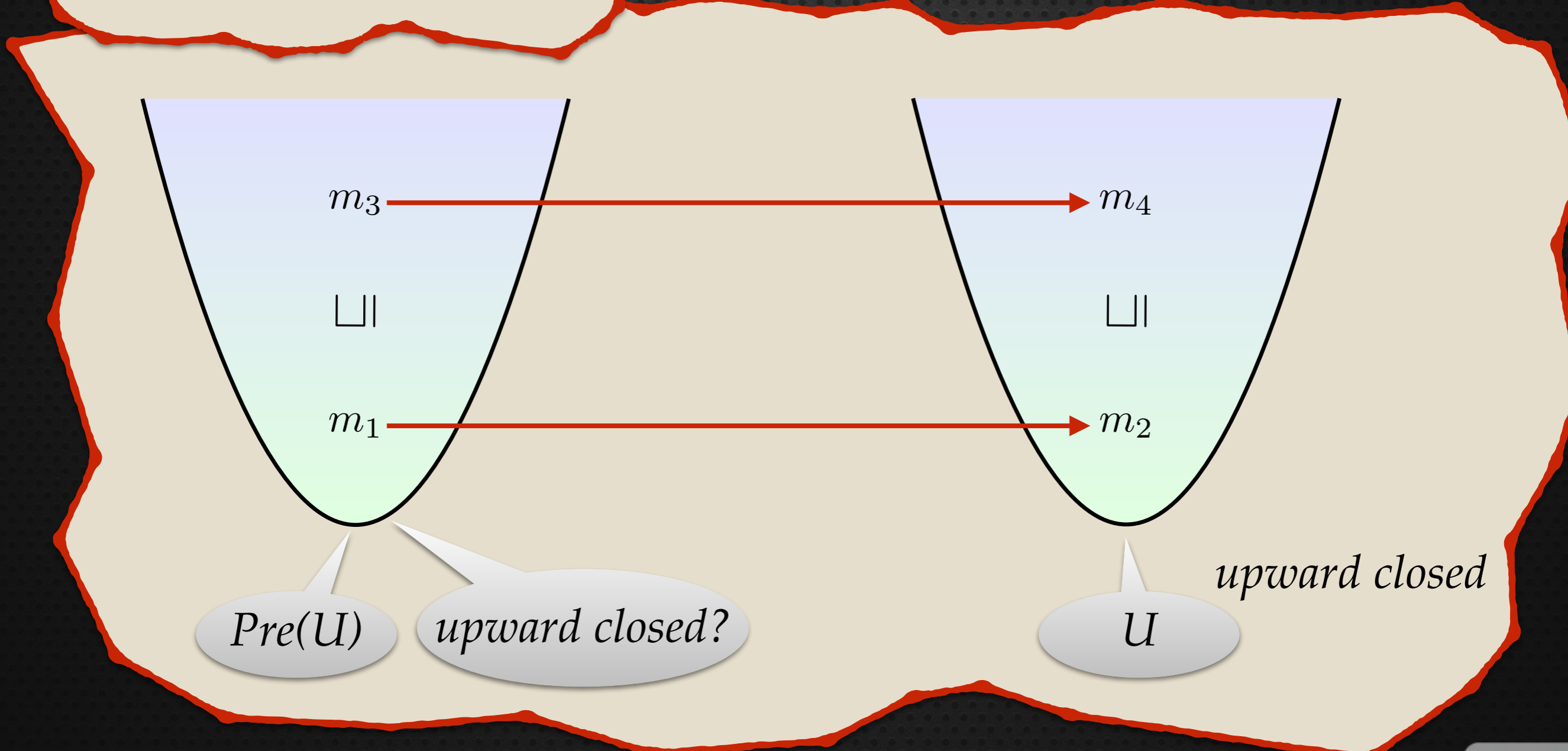
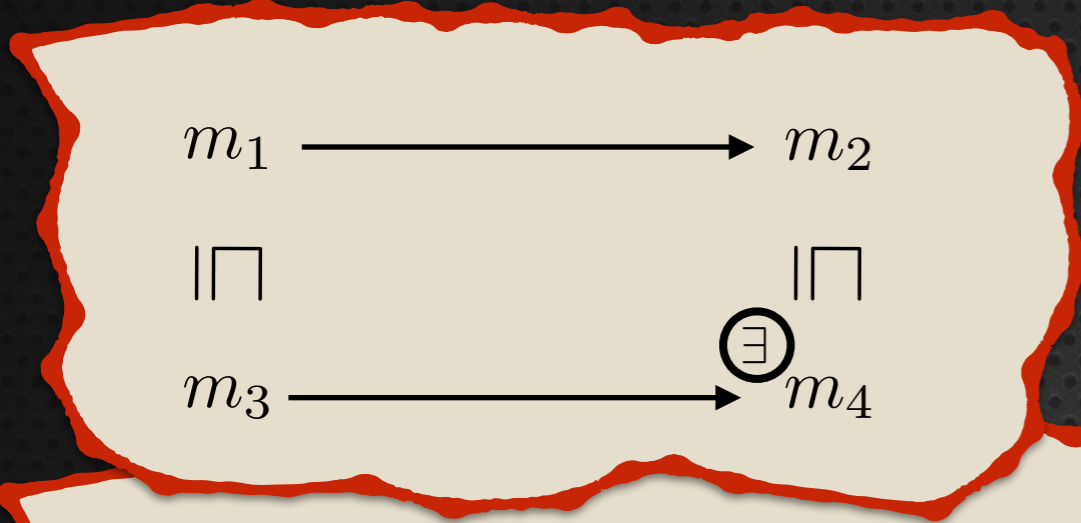
Monotonicity: UC persevered by *Pre*





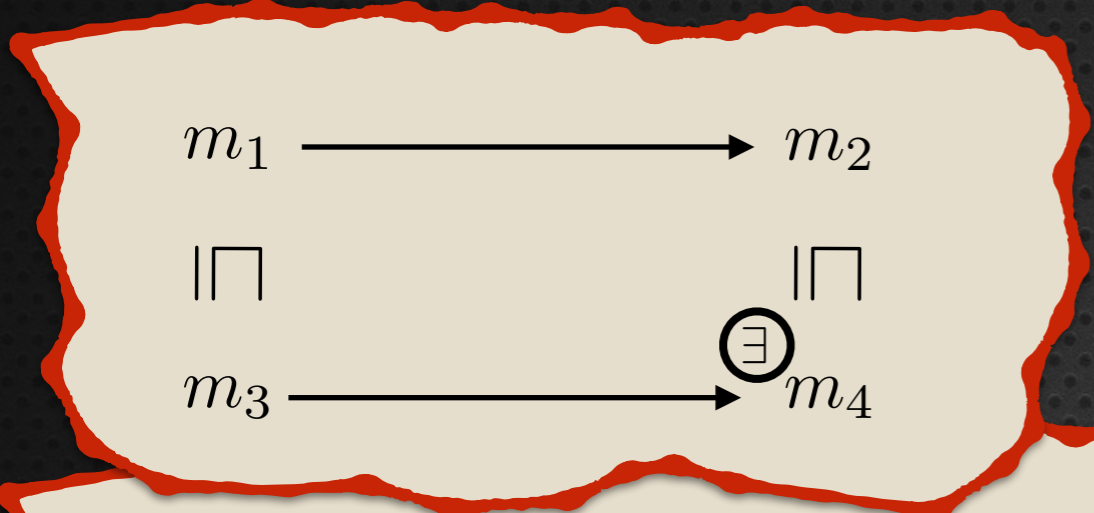
# Lossy Predecessors

Monotonicity: UC persevered by *Pre*

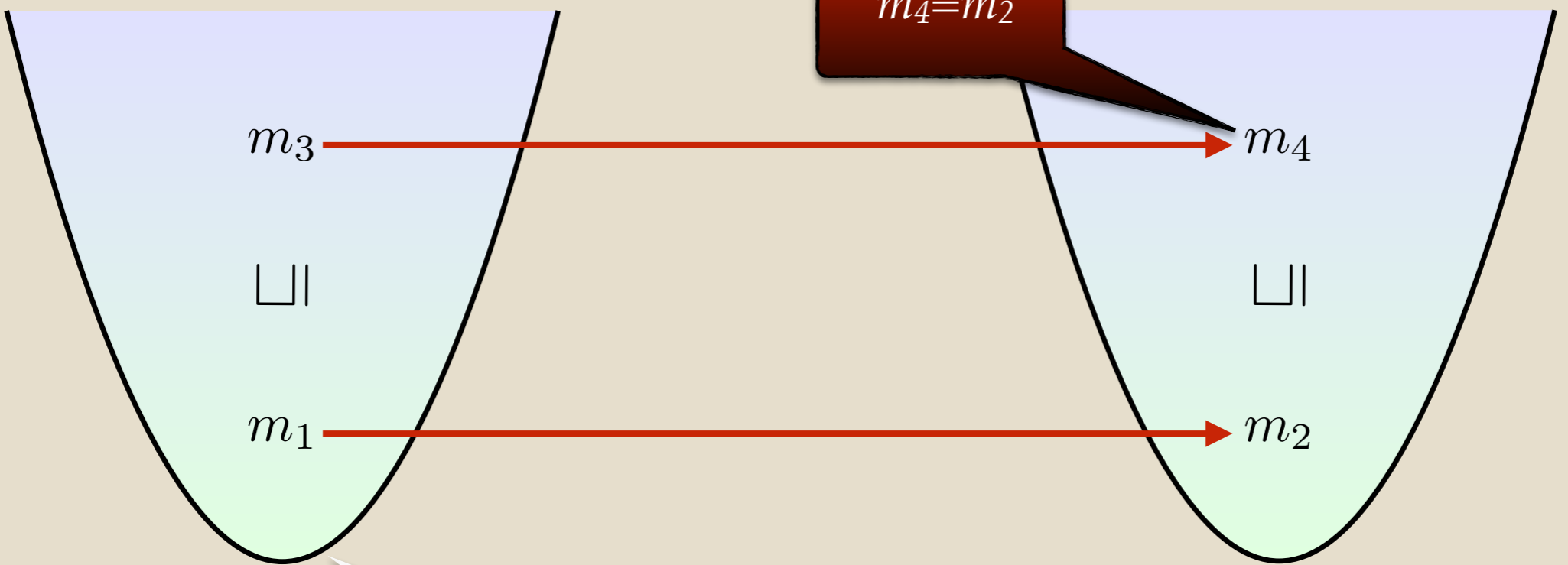


# Lossy Predecessors

Monotonicity: UC persevered by *Pre*



choose  
 $m_4 = m_2$



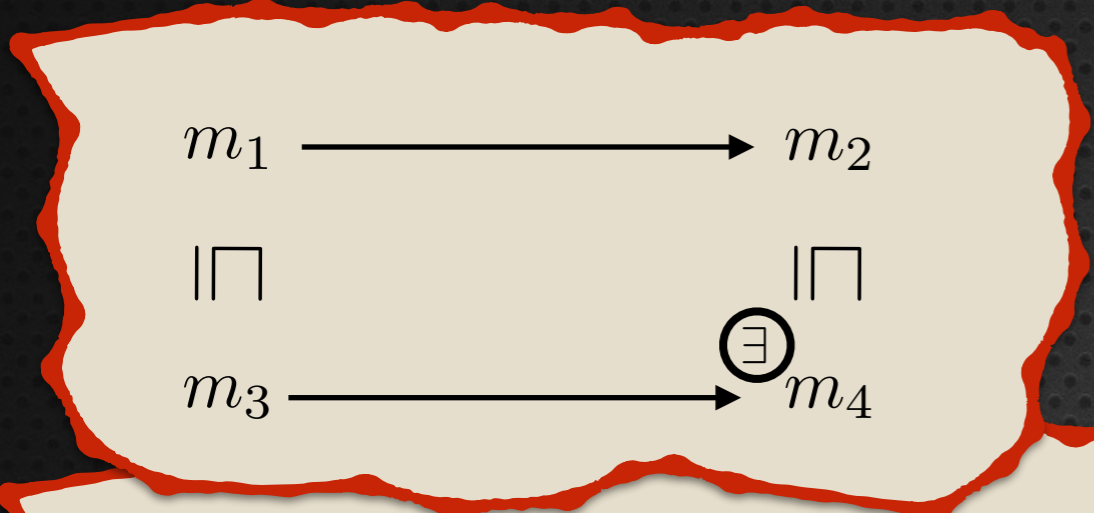
*Pre(U)* upward closed?

*U* upward closed

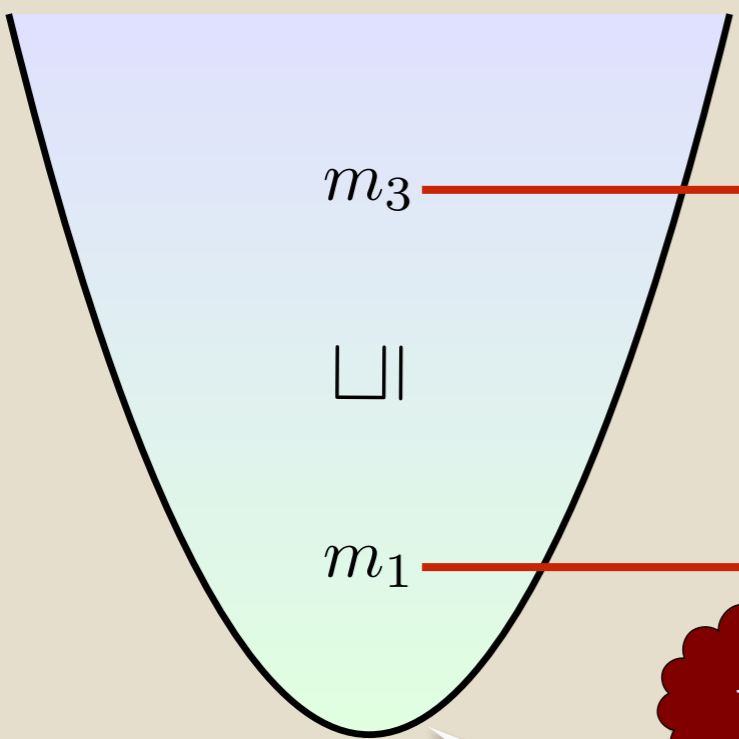


# Lossy Predecessors

Monotonicity: UC persevered by *Pre*

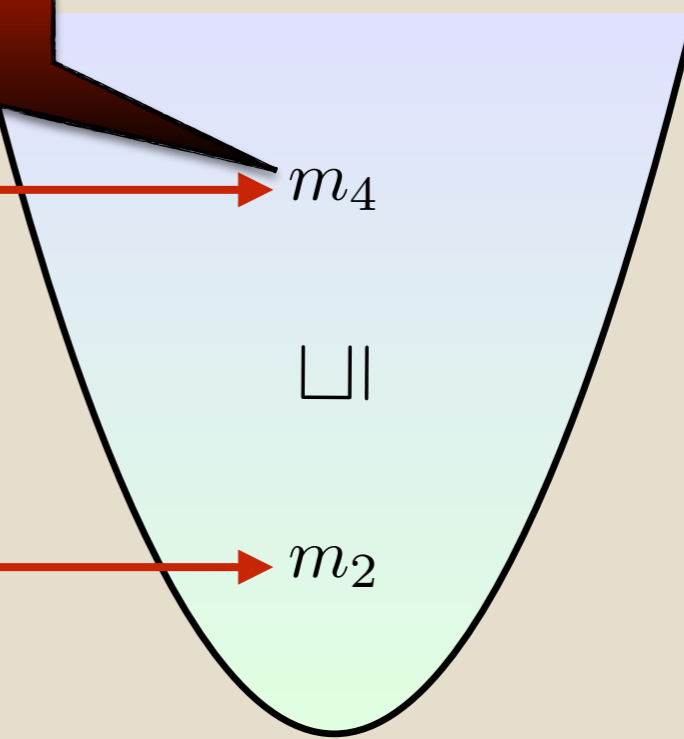


choose  
 $m_4 = m_2$



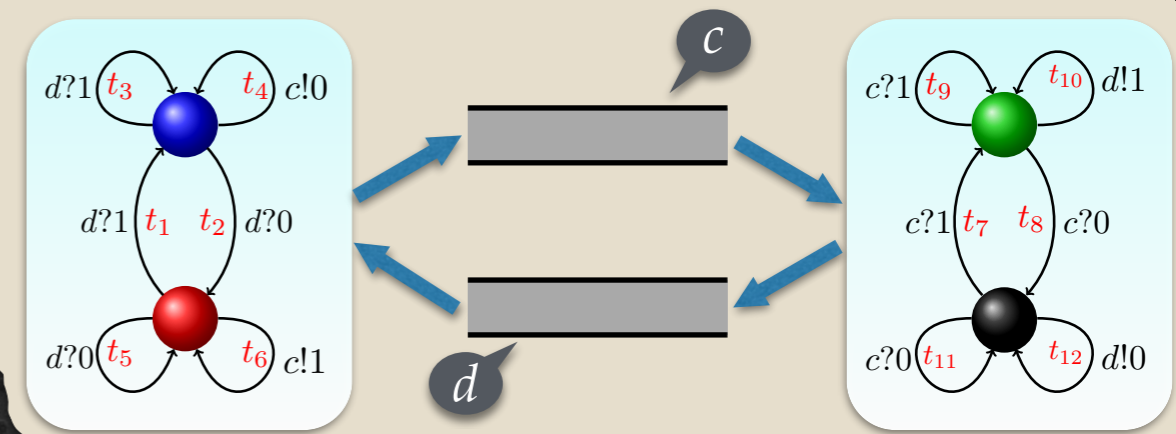
*Pre(U)*  
upward closed?

yes



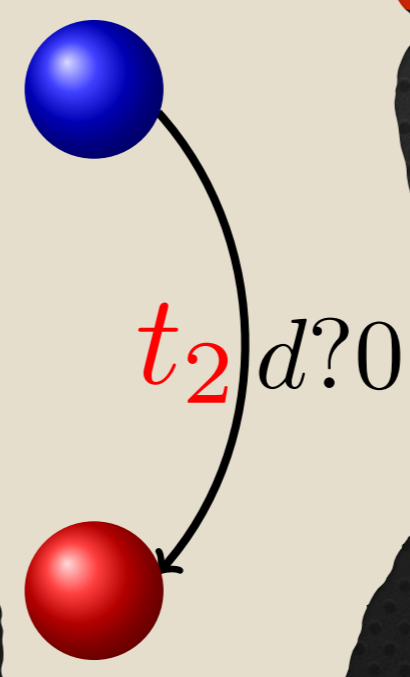
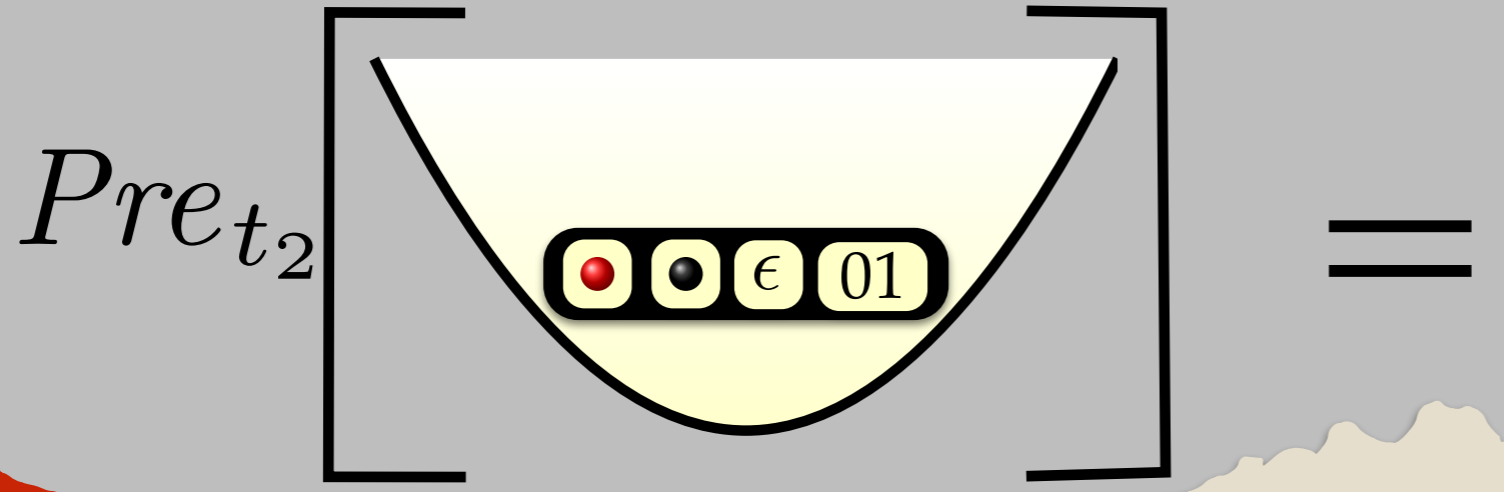
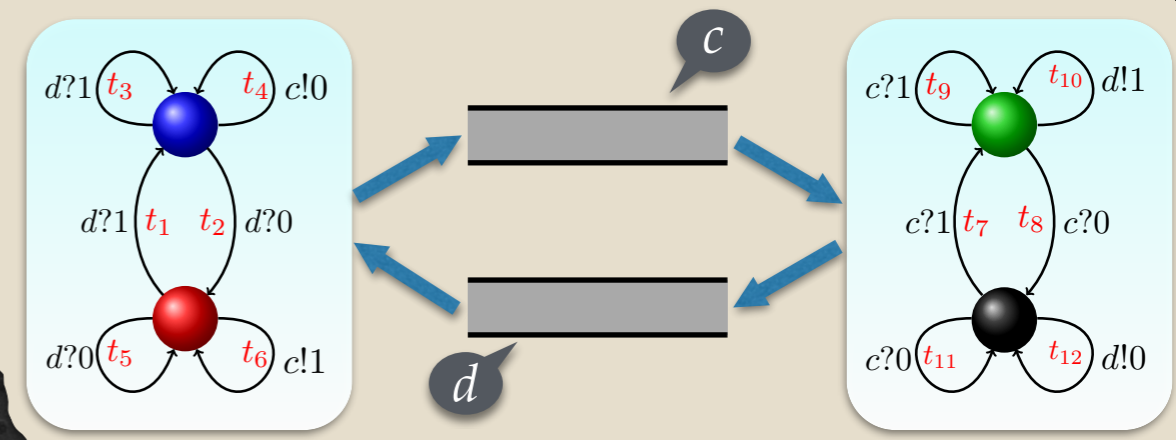
*U*  
upward closed

# Lossy Computing Predecessors

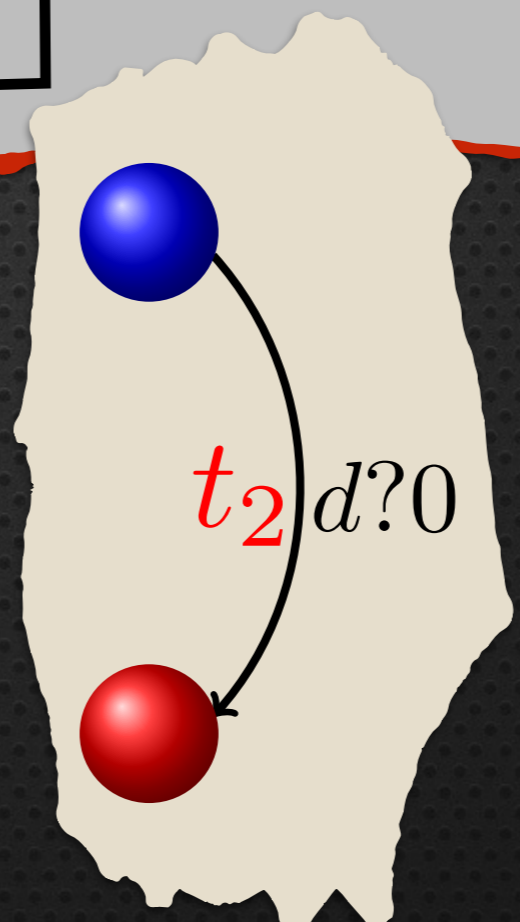
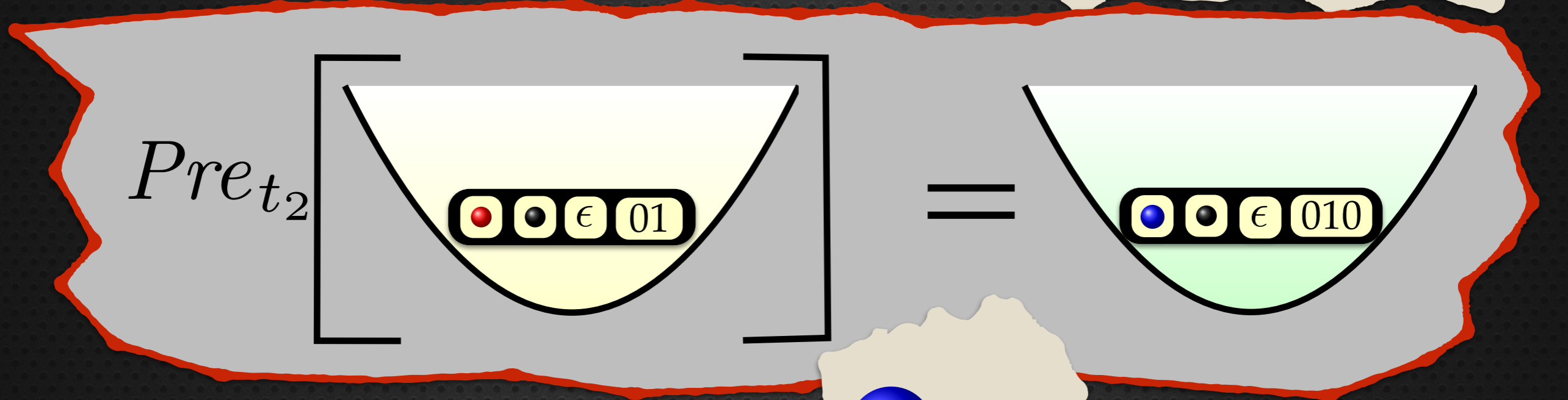
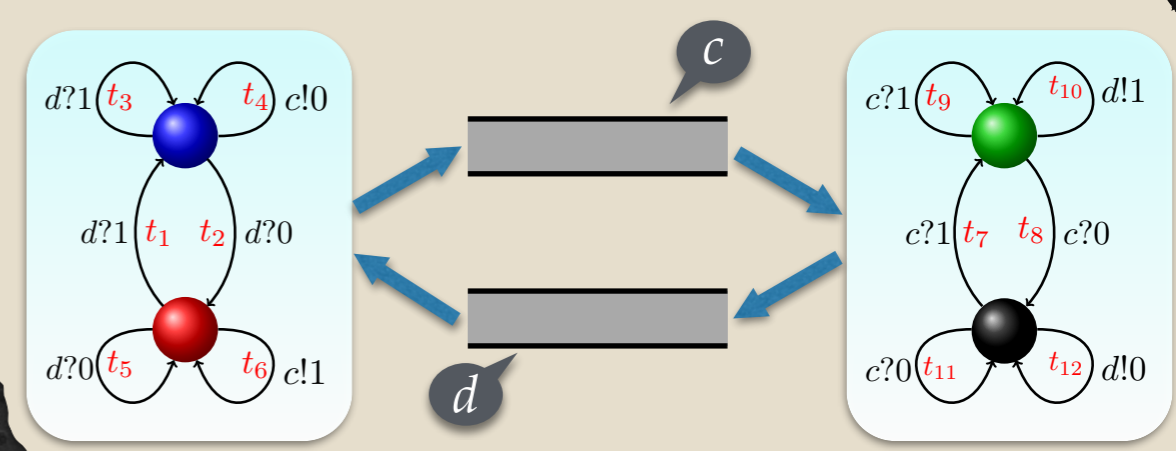




# Lossy Computing Predecessors

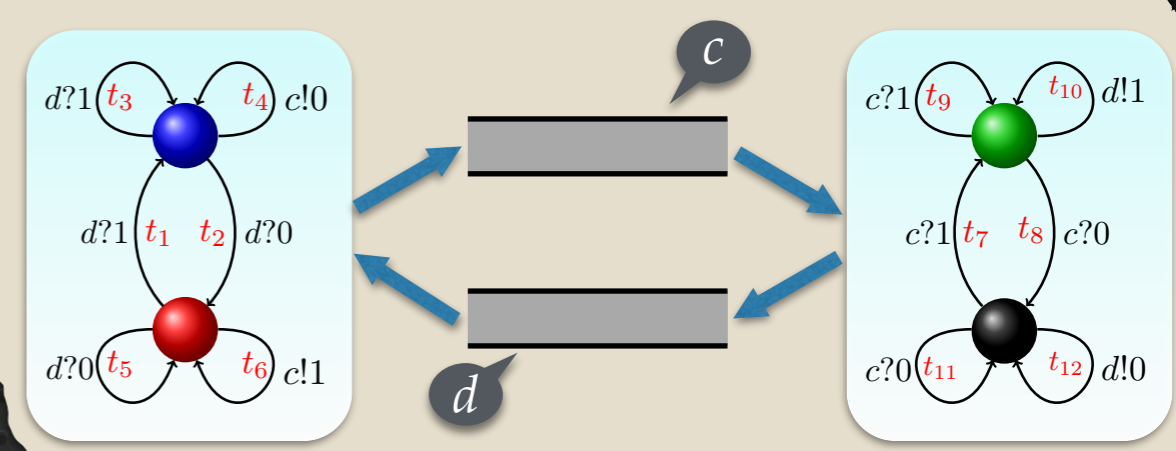


# Lossy Computing Predecessors

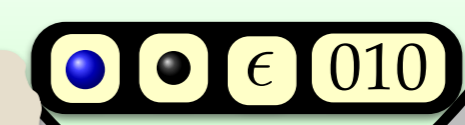
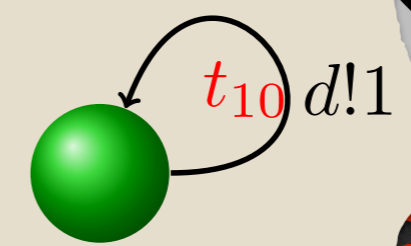
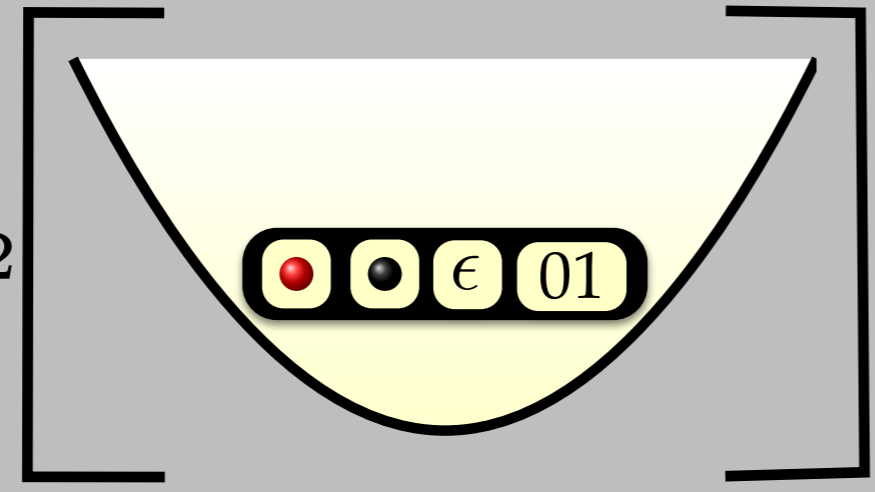




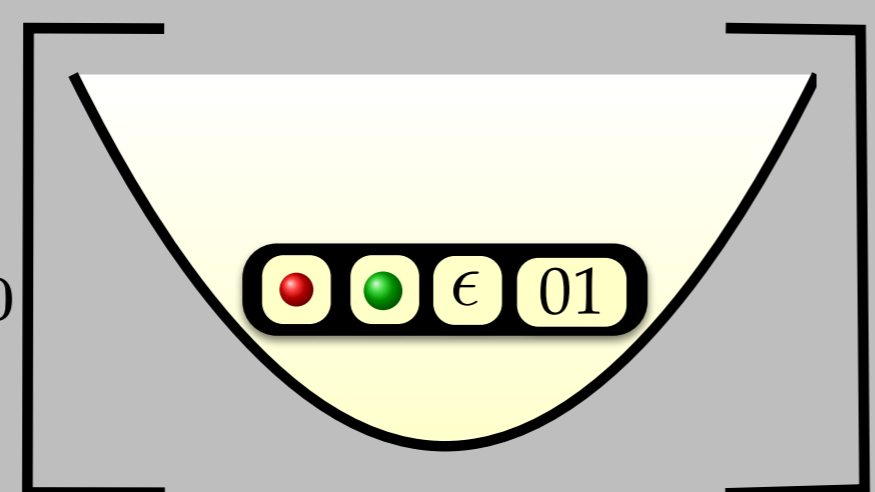
# Lossy Computing Predecessors



$Pre_{t_2}$

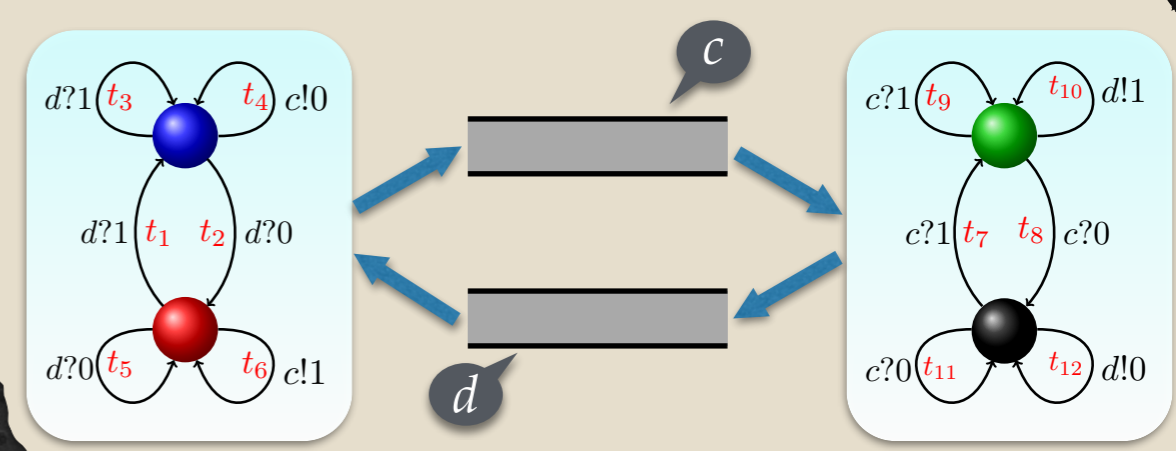


$Pre_{t_{10}}$

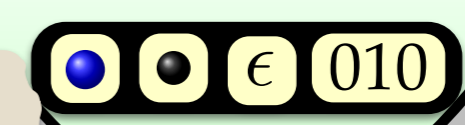
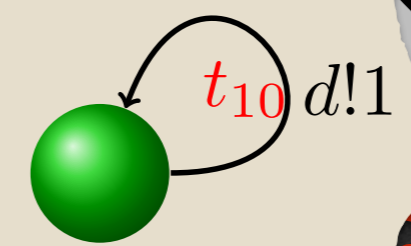
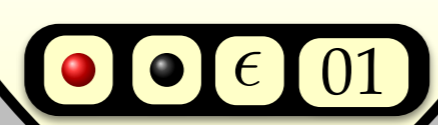


=

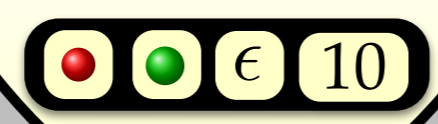
# Lossy Computing Predecessors



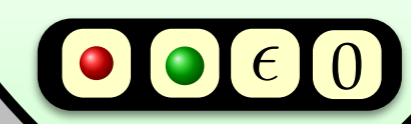
$Pre_{t_2}$



$Pre_{t_{10}}$

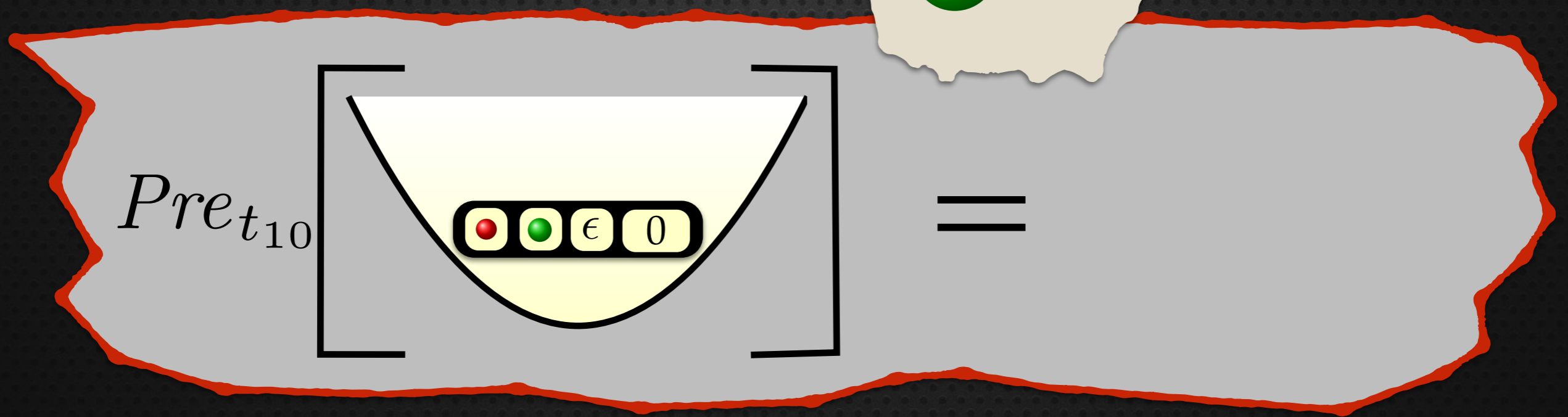
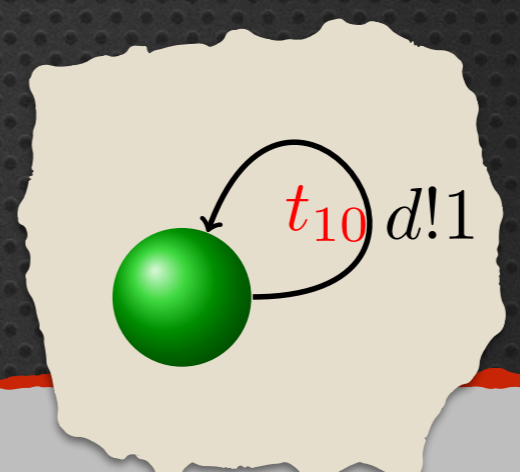
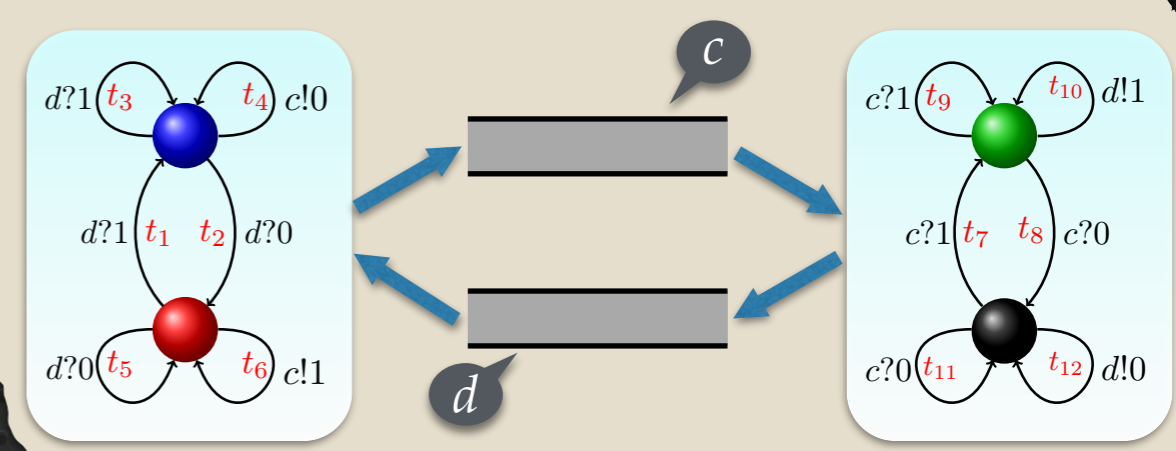


=

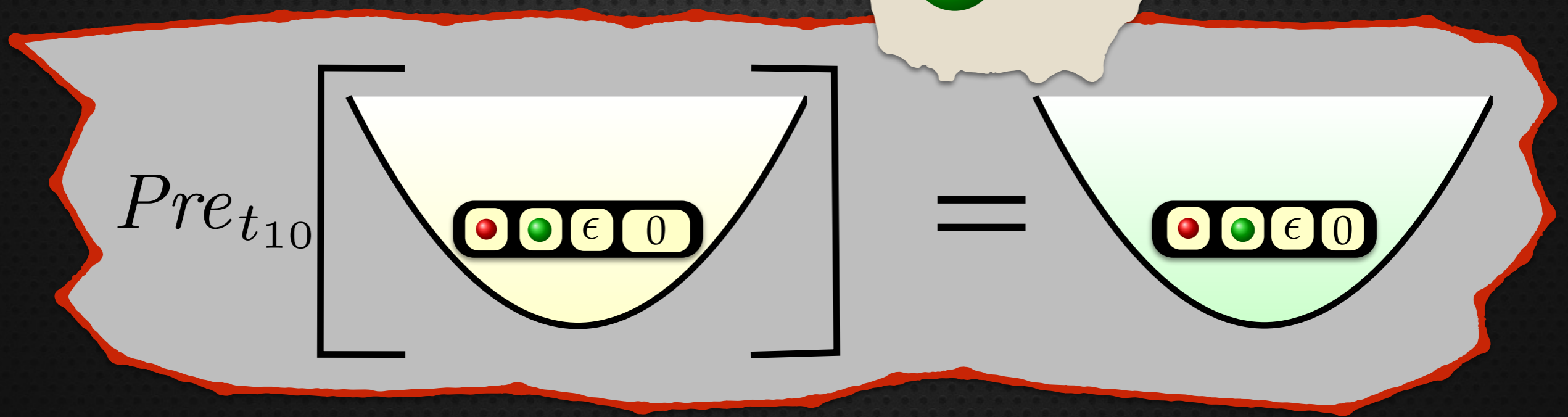
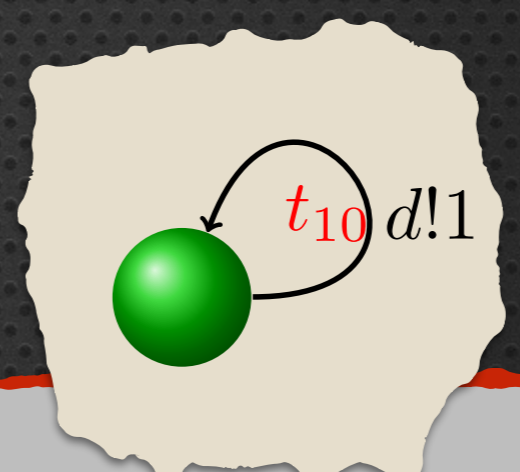
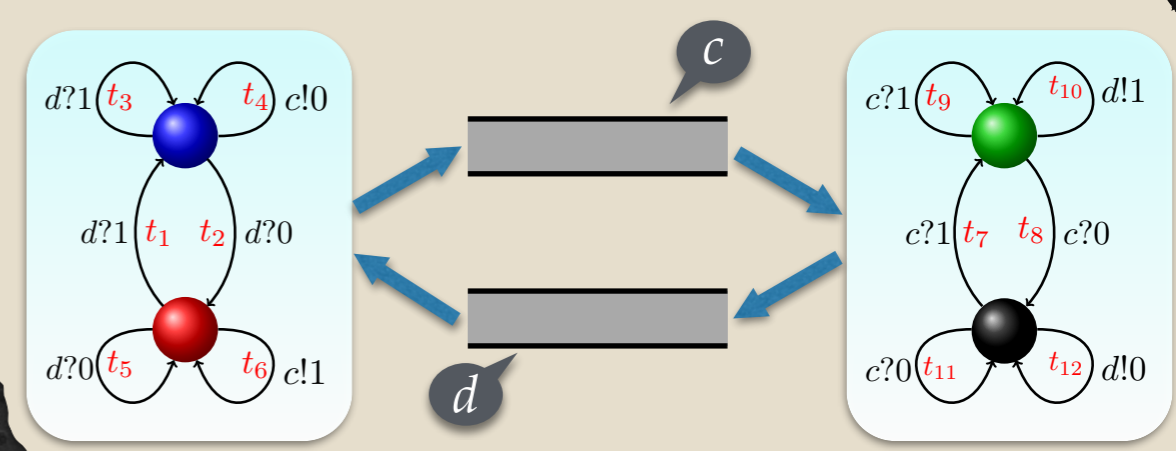




# Lossy Computing Predecessors

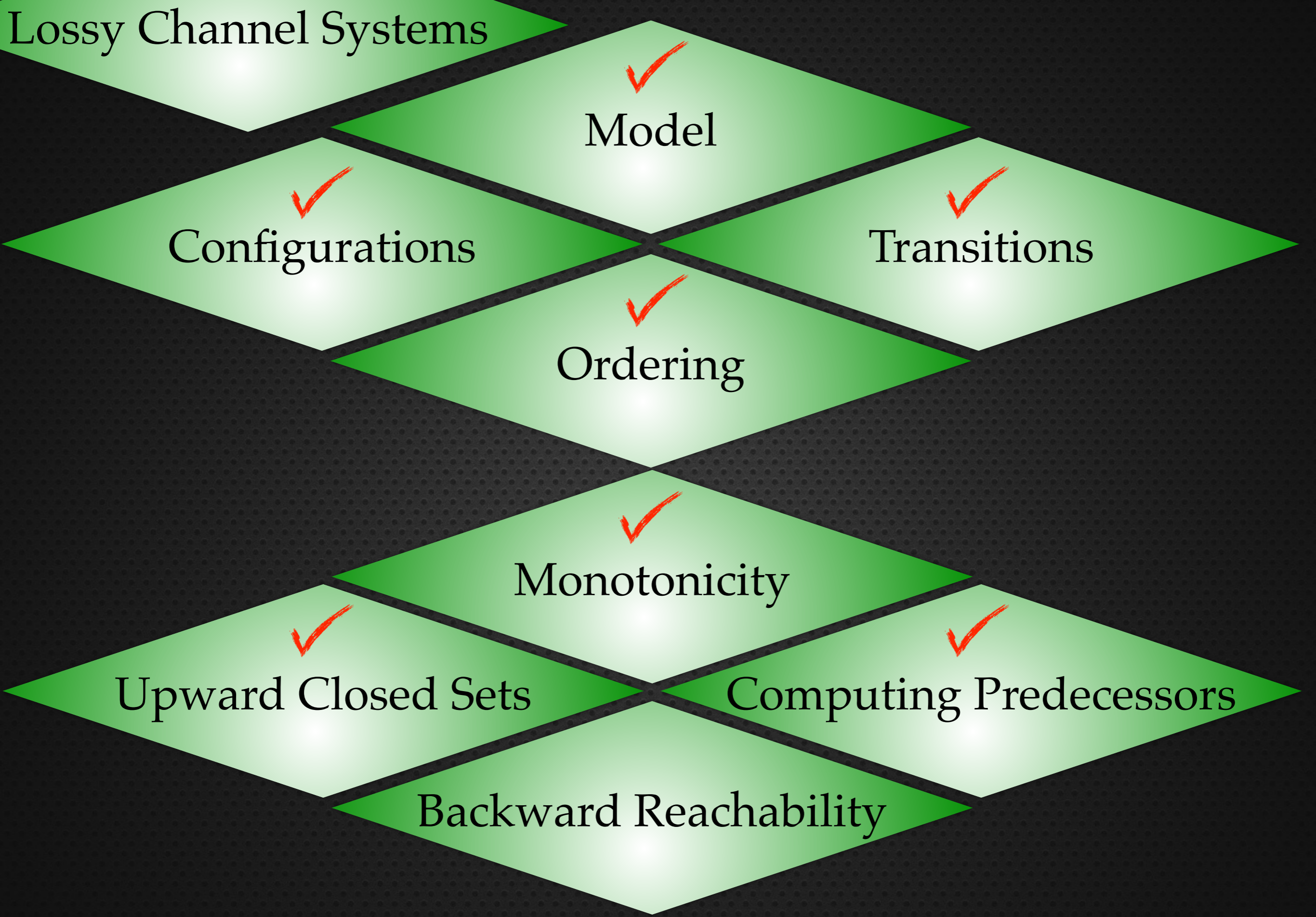


# Lossy Computing Predecessors



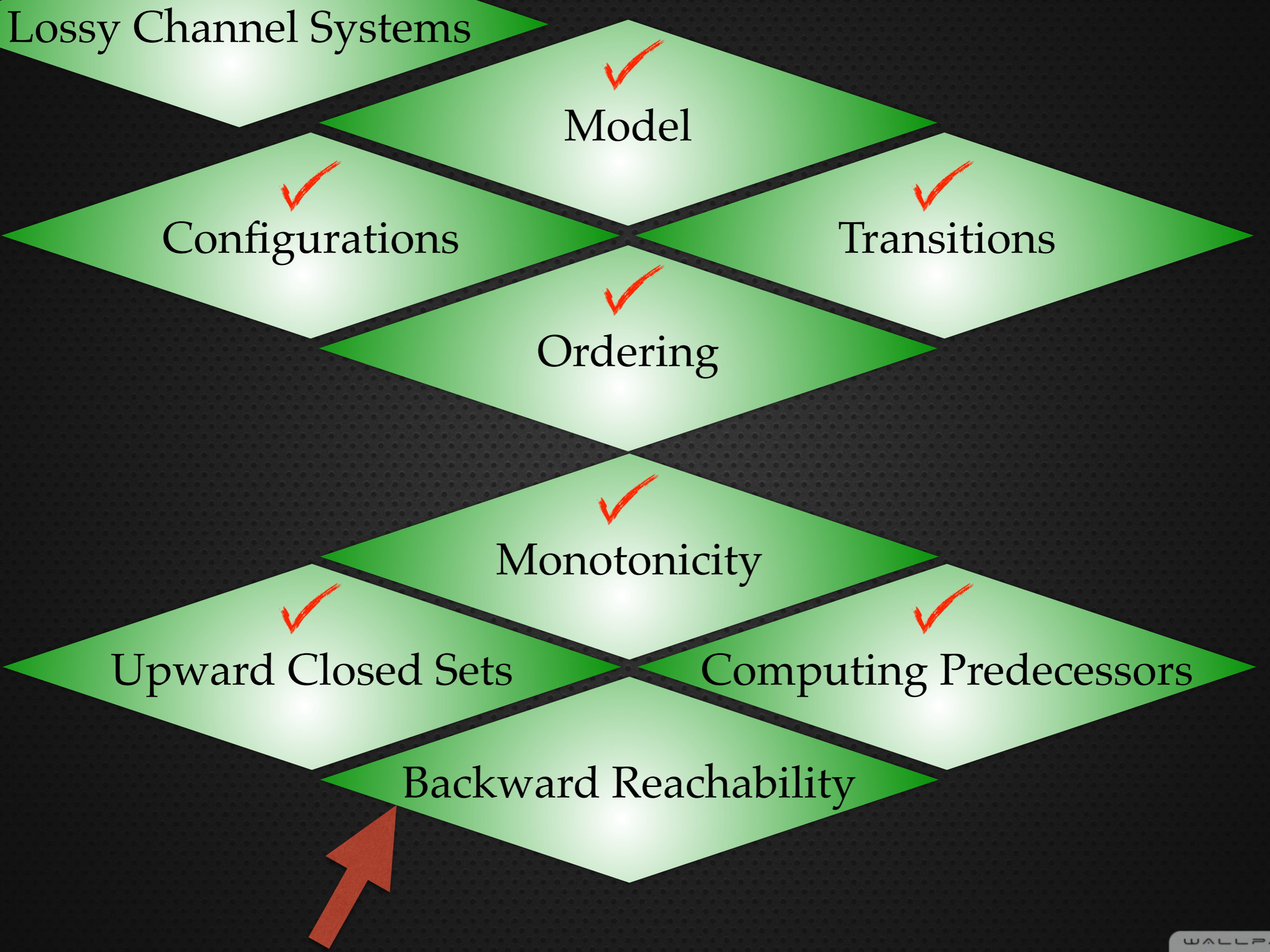


# Lossy Channel Systems





# Lossy Channel Systems



Model

Configurations

Transitions

Ordering

Monotonicity

Upward Closed Sets

Computing Predecessors

Backward Reachability



# Lossy Backward Reachability

● ● 1 0

● ● € 01

● ● 01 €

● ● 010 €

● ● € 01

● ● 101 €

symbolic representation = finite words

● ● € 101



# Lossy Backward Reachability

● ● 1 0

● ● € 01

● ● 01 €

● ● 010 €

● ● € 01

● ● 101 €

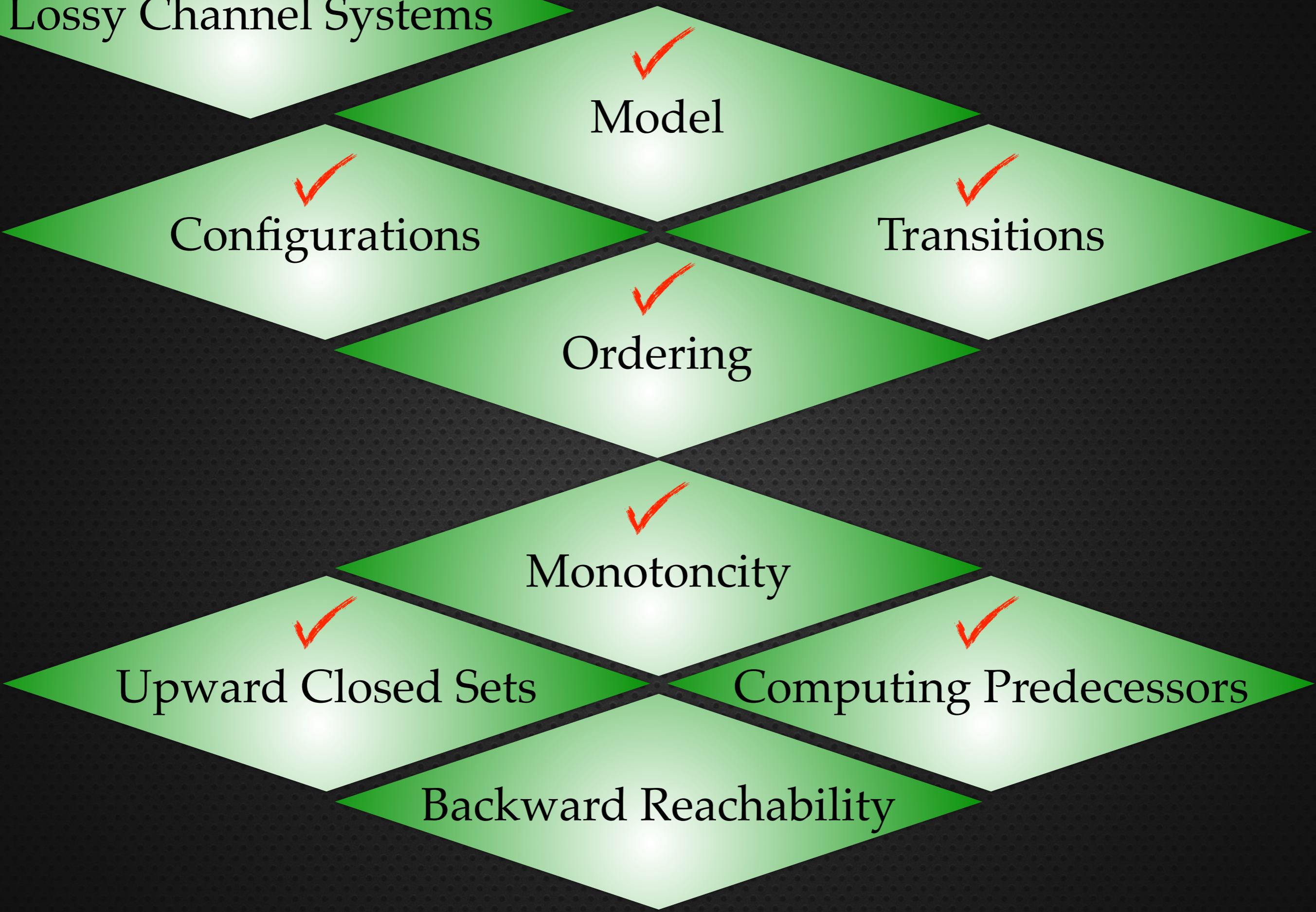
symbolic representation = finite words

● ● € 101

Termination: words well quasi-ordered

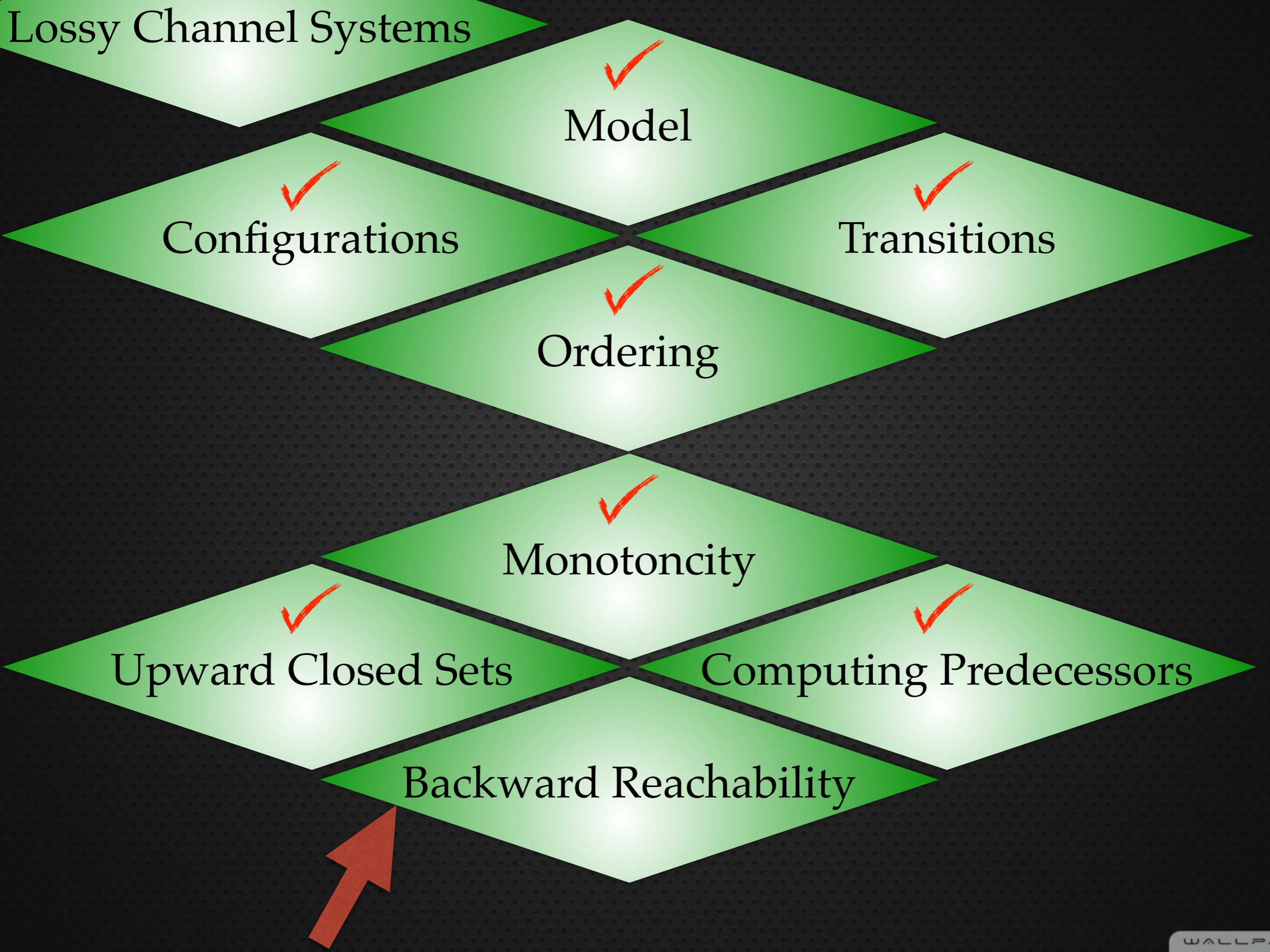


# Lossy Channel Systems





# Lossy Channel Systems



Model

Configurations

Transitions

Ordering

Monotoncity

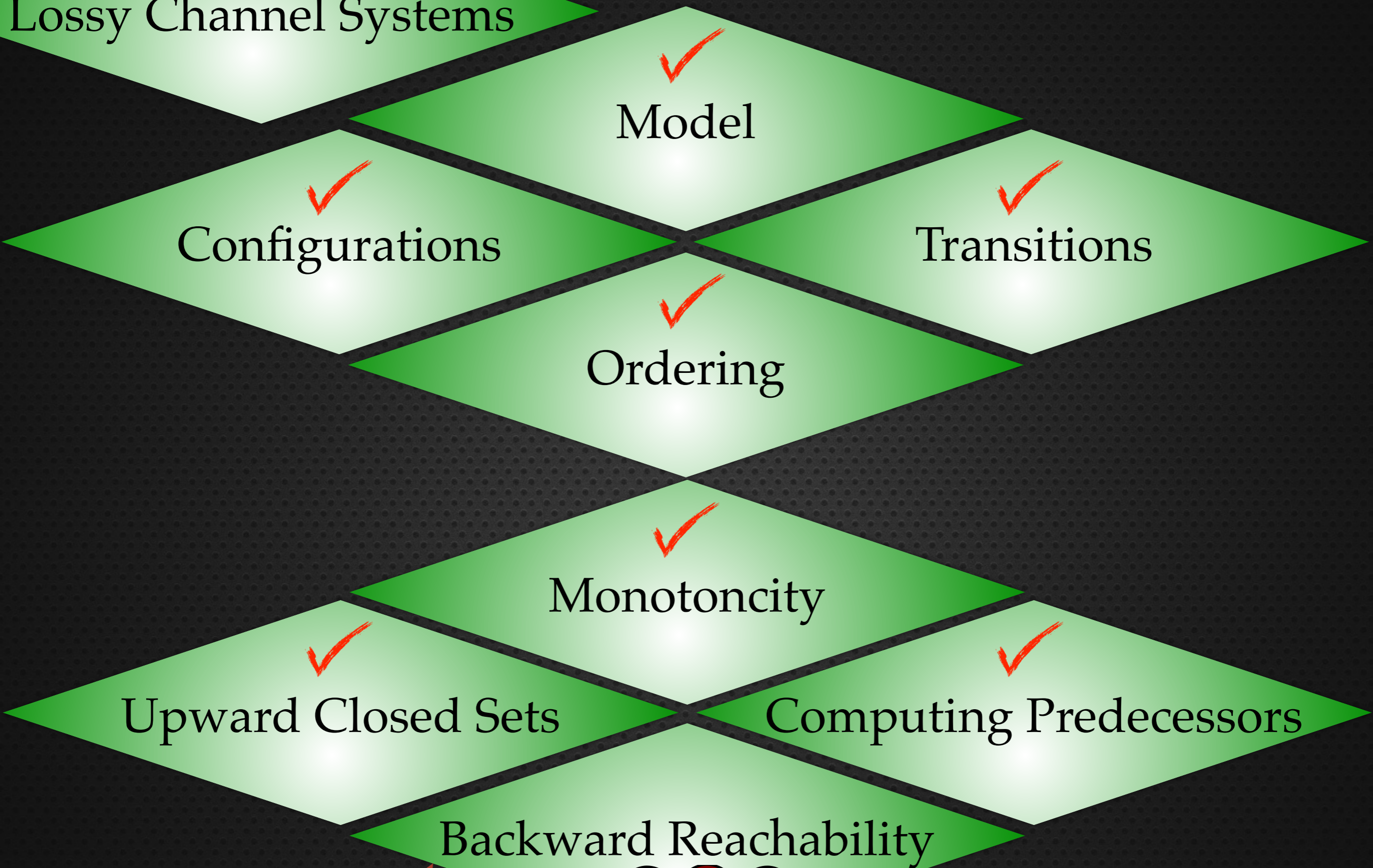
Upward Closed Sets

Computing Predecessors

Backward Reachability



# Lossy Channel Systems

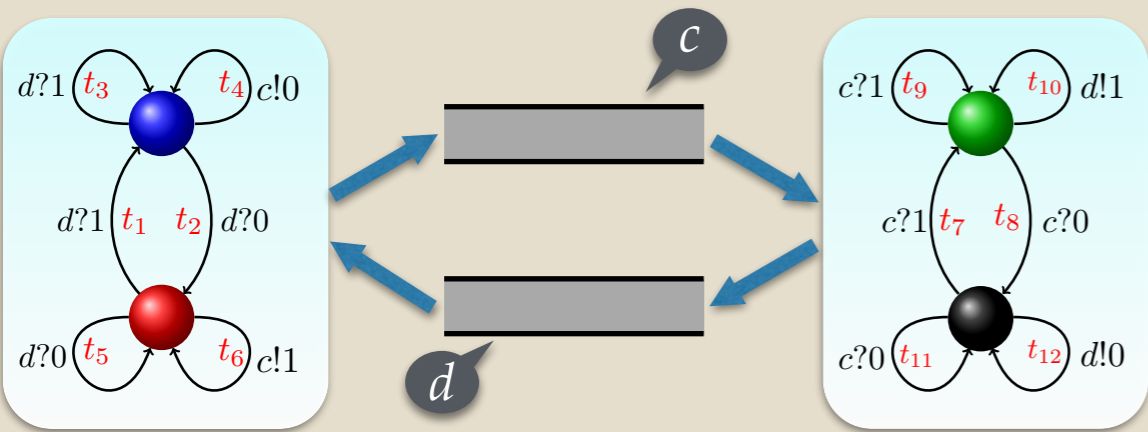


a more systematic algorithm





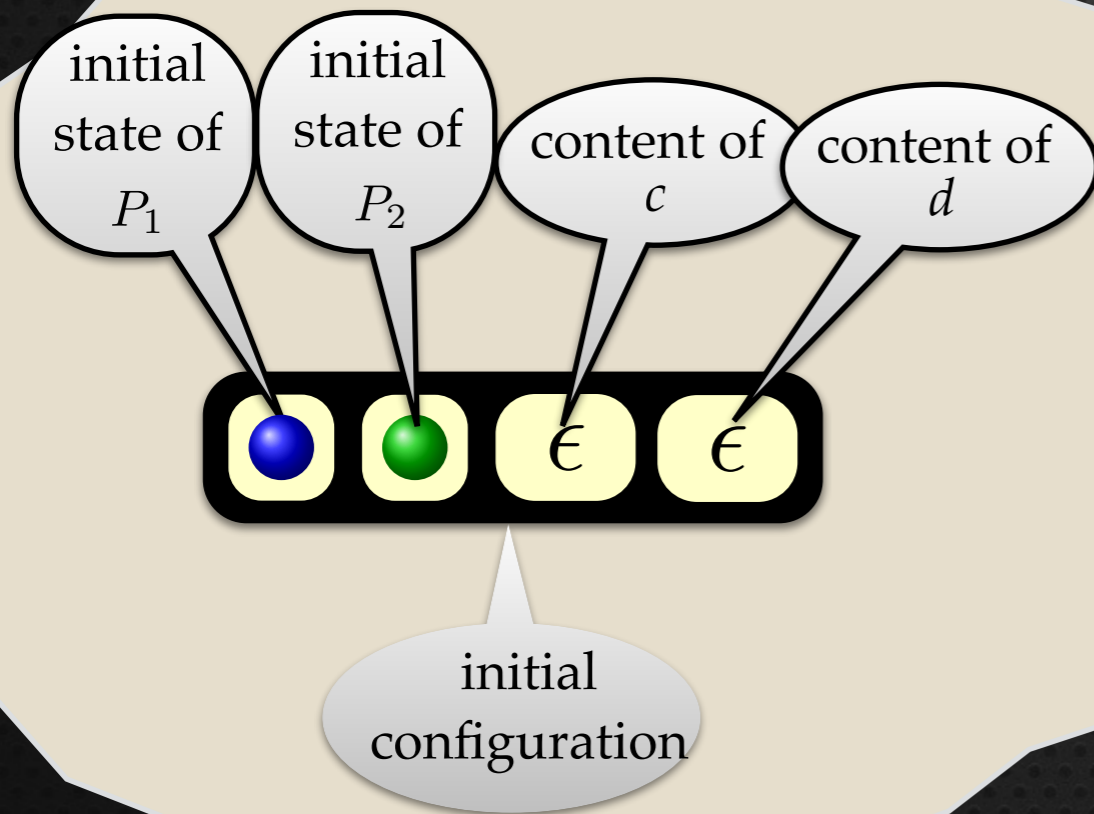
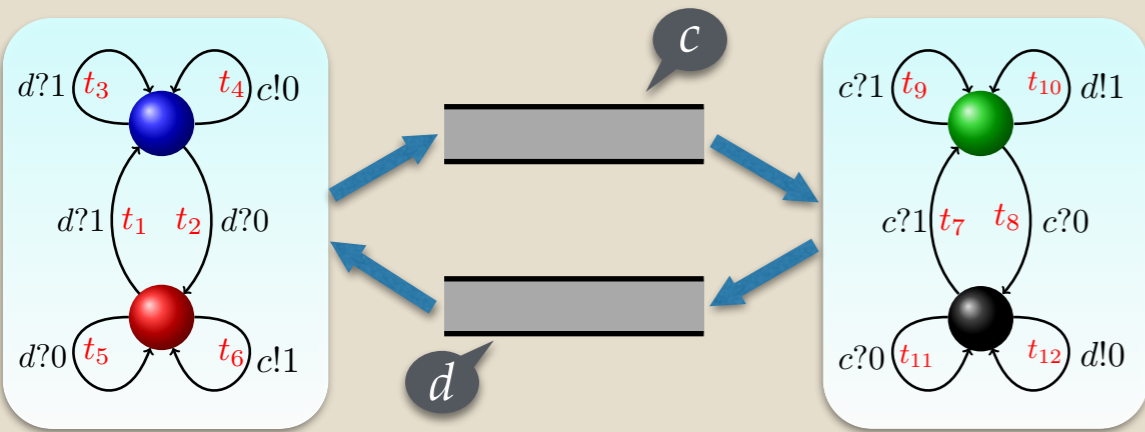
# Lossy Backward Reachability



€

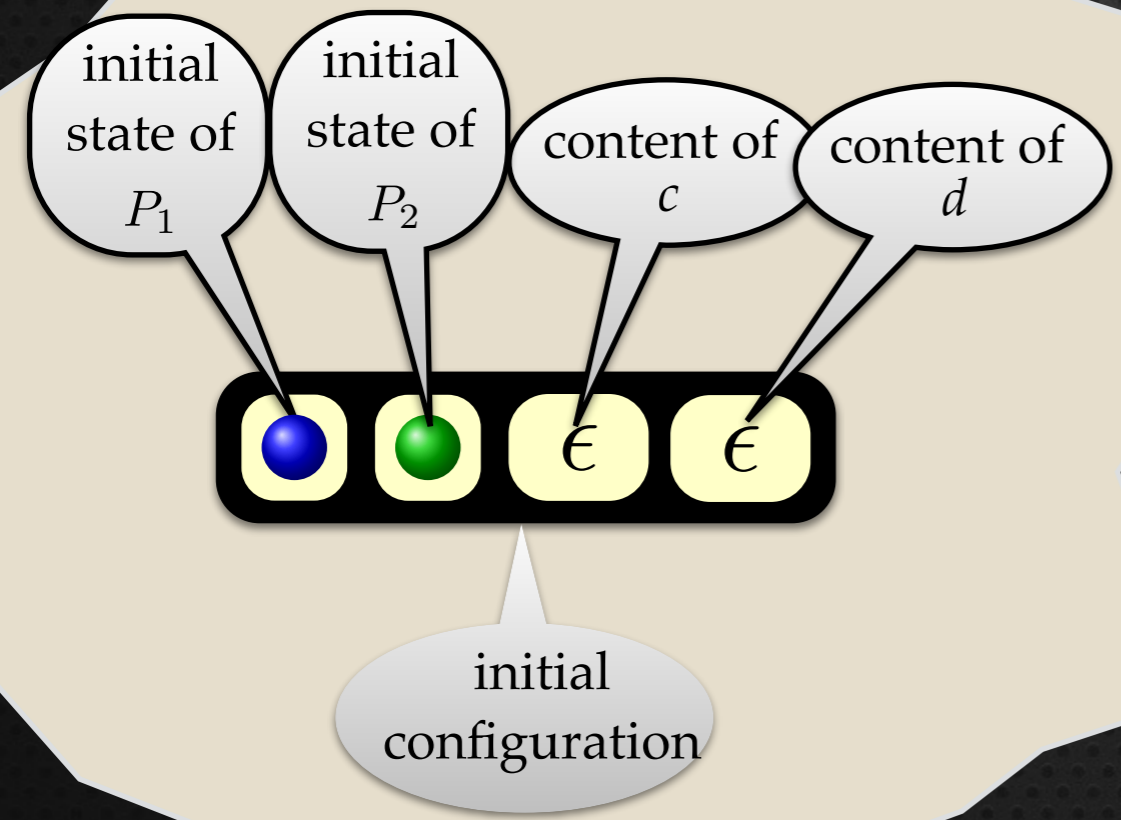
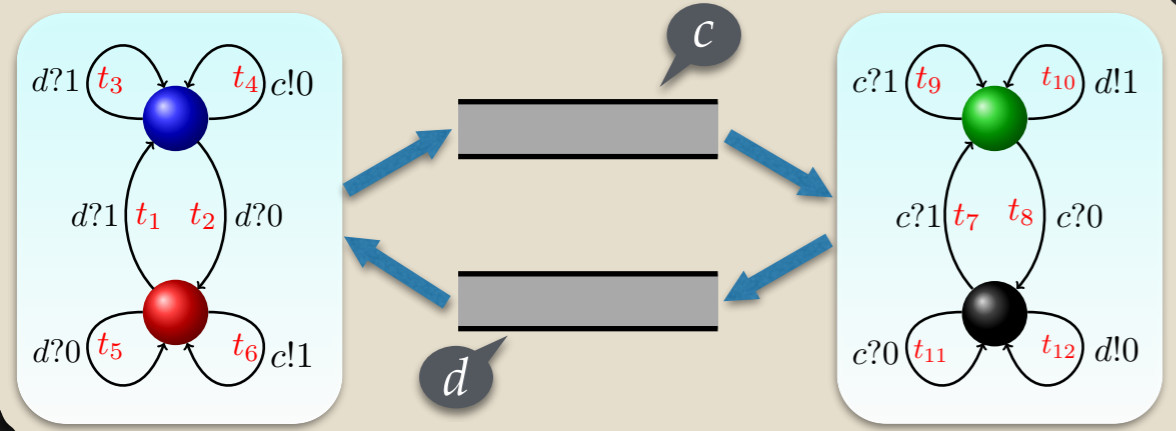
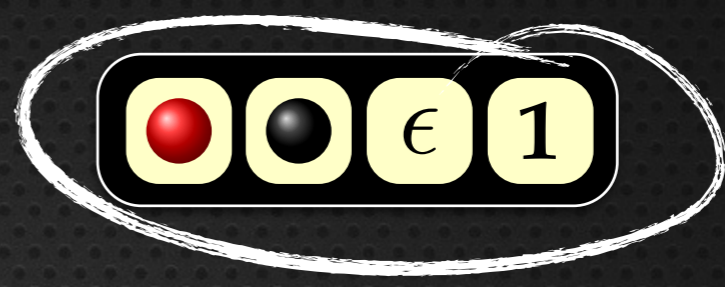


# Lossy Backward Reachability



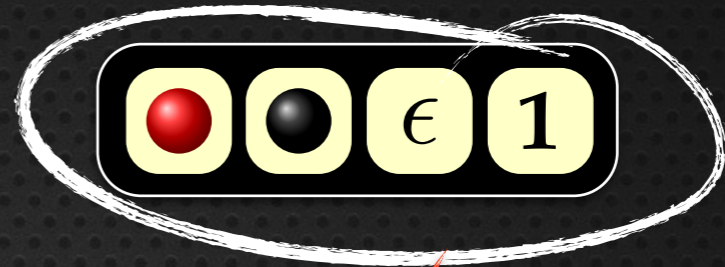
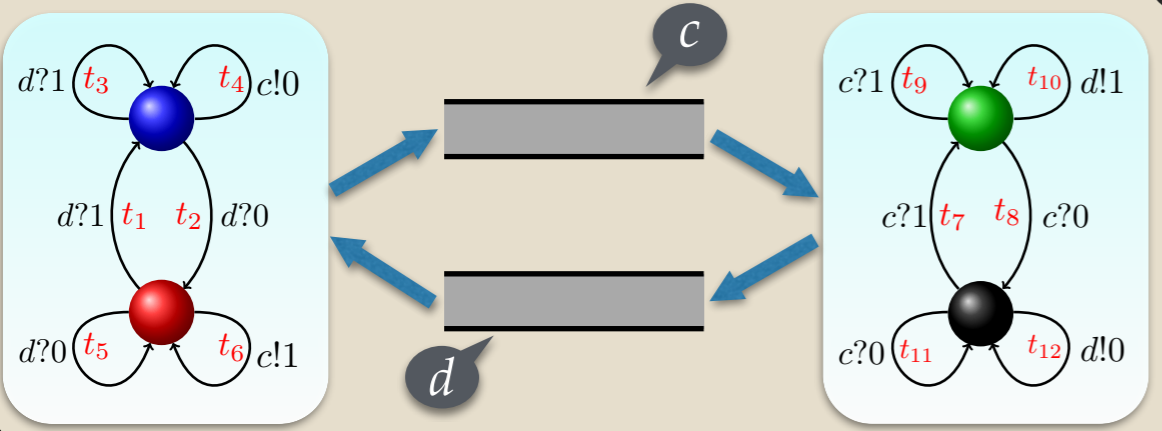


# Lossy Backward Reachability

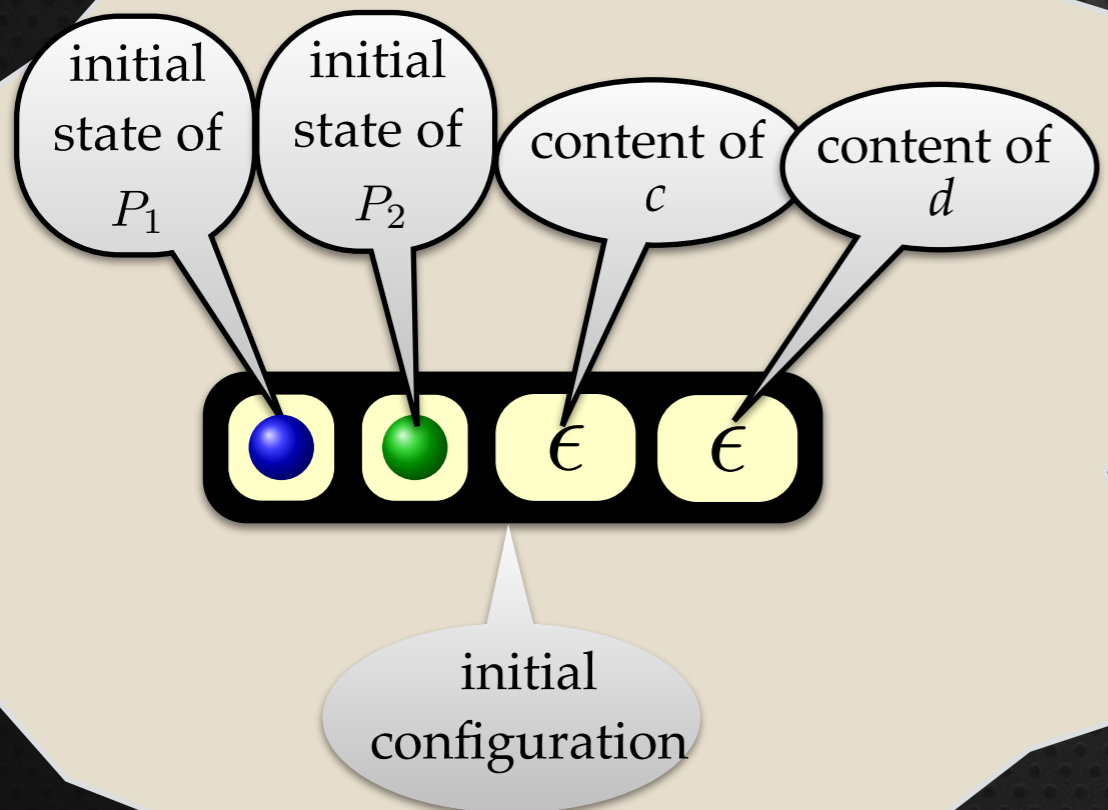




# Lossy Backward Reachability

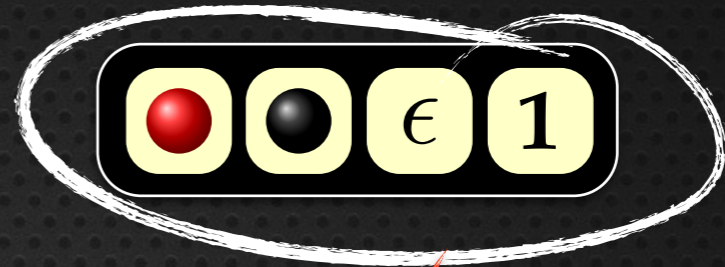
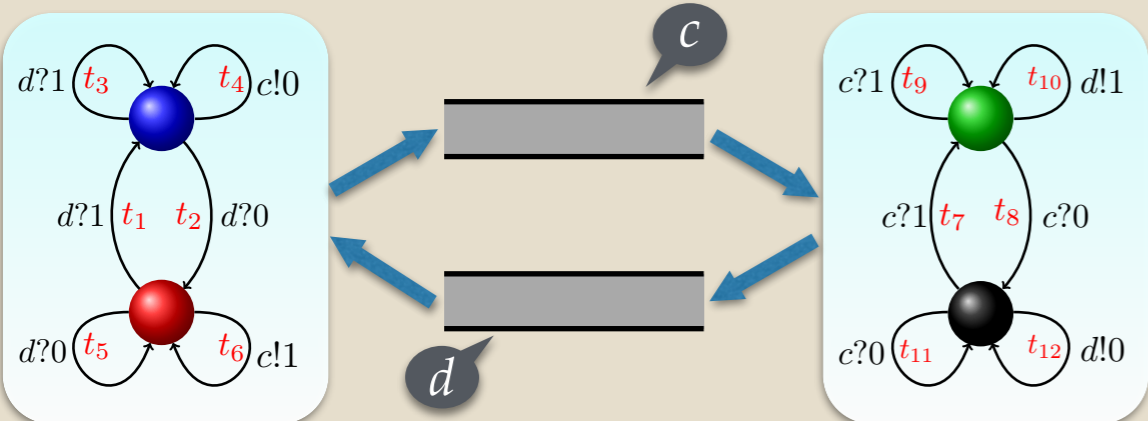


**target configurations**

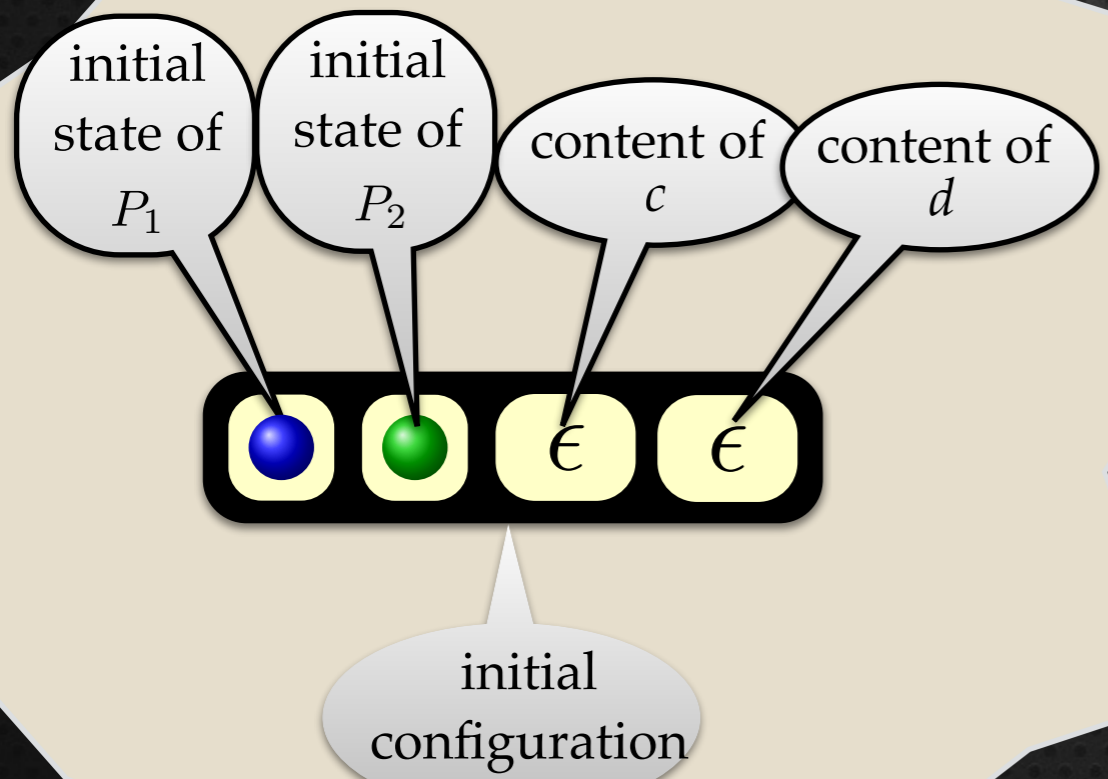




# Lossy Backward Reachability



**target configurations**

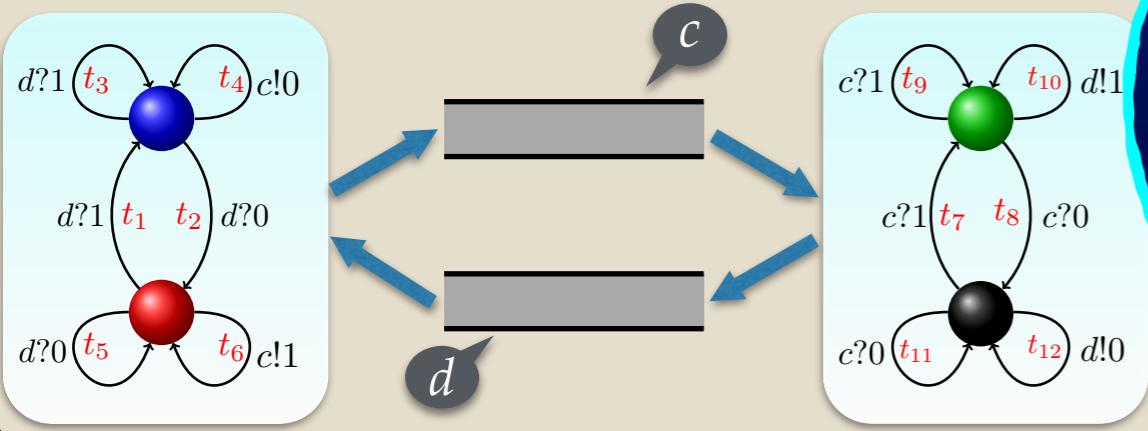


- **processes :**
  - **red and black states**
- **channel  $c$  :**
  - **any content**
- **channel  $d$  :**
  - **at least a "1"**



# Lossy Backward Reachability

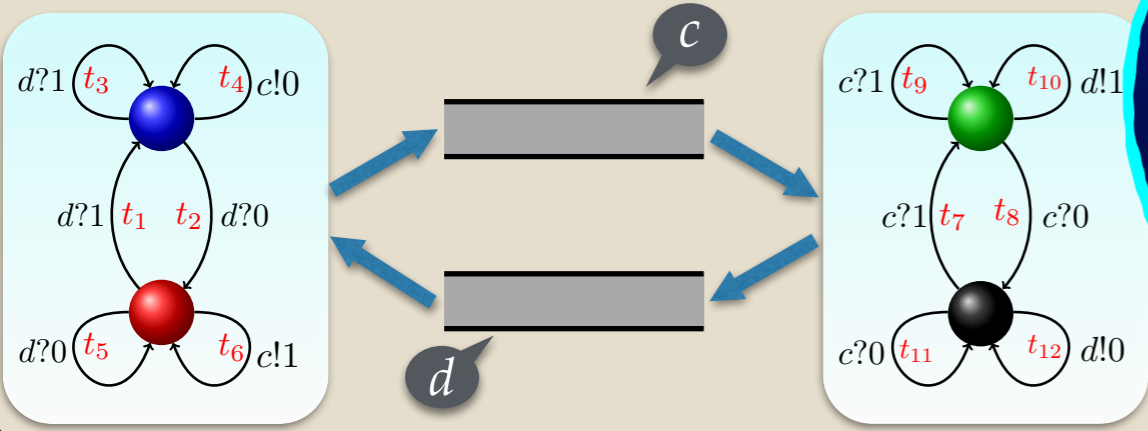
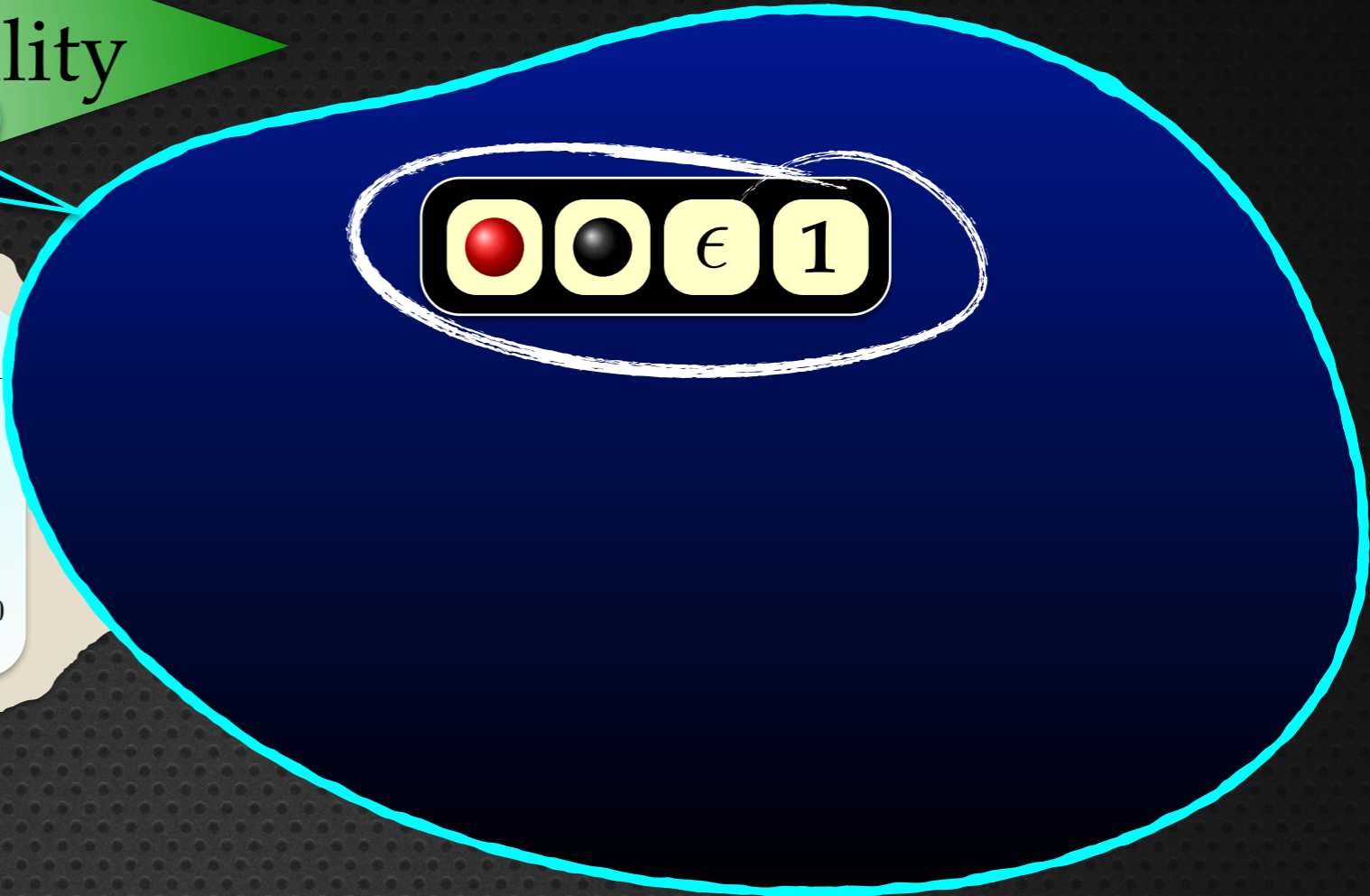
waiting



visited

# Lossy Backward Reachability

waiting

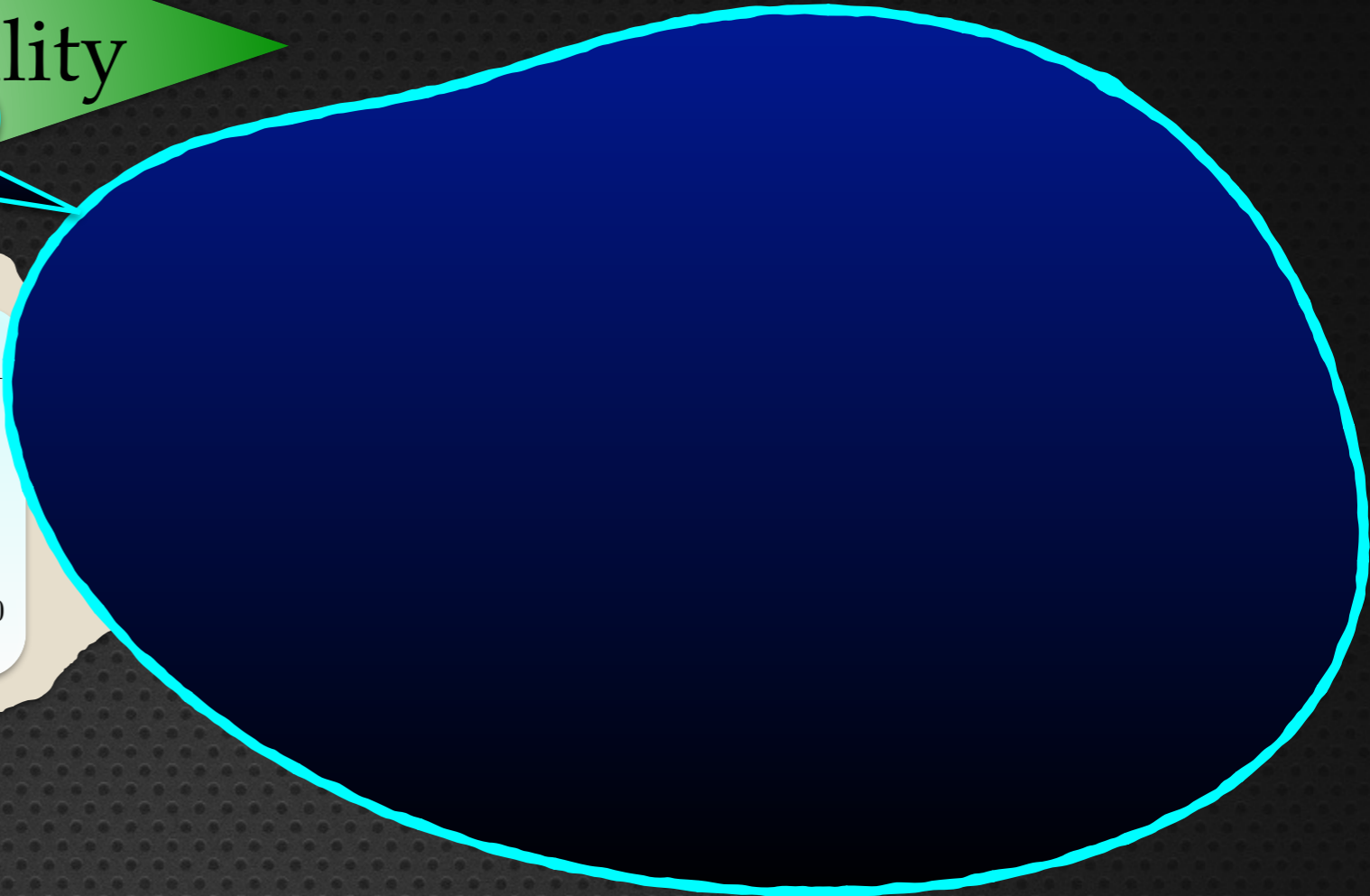


visited



# Lossy Backward Reachability

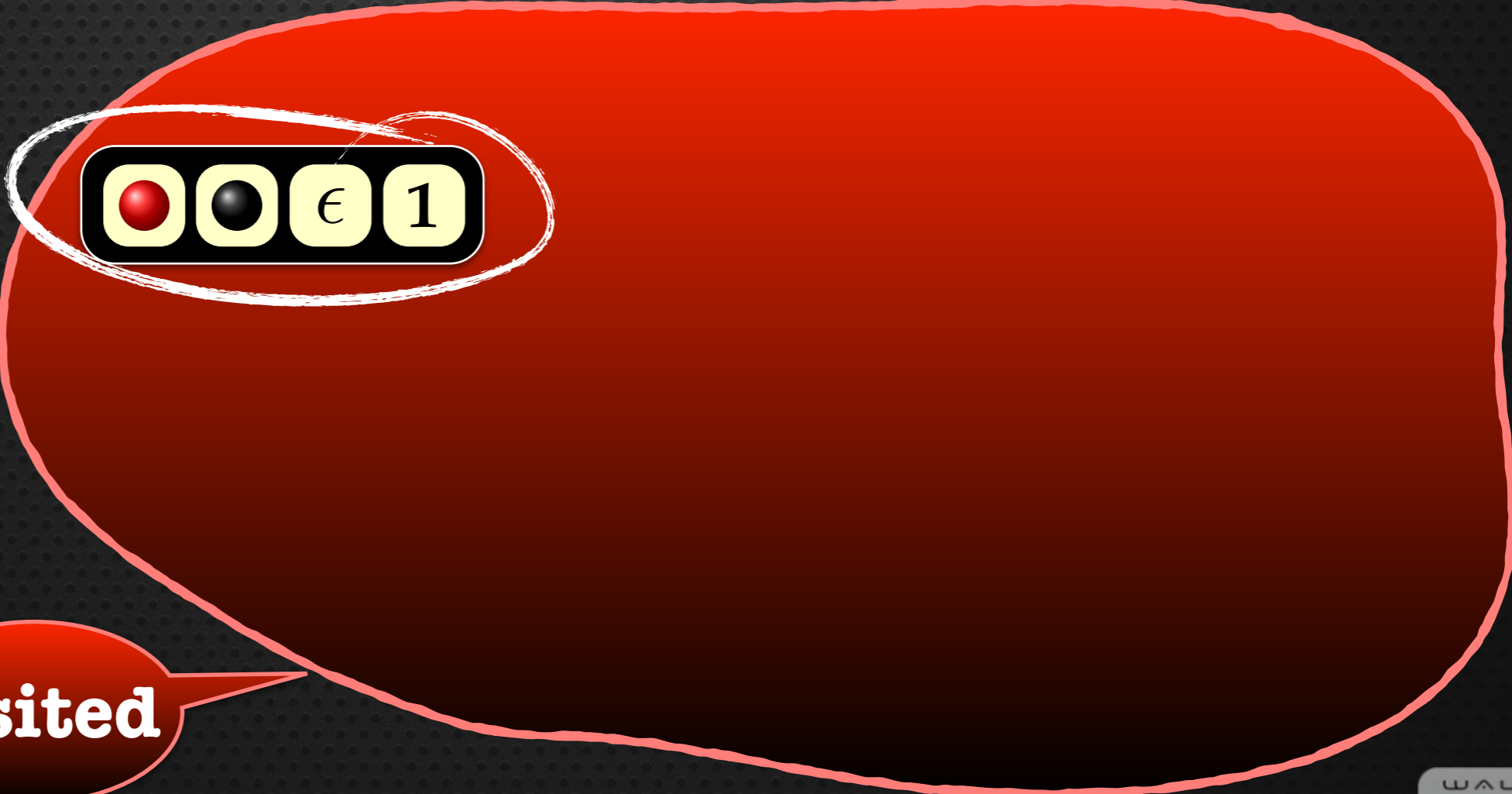
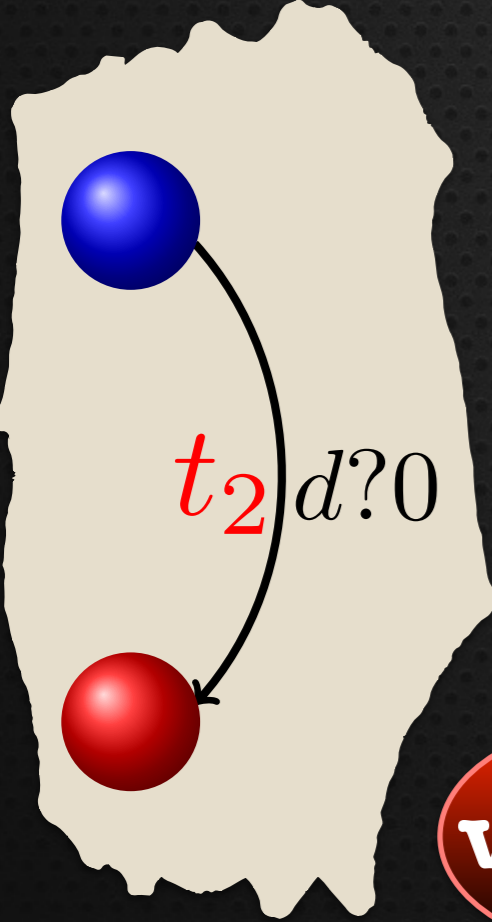
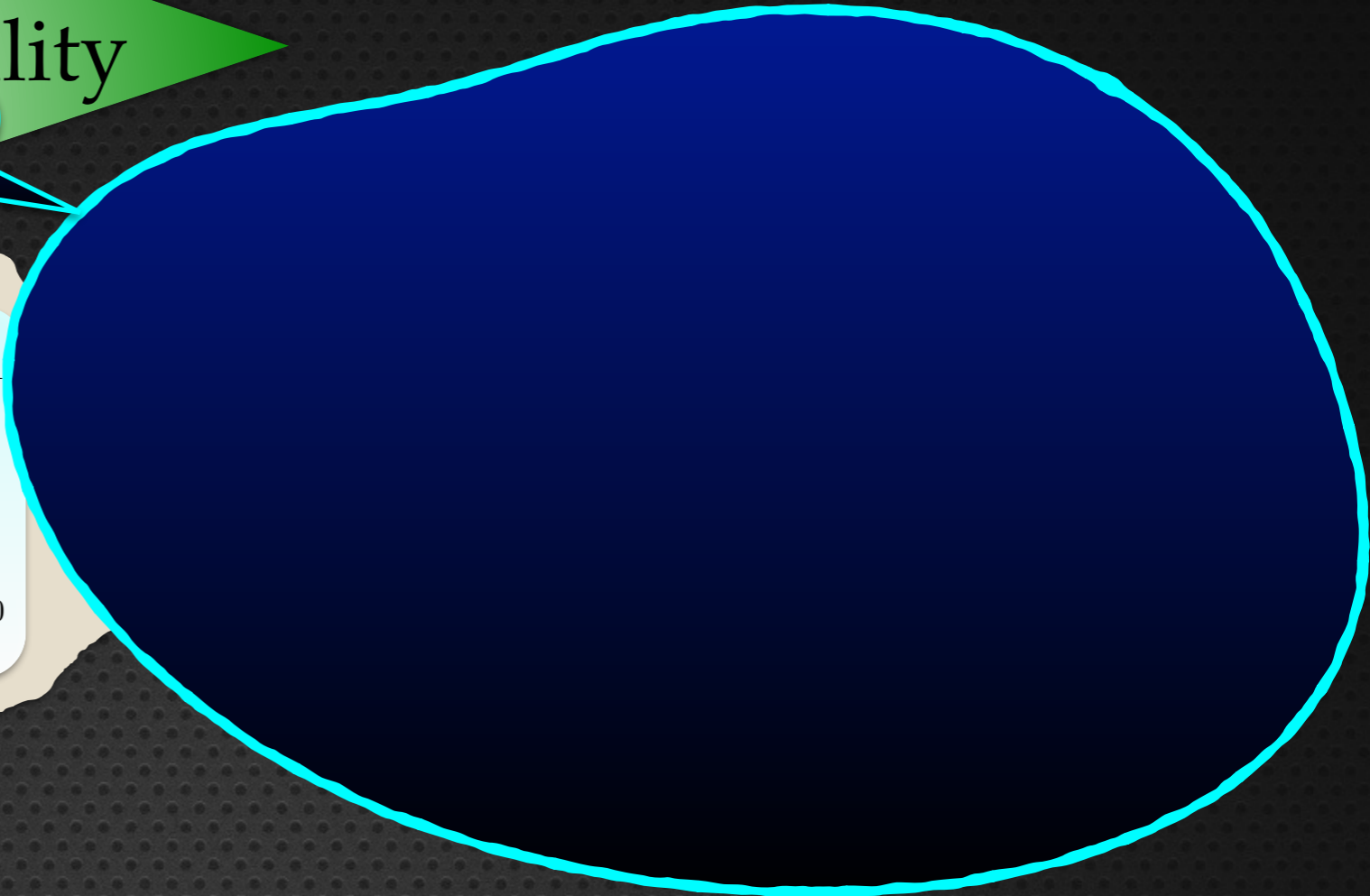
waiting



visited

# Lossy Backward Reachability

waiting



visited

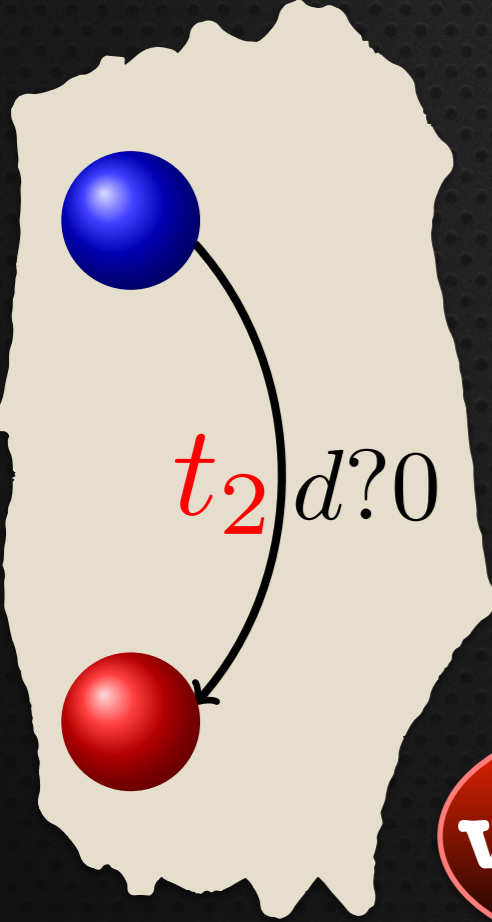


# Lossy Backward Reachability

waiting



Large blue oval containing a display with four segments: a blue dot, a black dot, a Euro symbol ( $\text{€}$ ), and the number 10.



Large red oval containing a display with four segments: a red dot, a black dot, a Euro symbol ( $\text{€}$ ), and the number 1.

visited

# Lossy Backward Reachability

waiting



00€10

00€1

visited

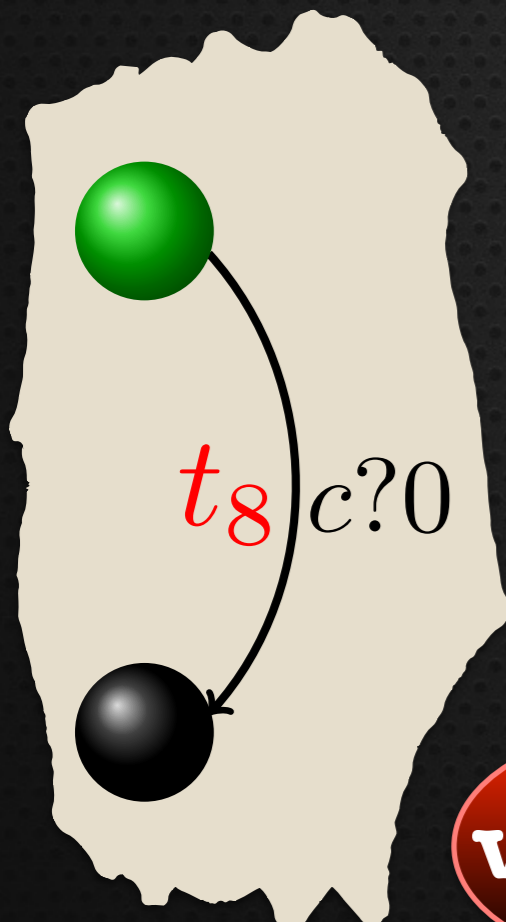


# Lossy Backward Reachability

waiting



A large blue oval containing a display with four segments: a blue dot, a black dot, a Euro symbol ( $\text{€}$ ), and the number 10.



A large red oval containing a display with four segments: a red dot, a black dot, a Euro symbol ( $\text{€}$ ), and the number 1.

visited

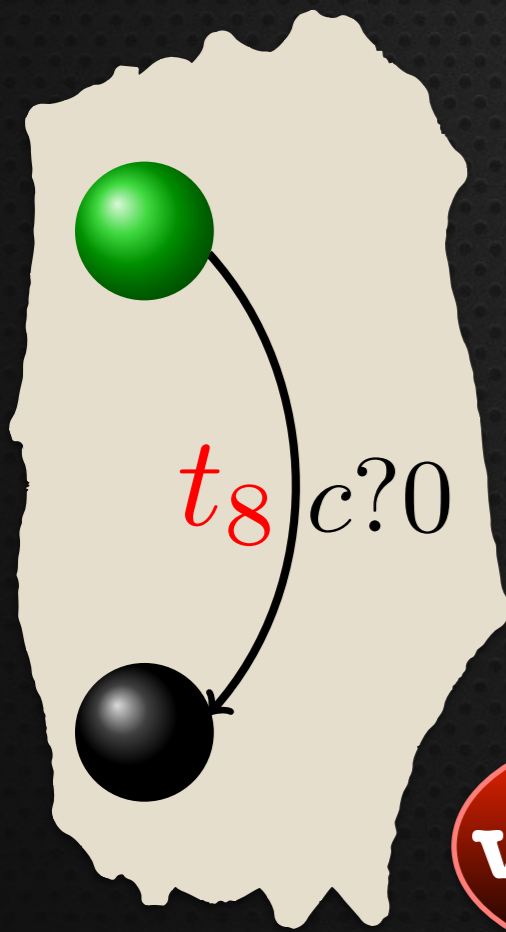
# Lossy Backward Reachability

waiting



State space representation in a blue oval:

- Row 1: Blue circle, Black circle, € symbol, 10
- Row 2: Red circle, Green circle, 0, 1



State space representation in a red oval, circled in white:

- Row 1: Red circle, Black circle, € symbol, 1

visited



# Lossy Backward Reachability

waiting



00€10

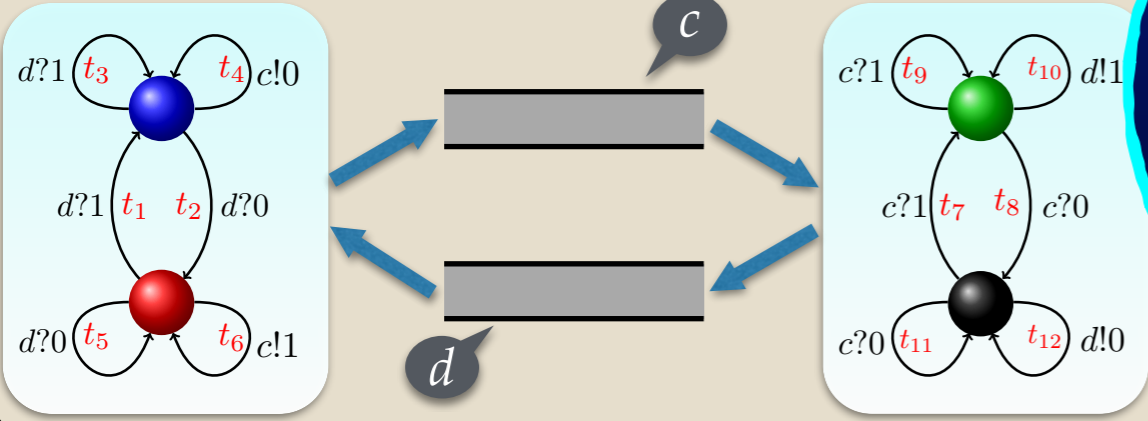
0001

00€1

visited

# Lossy Backward Reachability

waiting



waiting

● ○ € 10

● ● 0 1

● ○ € 1

visited



# Lossy Backward Reachability

waiting



waiting

● ● 0 1

● ● € 1

● ● € 10

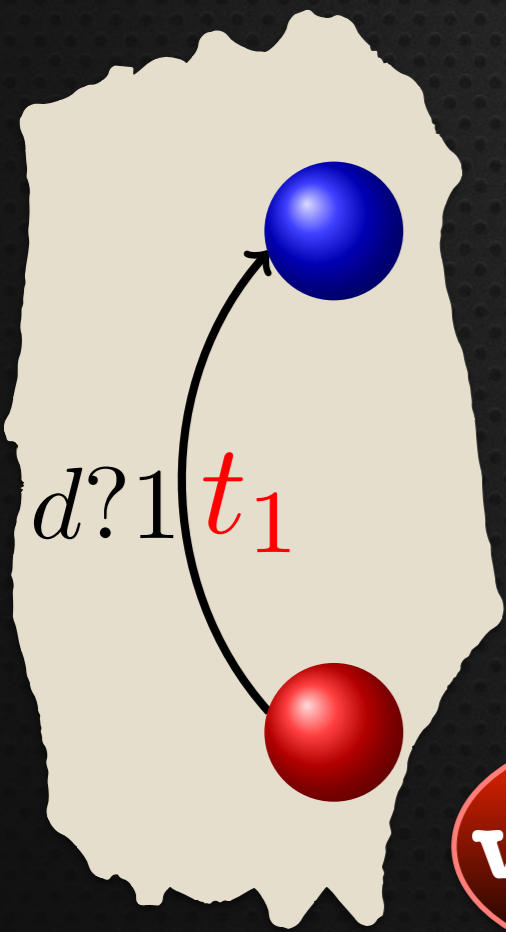
visited

Lossy Backward Reachability

**waiting**



Sequence of items:  $\bullet$   $\bullet$  0 1



$\bullet$   $\bullet$  € 1

$\bullet$   $\bullet$  € 10

**visited**



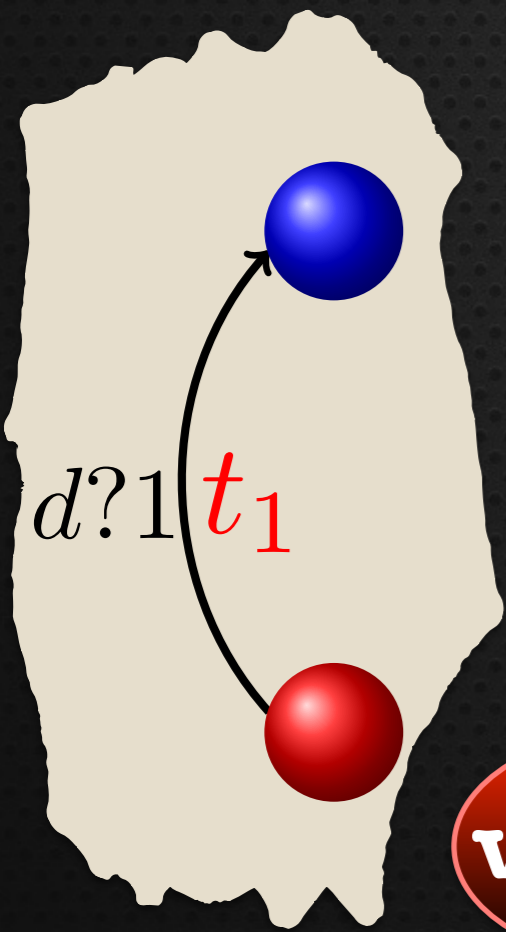
Lossy Backward Reachability

**waiting**



Top row: ●●€101

Bottom row: ●●01



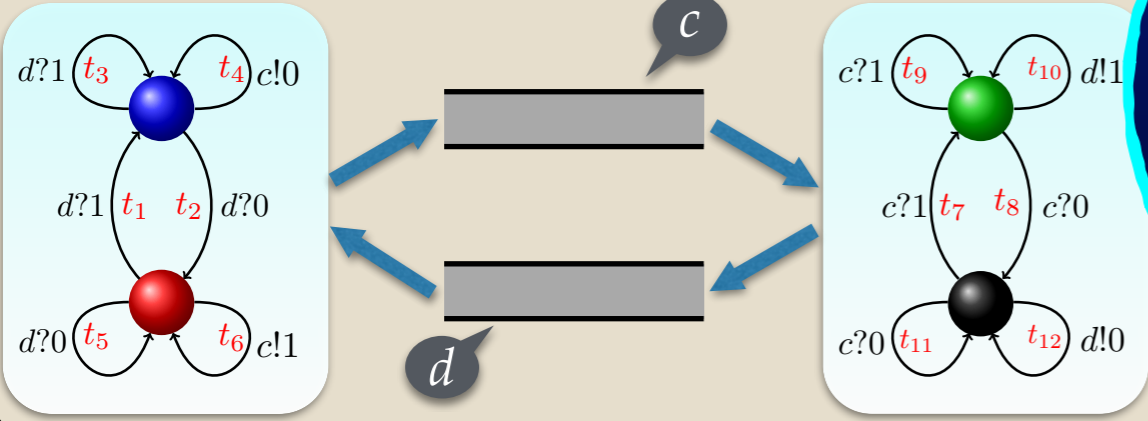
**visited**

Top row: ●●€1

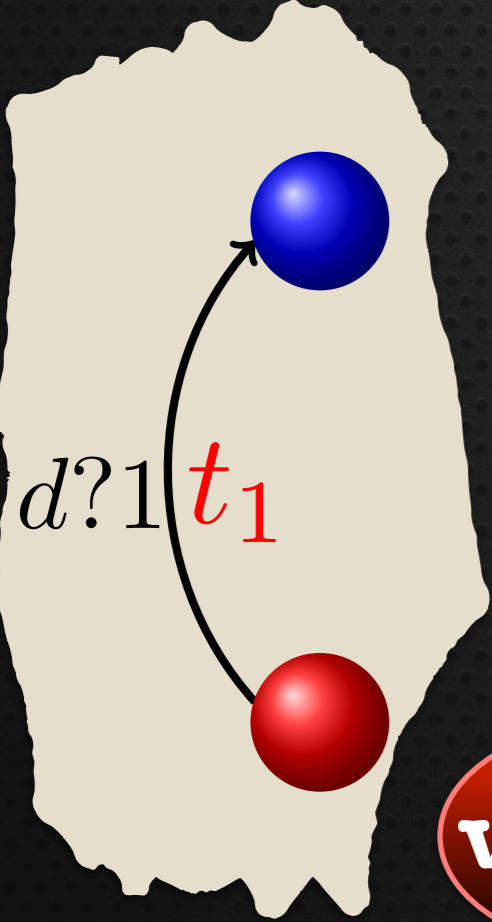
Bottom row: ●●€10

# Lossy Backward Reachability

waiting



A large blue thought bubble containing two displays. The top display shows a red dot, a black dot, a Euro symbol ( $\text{€}$ ), and the number 101. The bottom display shows a red dot, a green dot, the number 0, and the number 1. A dashed line connects the top display to the red bubble below.



A large red thought bubble containing two displays. The top display shows a red dot, a black dot, a Euro symbol ( $\text{€}$ ), and the number 1. The bottom display shows a blue dot, a black dot, a Euro symbol ( $\text{€}$ ), and the number 10. A dashed line connects the top display to the blue bubble above.

visited

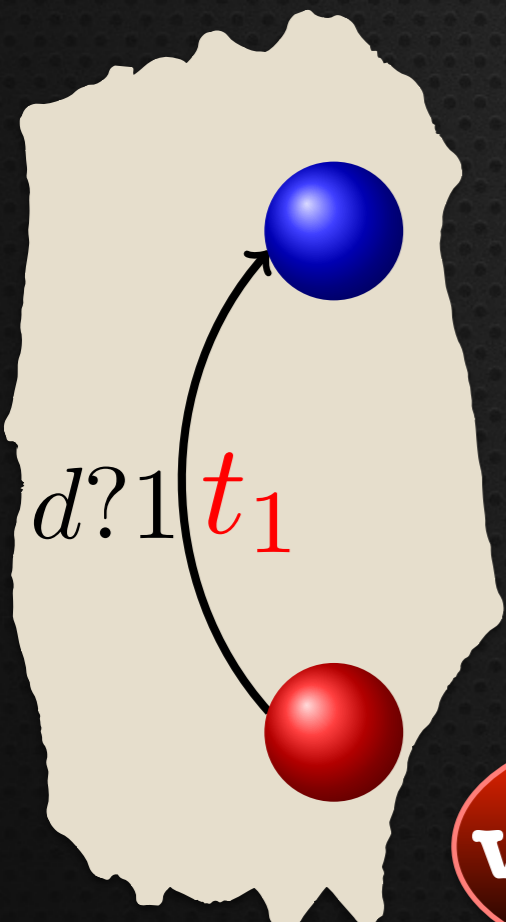


Lossy Backward Reachability

**waiting**



Sequence:  $\bullet$   $\bullet$  0 1



Sequence 1:  $\bullet$   $\bullet$  € 1

Sequence 2:  $\bullet$   $\bullet$  € 10

**visited**

# Lossy Backward Reachability

waiting



waiting

● ● 0 1

● ● € 1

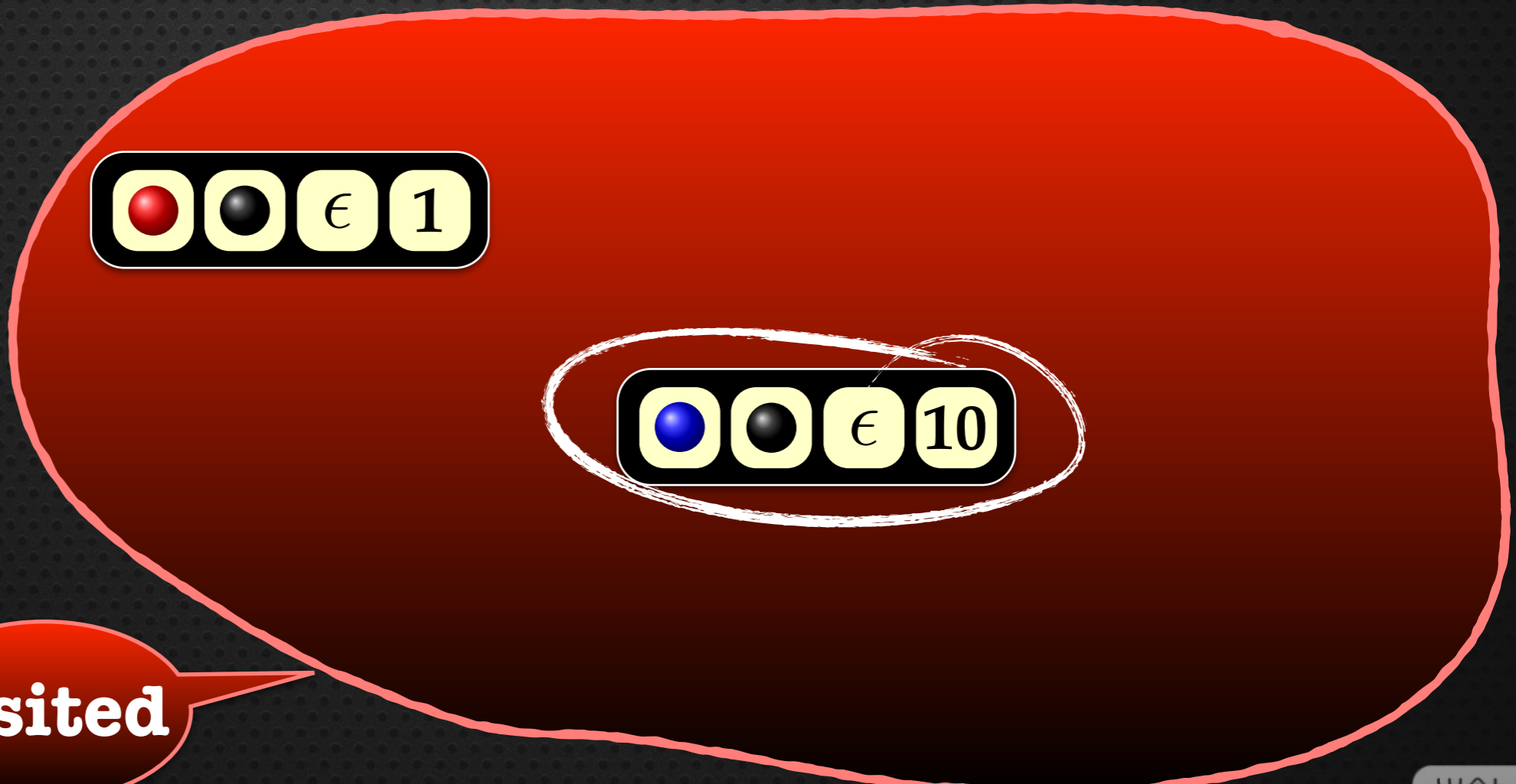
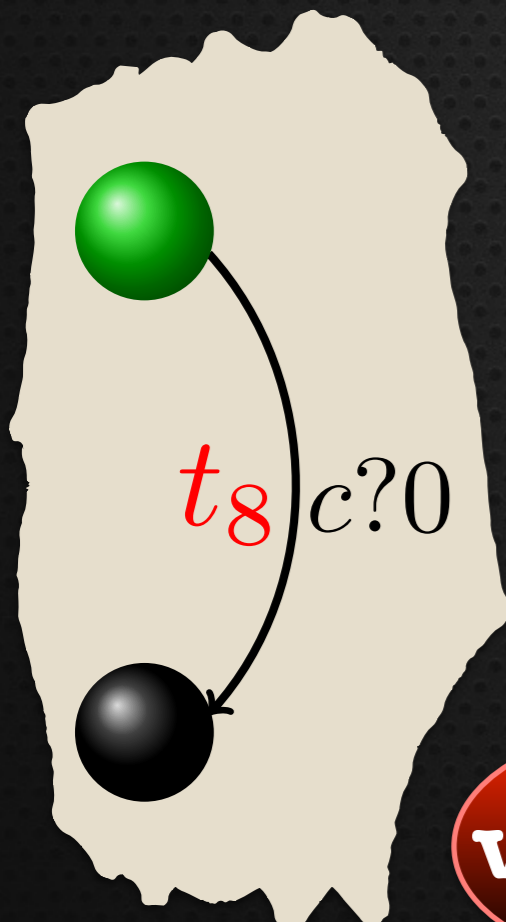
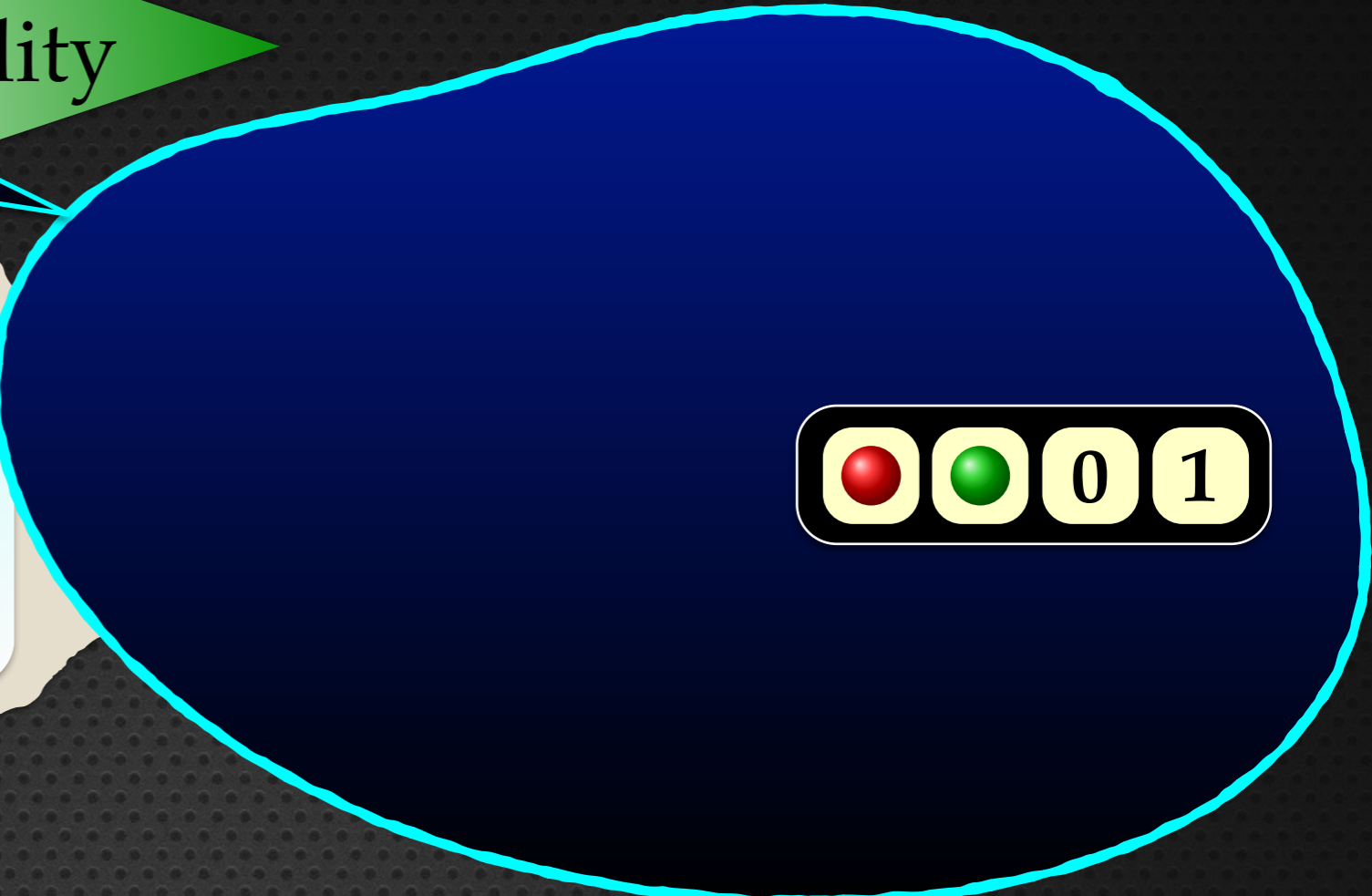
● ● € 10

visited



# Lossy Backward Reachability

waiting



visited

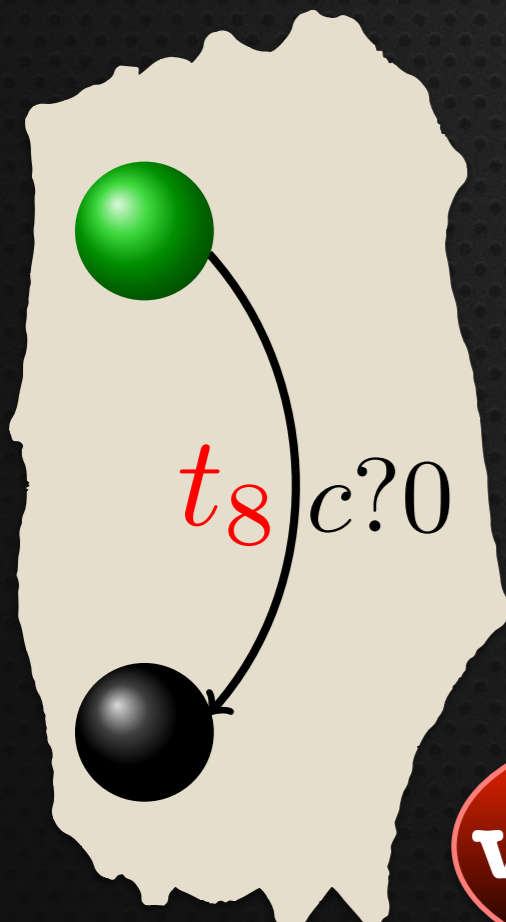
# Lossy Backward Reachability

waiting



State space representation in a blue oval:

- Top row: Blue circle, Green circle, 0, 10
- Bottom row: Red circle, Green circle, 0, 1



State space representation in a red oval:

- Top row: Red circle, Black circle, €, 1
- Bottom row (circled): Blue circle, Black circle, €, 10

visited



# Lossy Backward Reachability

waiting



00010

00001

00€1

00€10

visited

# Lossy Backward Reachability

waiting



00010

0001

00€1

00€10

visited



# Lossy Backward Reachability

waiting



00010

00€1

00€10

0001

visited

# Lossy Backward Reachability

waiting

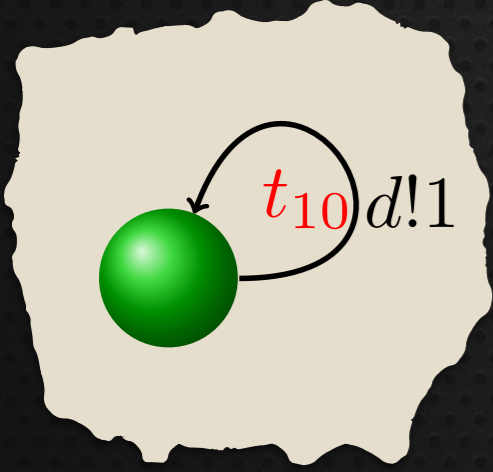


State representation:  $\bullet \bullet 0 10$

State representation:  $\bullet \bullet \epsilon 1$

State representation:  $\bullet \bullet \epsilon 10$

State representation:  $\bullet \bullet 0 1$



visited



# Lossy Backward Reachability

waiting

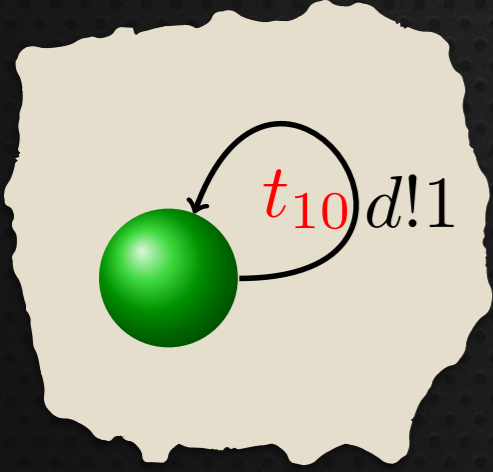


Blue oval containing two rows of colored circles and symbols:

- Top row: Blue circle, Green circle, 0, 10
- Bottom row: Red circle, Green circle, 0, €

Red oval containing three rows of colored circles and symbols:

- Top row: Red circle, Black circle, €, 1
- Middle row: Blue circle, Black circle, €, 10
- Bottom row (circled): Red circle, Green circle, 0, 1



visited

# Lossy Backward Reachability

waiting

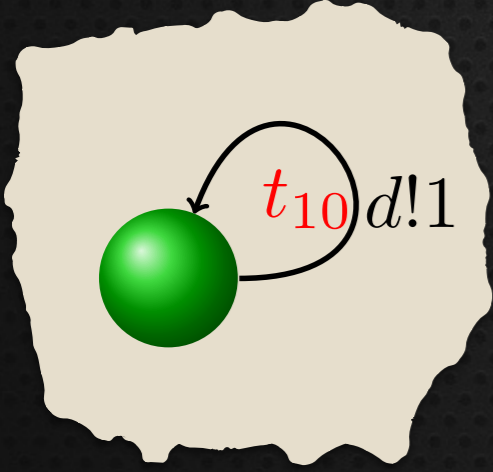


Blue bubble containing two rows of colored circles and symbols:

- Row 1: Blue circle, Green circle, 0, 10
- Row 2: Red circle, Green circle, 0, €

Red bubble containing three rows of colored circles and symbols:

- Row 1: Red circle, Black circle, €, 1
- Row 2: Blue circle, Black circle, €, 10
- Row 3: Red circle, Green circle, 0, 1



visited



# Lossy Backward Reachability

waiting



00010

000€

00€1

00€10

visited

# Lossy Backward Reachability

waiting



00010

000€

00€1

00€10

visited



# Lossy Backward Reachability

waiting



○ ● 0 10

● ○ € 1

○ ● € 10

○ ● 0 €

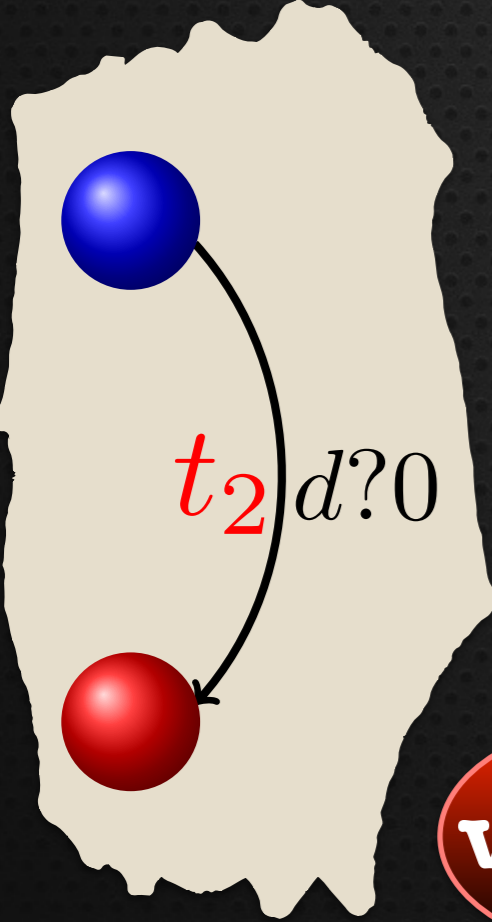
visited

# Lossy Backward Reachability

waiting



A large blue oval containing a display with four elements: a blue dot, a green dot, a '0', and a '10'.



A large red oval containing three displays: [red dot, black dot, €, 1], [blue dot, black dot, €, 10], and [red dot, green dot, 0, €].

visited



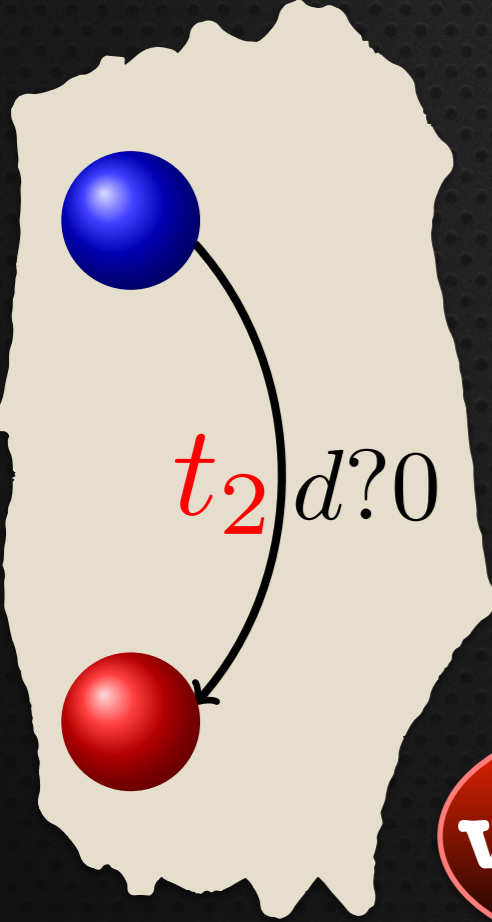
# Lossy Backward Reachability

**waiting**



Top display: ● ● 0 10

Bottom display: ● ● 0 0



**visited**

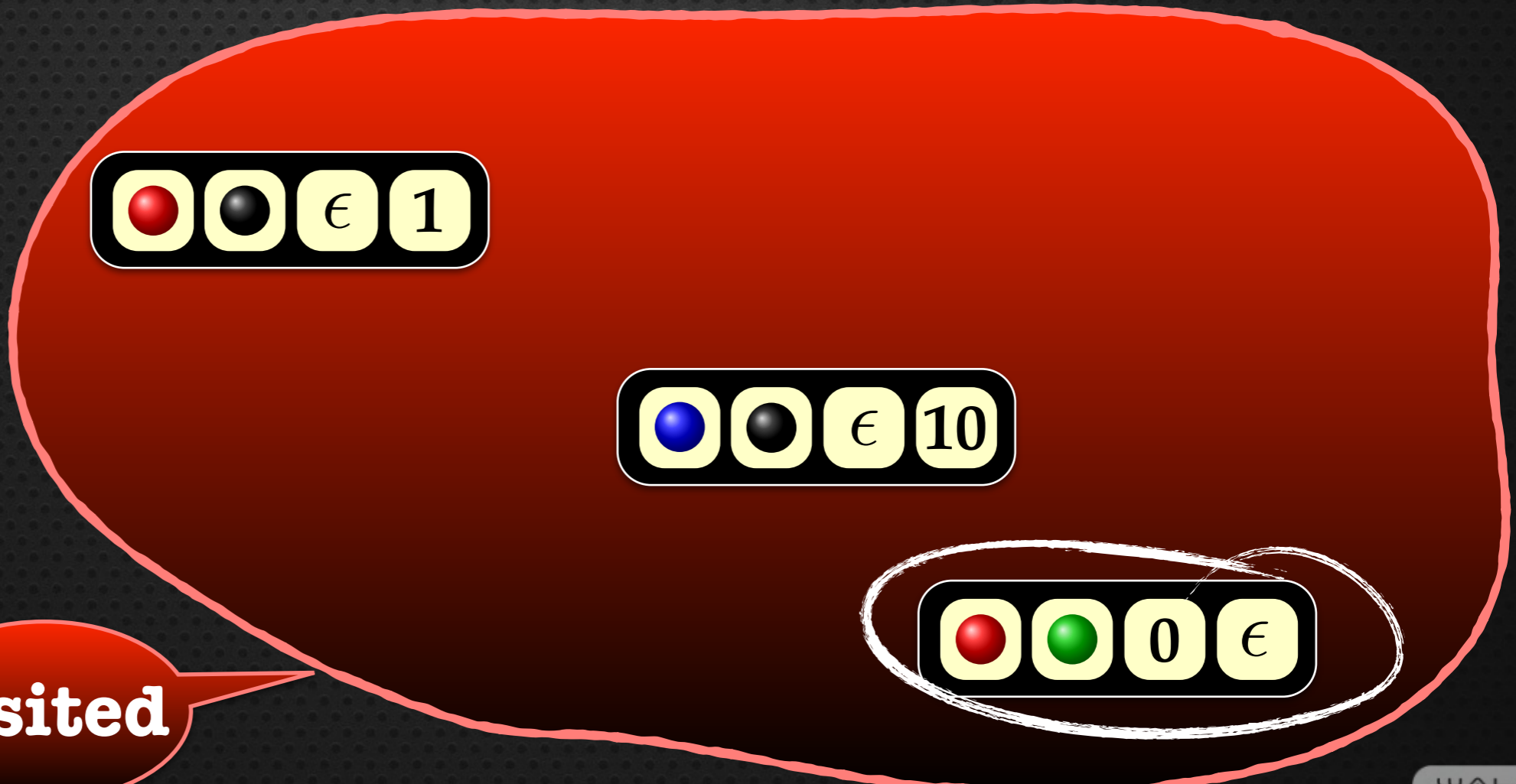
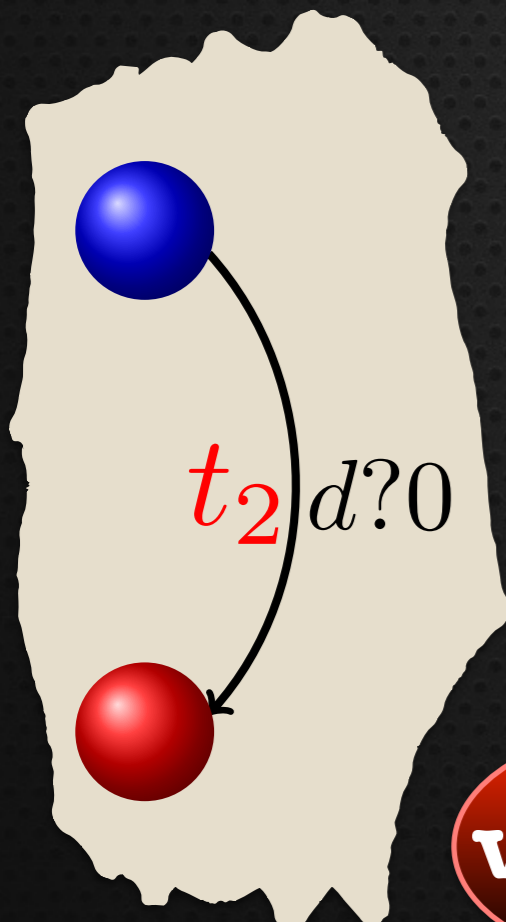
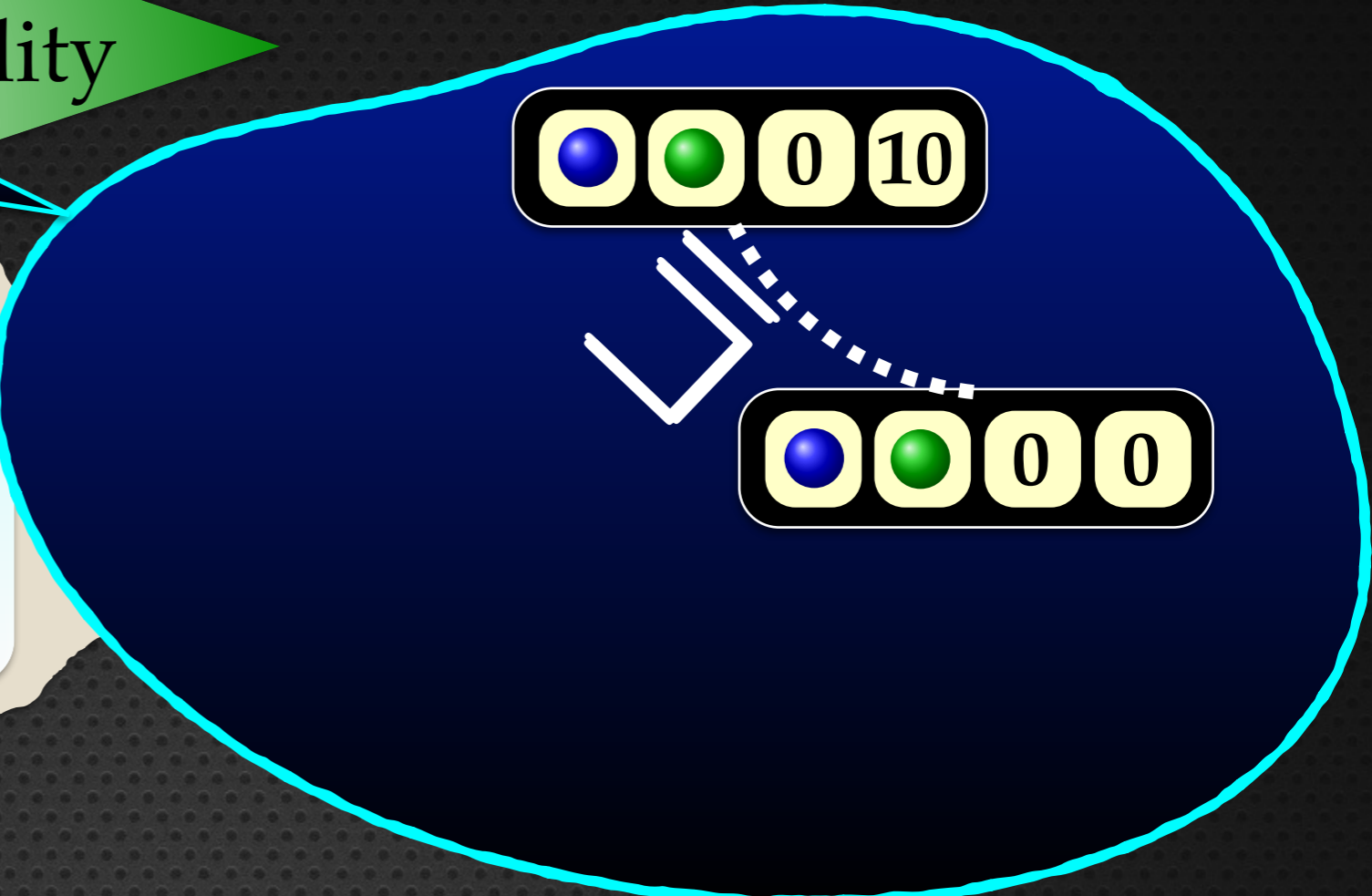
Top display: ● ● € 1

Middle display: ● ● € 10

Bottom display: ● ● 0 €

# Lossy Backward Reachability

waiting



visited

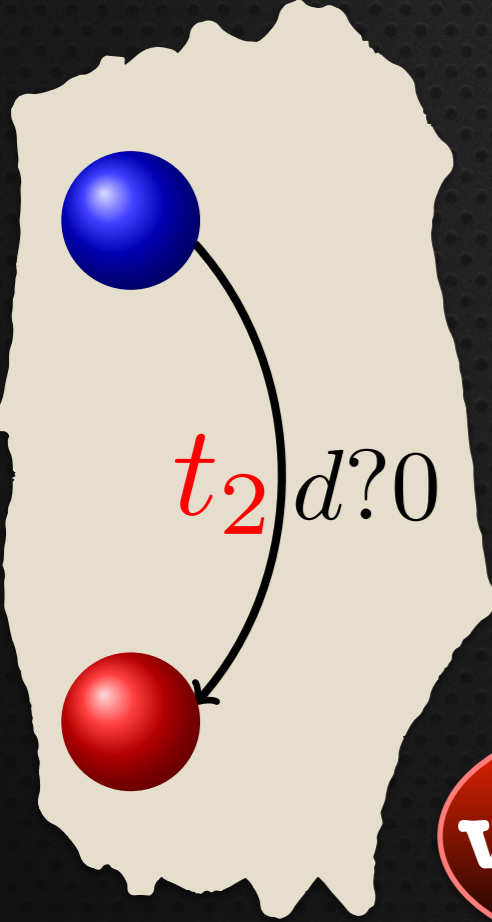


# Lossy Backward Reachability

**waiting**



Sequence:  $\text{blue sphere}, \text{green sphere}, 0, 0$



**visited**

Sequence:  $\text{red sphere}, \text{black sphere}, \text{€}, 1$

Sequence:  $\text{blue sphere}, \text{black sphere}, \text{€}, 10$

Sequence:  $\text{red sphere}, \text{green sphere}, 0, \text{€}$

# Lossy Backward Reachability

waiting



A large blue oval containing a display with four slots. The first slot contains a blue dot, the second a green dot, and the last two slots contain the digit '0'.

A large red oval containing three displays. The top display shows a red dot, a black dot, the symbol €, and the number 1. The middle display shows a blue dot, a black dot, the symbol €, and the number 10. The bottom display shows a red dot, a green dot, the number 0, and the symbol €, and is circled in white.

visited



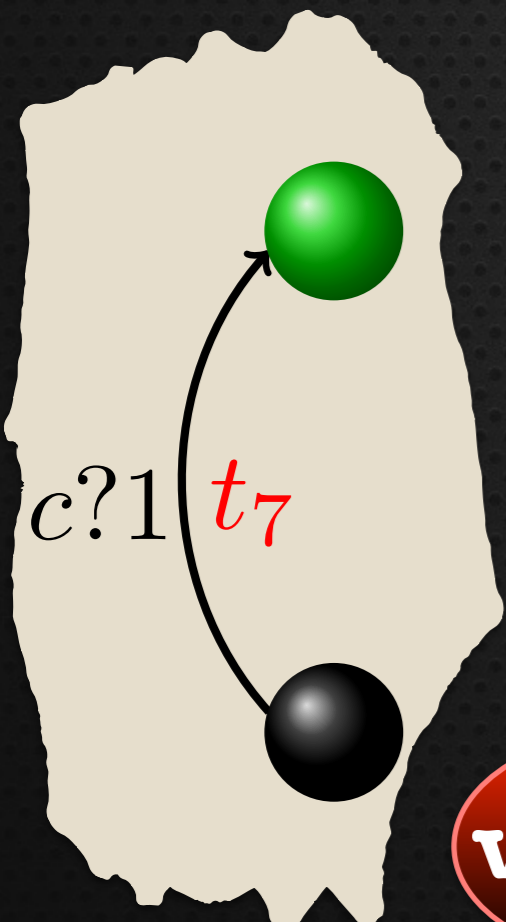
Lossy Backward Reachability

waiting



waiting

● ● 0 0



visited

● ● € 1

● ● € 10

● ● 0 €

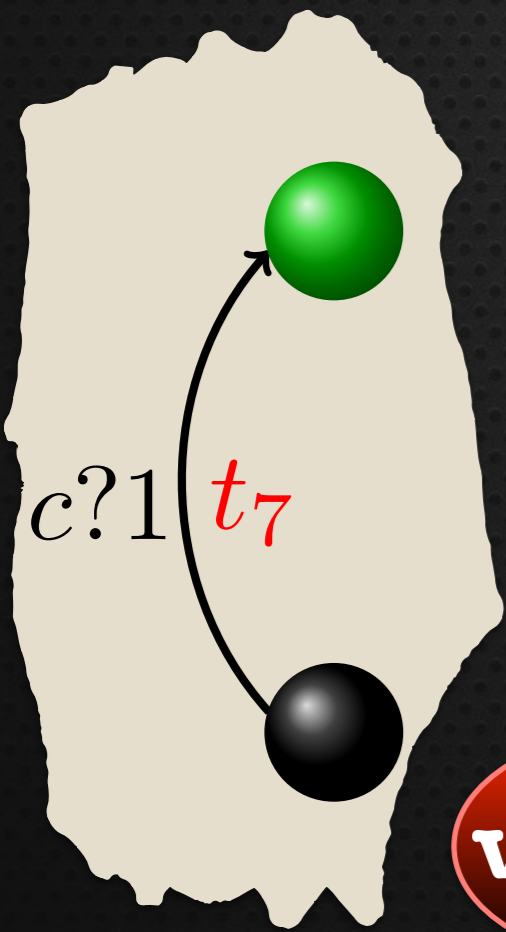
# Lossy Backward Reachability

waiting



Red: ● ● 01 €

Blue: ● ● 0 0



visited

Red: ● ● € 1

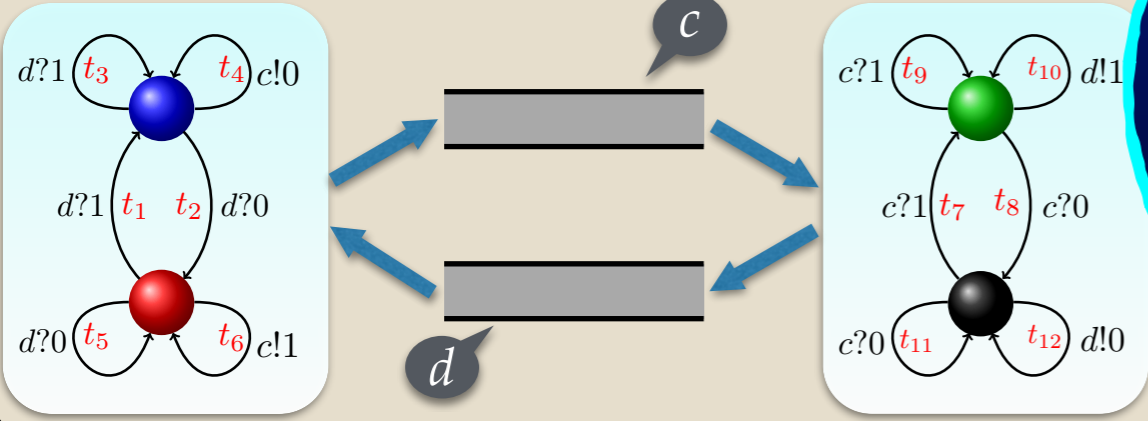
Blue: ● ● € 10

Red: ● ● 0 €



# Lossy Backward Reachability

waiting



waiting

● ● 01 €

● ● 0 0

visited

● ● € 1

● ● € 10

● ● 0 €

# Lossy Backward Probability

waiting



0001€

0000

00€1

00€10

000€

visited



# Lossy Backward Reachability

waiting



waiting

● ● 01 €

visited

● ● € 1

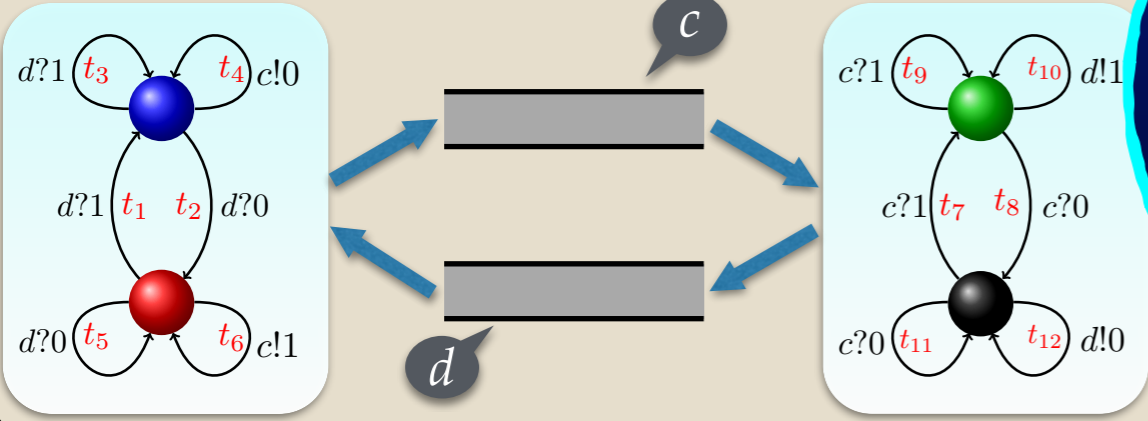
● ● 0 0

● ● € 10

● ● 0 €

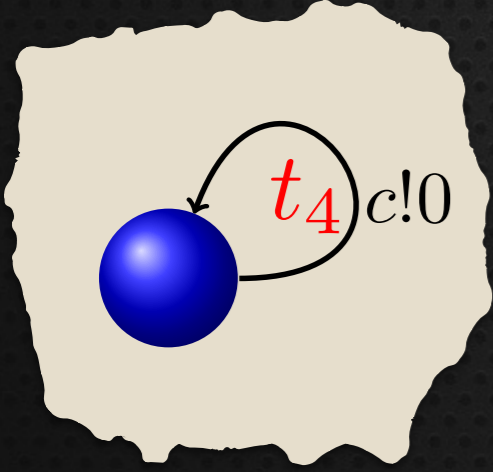
# Lossy Backward Reachability

waiting



Redundant state representation:

●	●	01	€
---	---	----	---



Visited state representation:

●	●	€	1
●	●	€	10
●	●	0	€

Highlighted state:

●	●	0	0
---	---	---	---

visited



# Lossy Backward Reachability

**waiting**



Top row: ● ● 01 €

Bottom row: ● ● € 0

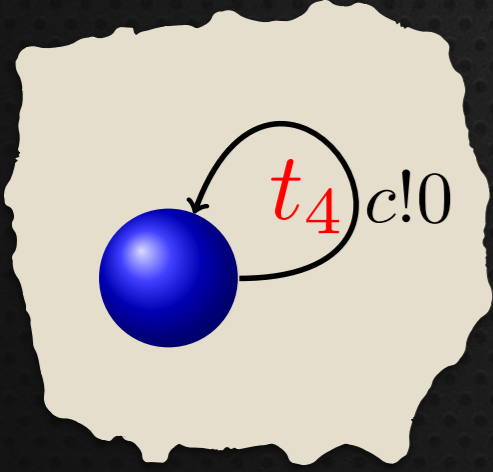
Top row: ● ● € 1

Middle row: ● ● € 10

Bottom row: ● ● 0 €

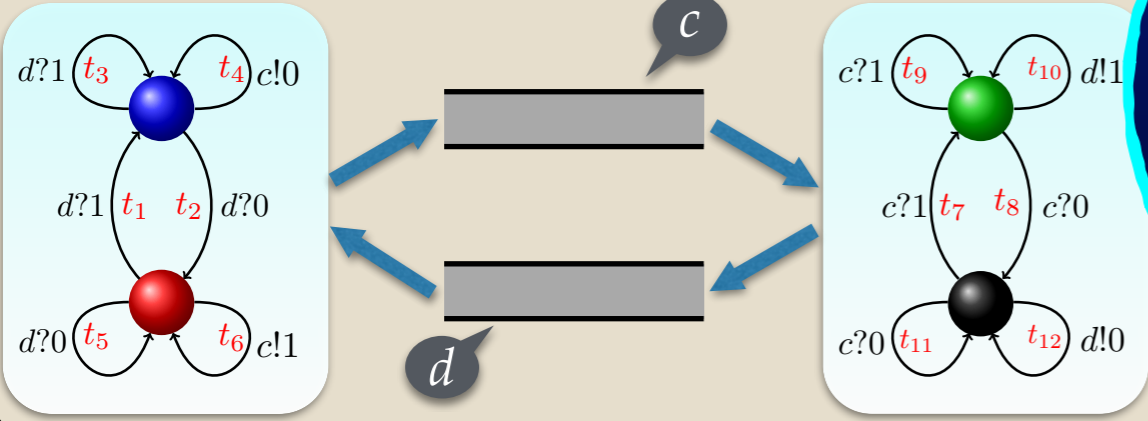
Right side (circled): ● ● 0 0

**visited**



# Lossy Backward Reachability

waiting



● ● 01 €

● ● € 0

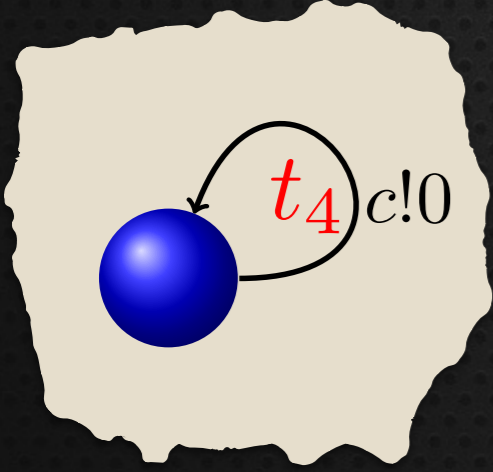
● ● € 1

● ● 0 0

● ● € 10

● ● 0 €

visited





# Lossy Backward Reachability

waiting



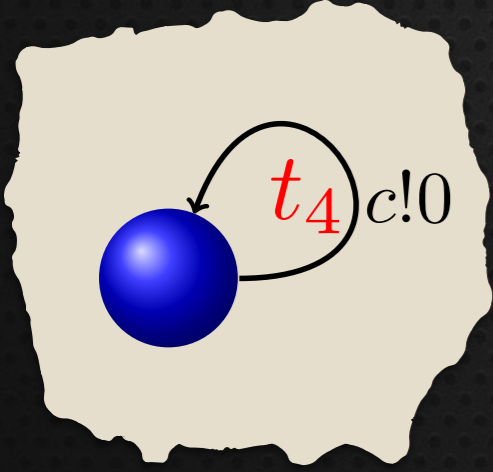
● ● 01 €

● ● € 0

● ● € 1

● ● € 10

● ● 0 €



visited

# Lossy Backward Reachability

waiting



waiting

● ○ 01 €

● ● € 0

visited

● ● € 1

● ● € 10

● ● 0 €



# Lossy Backward Reachability

waiting



waiting

● ● 01 €

● ● € 0

visited

● ● € 1

● ● € 10

● ● 0 €

# Lossy Backward Reachability

waiting



waiting

● ● 01 €

visited

● ● € 1

● ● € 10

● ● € 0

● ● 0 €



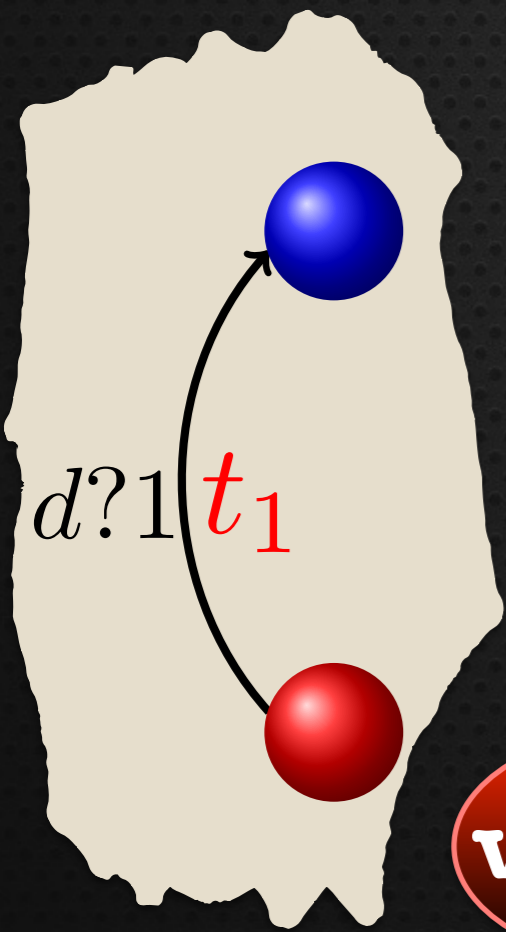
Lossy Backward Reachability

waiting



waiting

● ● 01 €



visited

● ● € 1

● ● € 10

● ● € 0

● ● 0 €

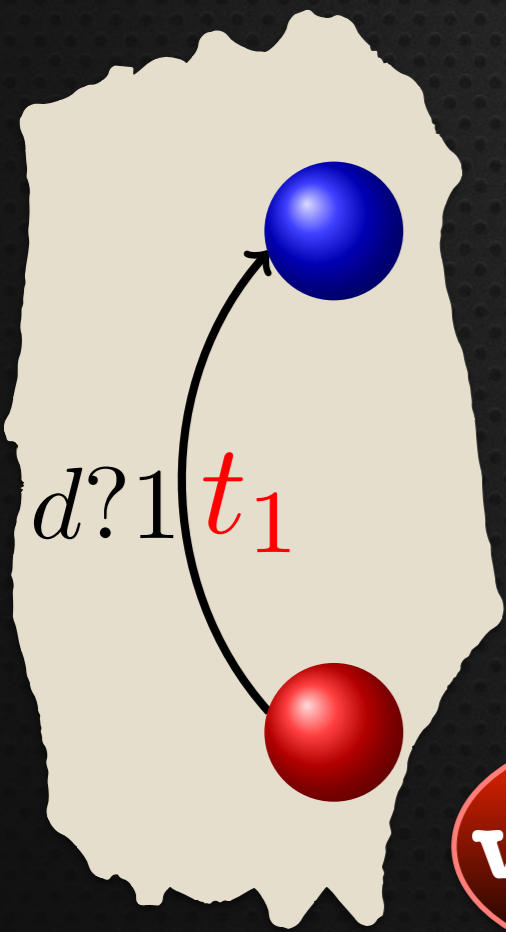
# Lossy Backward Reachability

**waiting**



Waiting state visualization:

- Top row:  $\text{Red} \text{ Black } 01 \text{ €}$
- Bottom row:  $\text{Red} \text{ Green } \text{€} 01$



**visited**

Visited state visualization:

- Top row:  $\text{Red} \text{ Black } \text{€} 1$
- Middle row:  $\text{Blue} \text{ Black } \text{€} 10$
- Bottom row (circled):  $\text{Blue} \text{ Green } \text{€} 0$  and  $\text{Red} \text{ Green } 0 \text{ €}$



# Lossy Backward Reachability

waiting



waiting

● ● 01 €

● ● € 01

€

visited

● ● € 1

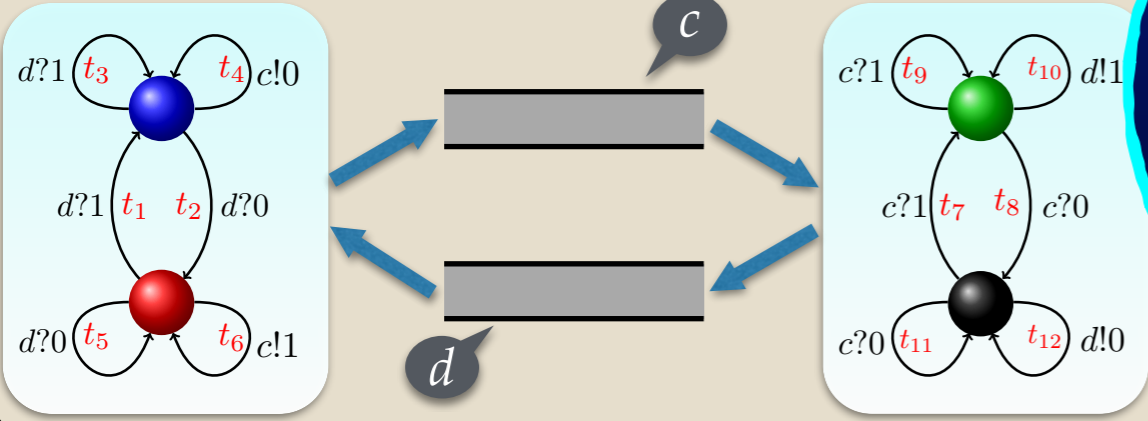
● ● € 10

● ● € 0

● ● 0 €

Lossy Backward Reachability

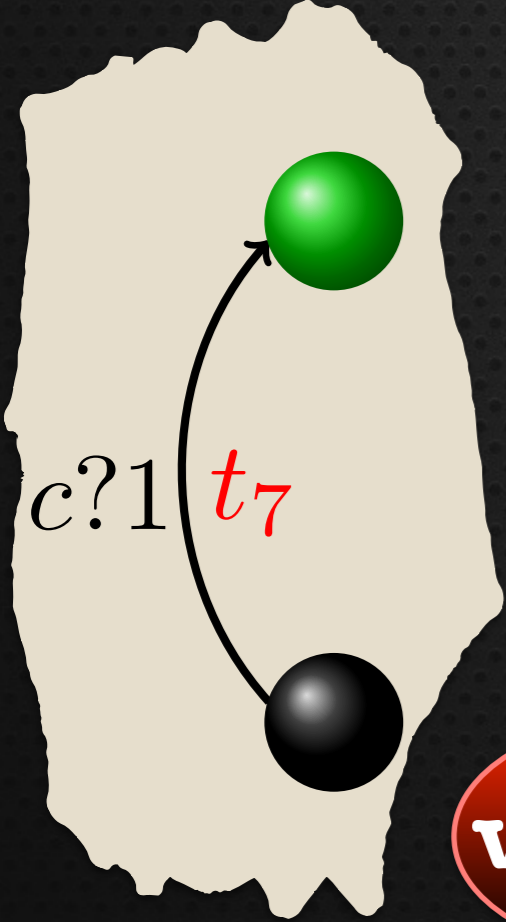
waiting



Red, Black, 01, €

Red, Green, €, 01

€



visited

Red, Black, €, 1

Blue, Black, €, 10

Blue, Green, €, 0

Red, Green, 0, €



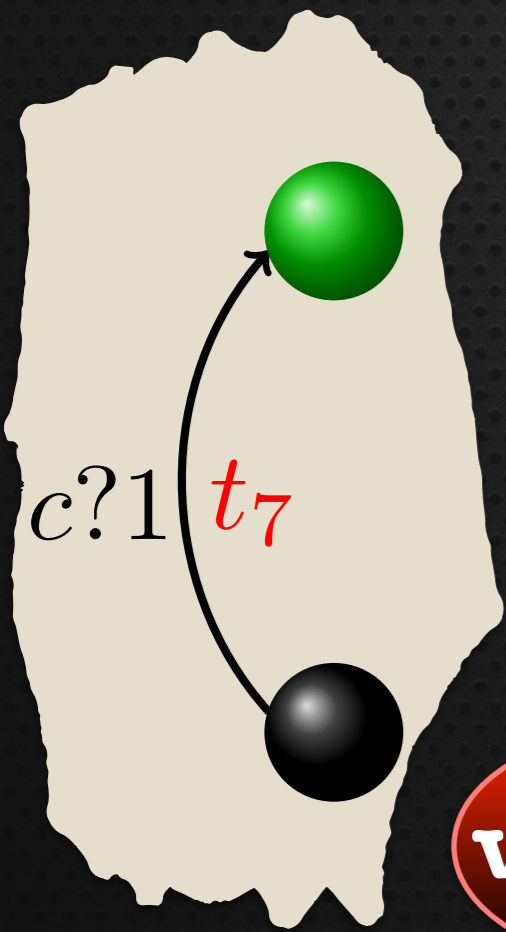
# Lossy Backward Reachability

waiting



Large blue oval containing four state representations:

- Top-left:  $\text{red node} \text{ black node } 01 \text{ €}$
- Top-right:  $\text{red node} \text{ green node } \text{€ } 01$
- Bottom-left:  $\text{blue node} \text{ black node } 10$
- Bottom-right:  $\text{blue node} \text{ black node } 10$



visited

Large red oval containing four state representations:

- Top:  $\text{red node} \text{ black node } \text{€ } 1$
- Middle:  $\text{blue node} \text{ black node } \text{€ } 10$
- Bottom-left:  $\text{blue node} \text{ green node } \text{€ } 0$
- Bottom-right:  $\text{red node} \text{ green node } 0 \text{ €}$

# Lossy Backward Reachability

waiting



waiting

- Red ● Black ● 01 €
- Red ● Green ● € 01
- Blue ● Black ● 1 0

visited

- Red ● Black ● € 1
- Blue ● Black ● € 10
- Blue ● Green ● € 0
- Red ● Green ● 0 €



# Lossy Backward Reachability

waiting



waiting

● ● 01 €

● ● € 01

● ● 1 0

visited

● ● € 1

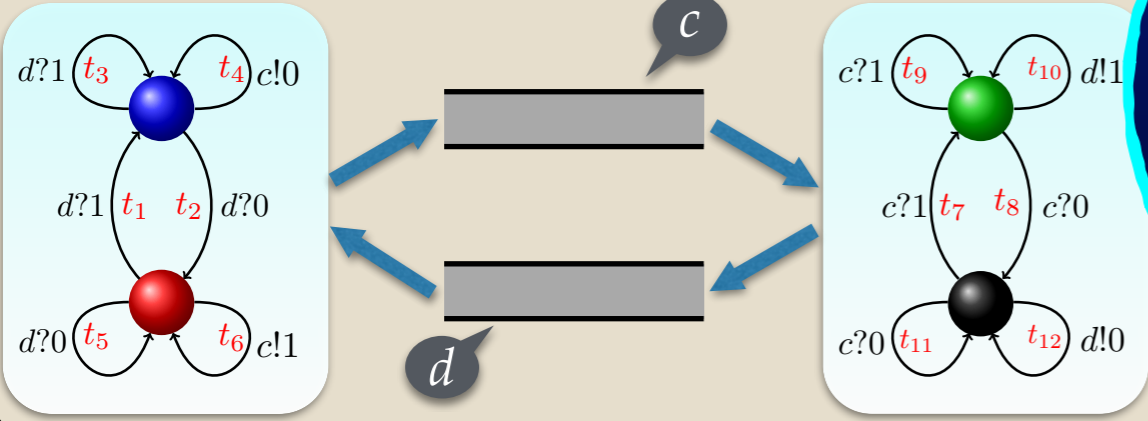
● ● € 10

● ● € 0

● ● 0 €

# Lossy Backward Reachability

waiting



waiting

● ● 01 €

● ● € 01

€

visited

● ● € 1

● ● 1 0

● ● € 10

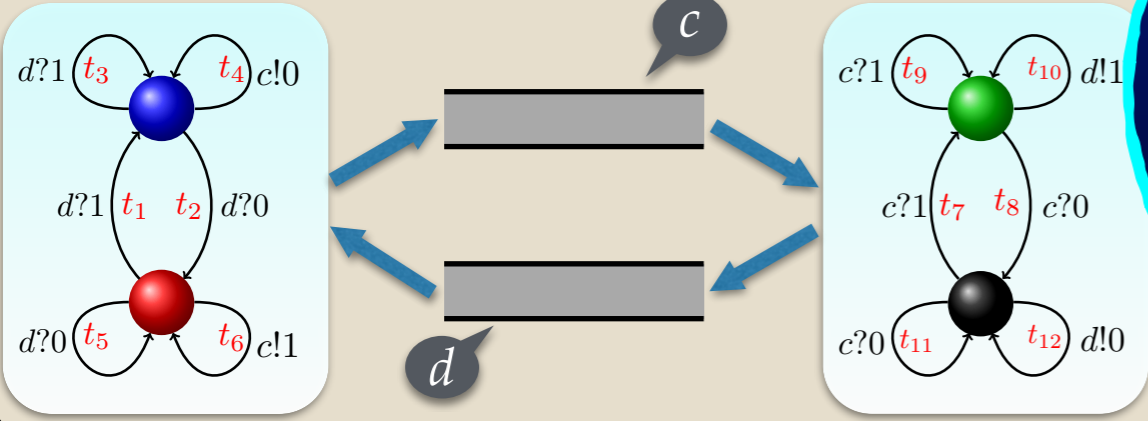
● ● € 0

● ● 0 €



Lossy Backward Reachability

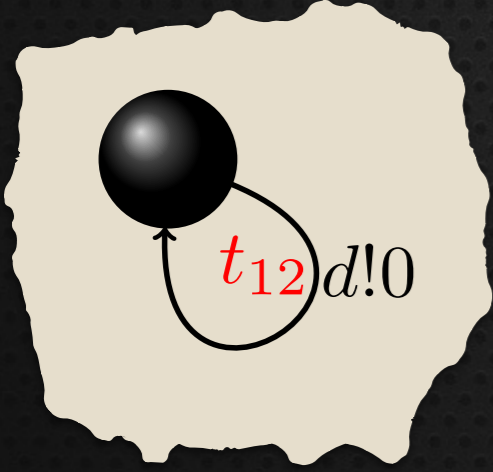
waiting



waiting

● 0 0 01 €
● ● € 01

€



visited

● ● € 1
● ● 1 0

● ● € 1 0

● ● € 0
● ● 0 €

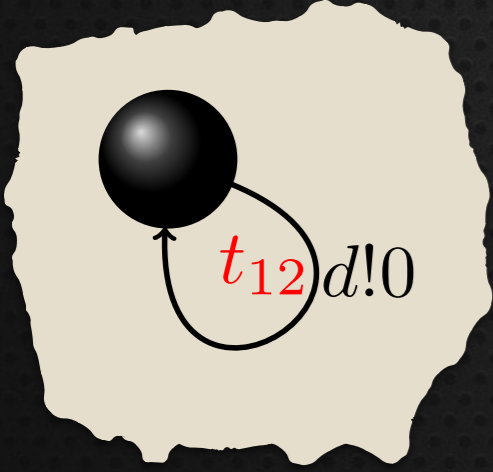
Lossy Backward Reachability

waiting



Blue bubble containing state representations:

- Top row: [Red dot][Black dot][01][€]
- Bottom row: [Red dot][Green dot][€][01]
- Middle row: [Blue dot][Black dot][1][€]
- Bottom right: [€]



Red bubble containing state representations:

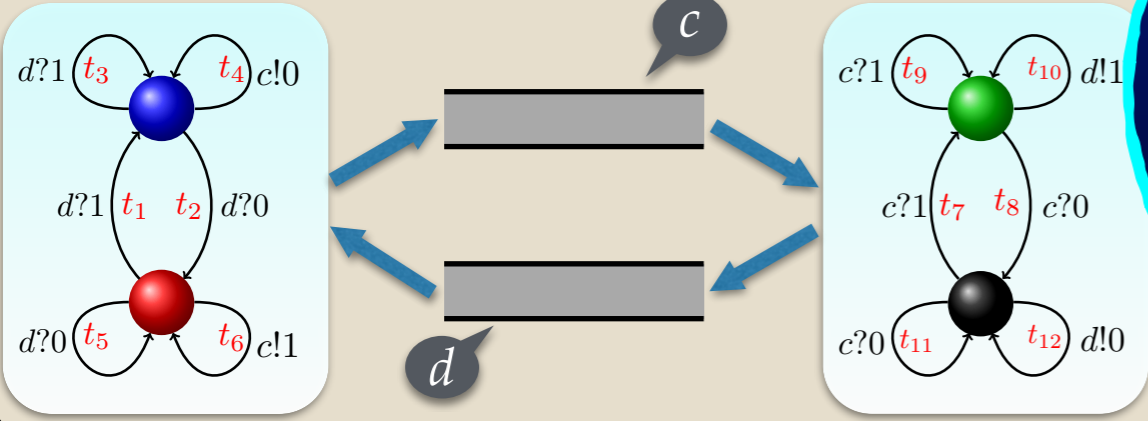
- Top left: [Red dot][Black dot][€][1]
- Top right (circled): [Blue dot][Black dot][1][0]
- Middle: [Blue dot][Black dot][€][10]
- Bottom left: [Blue dot][Green dot][€][0]
- Bottom right: [Red dot][Green dot][0][€]

visited



# Lossy Backward Reachability

waiting



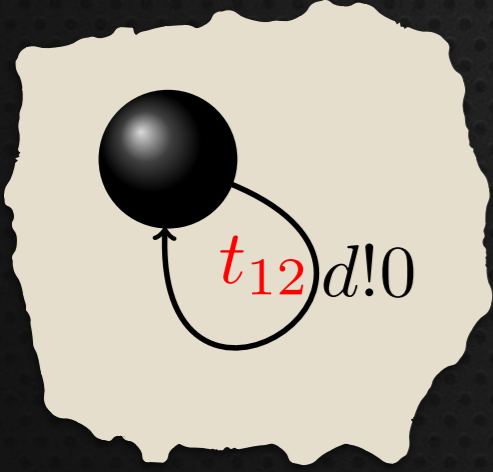
Blue thought bubble containing four state representations:

- Top-left:  $\text{Red Node} \text{ Black Node } 01 \text{ €}$
- Top-right:  $\text{Red Node} \text{ Green Node } \text{€} 01$
- Middle-left:  $\text{Blue Node} \text{ Black Node } 1 \text{ €}$
- Middle-right:  $\text{€}$

A dashed line with a white box at the end points from the middle-right state to the red bubble below.

Red thought bubble containing five state representations:

- Top-left:  $\text{Red Node} \text{ Black Node } \text{€} 1$
- Top-right:  $\text{Blue Node} \text{ Black Node } 1 0$  (circled in white)
- Middle:  $\text{Blue Node} \text{ Black Node } \text{€} 1 0$
- Bottom-left:  $\text{Blue Node} \text{ Green Node } \text{€} 0$
- Bottom-right:  $\text{Red Node} \text{ Green Node } 0 \text{ €}$



visited

# Lossy Backward Reachability

waiting



waiting

- Red dot, Black dot, 01, €
- Red dot, Green dot, €, 01
- Blue dot, Black dot, 1, €

€

visited

- Red dot, Black dot, €, 1
- Blue dot, Black dot, €, 10
- Blue dot, Green dot, €, 0
- Red dot, Green dot, 0, €



# Lossy Backward Reachability

waiting



waiting

● ● 01 €

● ● € 01

● ● 1 €

visited

● ● € 1

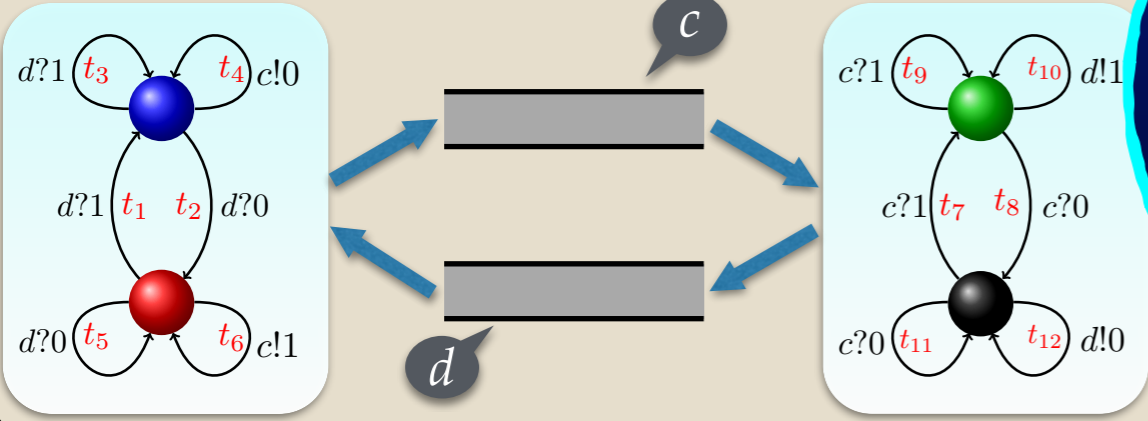
● ● € 10

● ● € 0

● ● 0 €

# Lossy Backward Reachability

waiting



waiting

● ● 01 €

● ● € 01

€

visited

● ● € 1

● ● 1 €

● ● € 10

● ● € 0

● ● 0 €



# Lossy Backward Reachability

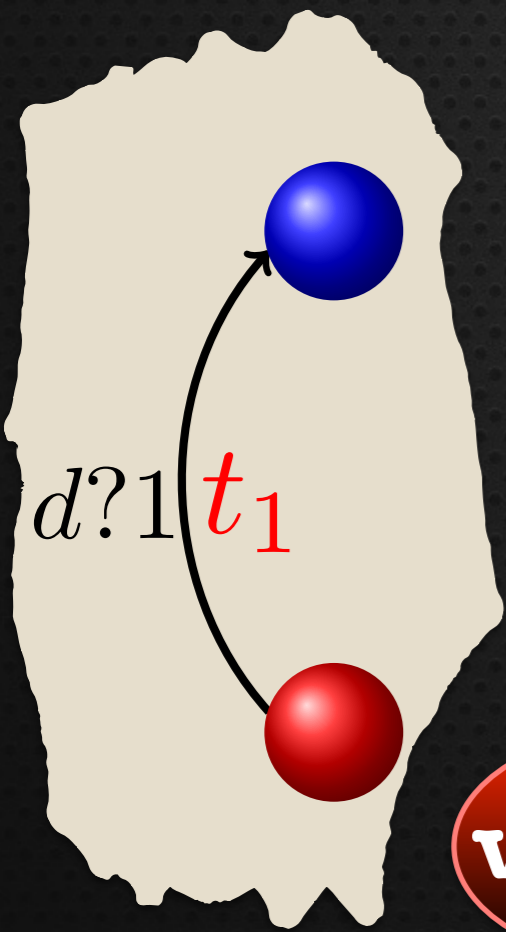
**waiting**



Waiting state visualization:

- Top row:  $\text{Red} \text{ Black } 01 \text{ €}$
- Bottom row:  $\text{Red} \text{ Green } \text{€} 01$

€



**visited**

Visited state visualization:

- Top row:  $\text{Red} \text{ Black } \text{€} 1$
- Bottom row:  $\text{Blue} \text{ Black } 1 \text{ €}$  (circled)
- Middle row:  $\text{Blue} \text{ Black } \text{€} 10$
- Bottom row:  $\text{Blue} \text{ Green } \text{€} 0$  and  $\text{Red} \text{ Green } 0 \text{ €}$

# Lossy Backward Reachability

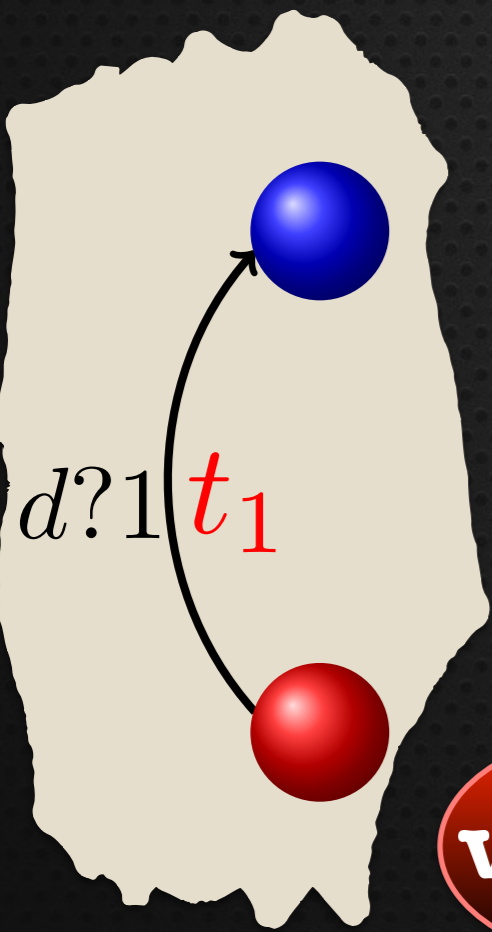
waiting



Waiting state visualization:

- Top row: [Red] [Black] [01] [€]
- Bottom row: [Red] [Black] [1] [1]

Additional elements: [Red] [Green] [€] [01], [€]



visited

Visited state visualization:

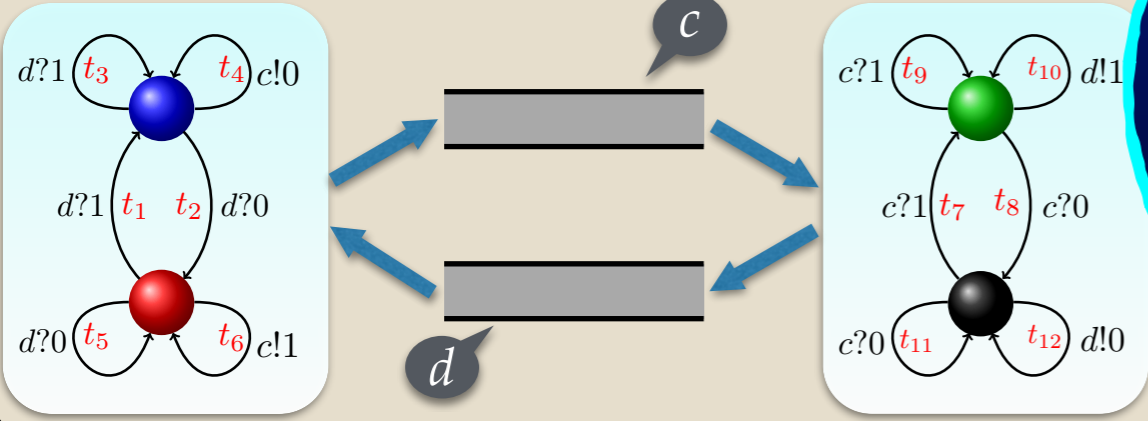
- Top row: [Red] [Black] [€] [1]
- Bottom row: [Blue] [Black] [€] [10]
- Bottom row: [Blue] [Green] [€] [0]
- Bottom row: [Red] [Green] [0] [€]

Highlighted element: [Blue] [Black] [1] [€]



# Lossy Backward Reachability

**waiting**



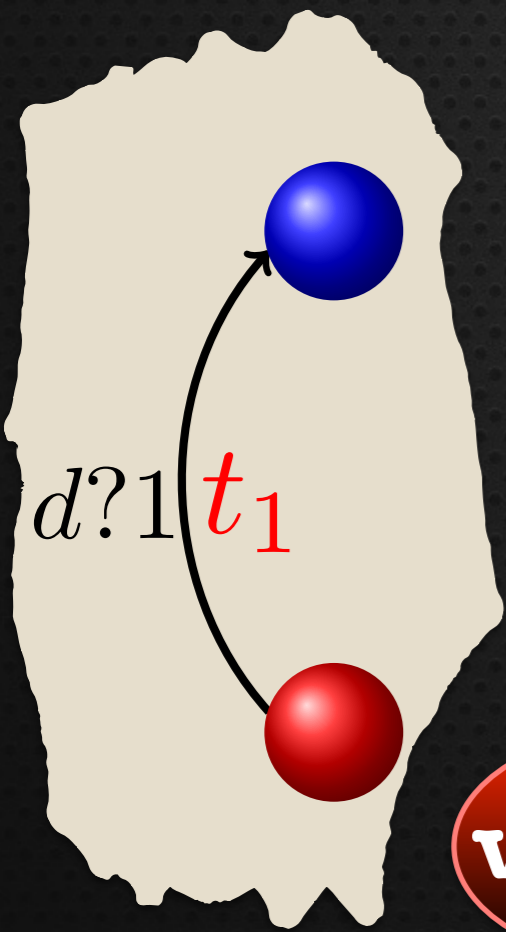
**waiting**

Red ● Black ● 01 €

Red ● Green ● € 01

Red ● Black ● 1 1

€



**visited**

Red ● Black ● € 1

Blue ● Black ● 1 €

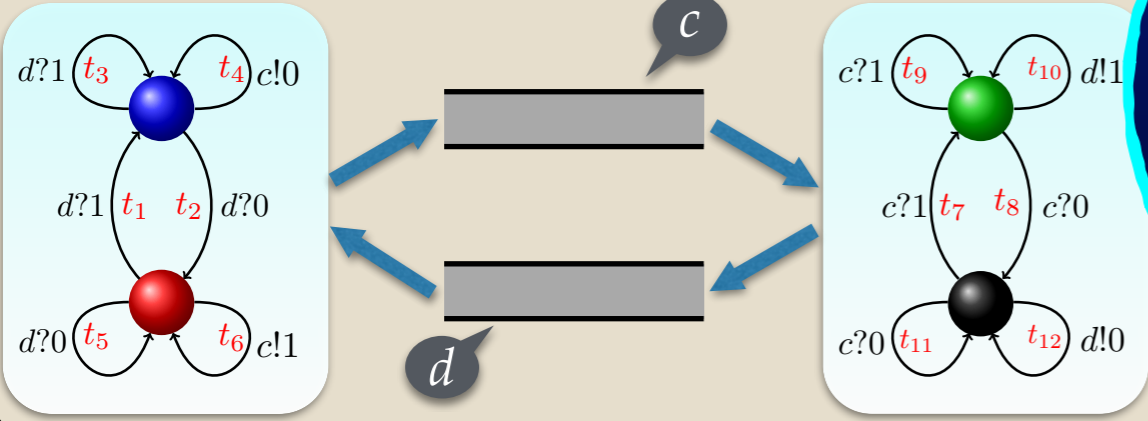
Blue ● Black ● € 10

Blue ● Green ● € 0

Red ● Green ● 0 €

# Lossy Backward Reachability

waiting



waiting

● ● 01 €

● ● € 01

€

visited

● ● € 1

● ● 1 €

● ● € 10

● ● € 0

● ● 0 €



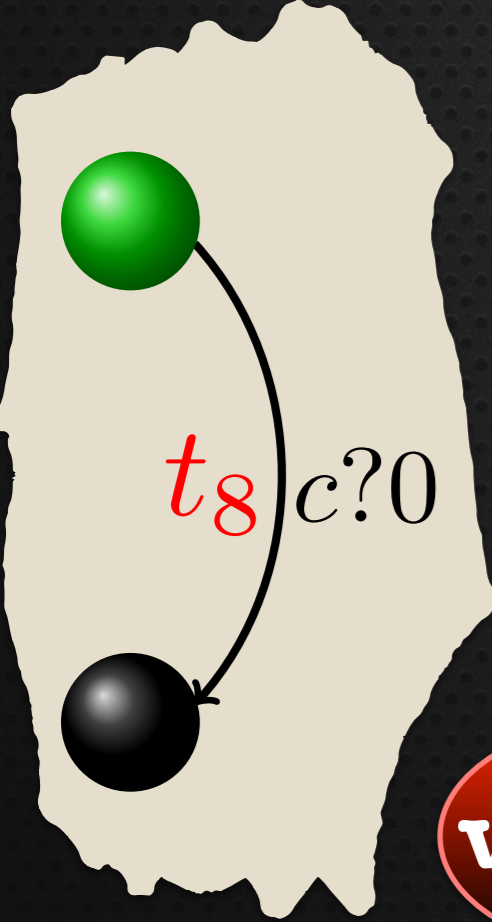
Lossy Backward Reachability

waiting



Blue bubble containing state representations:

- Top-left: [Red dot] [Black dot] [01] [€]
- Top-right: [Red dot] [Green dot] [€] [01]
- Bottom: [€]



visited

Red bubble containing state representations:

- Top-left: [Red dot] [Black dot] [€] [1]
- Top-right: [Blue dot] [Black dot] [1] [€]
- Middle: [Blue dot] [Black dot] [€] [10]
- Bottom-left: [Blue dot] [Green dot] [€] [0]
- Bottom-right: [Red dot] [Green dot] [0] [€]

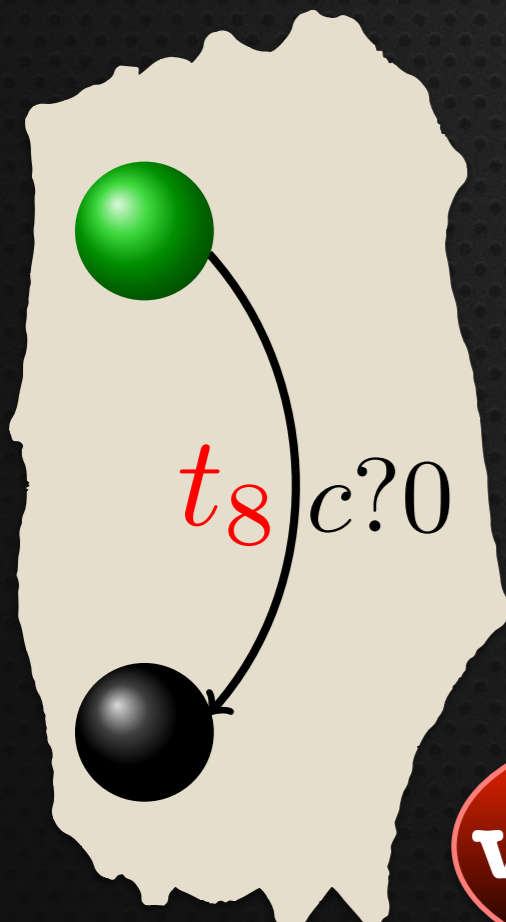
# Lossy Backward Reachability

**waiting**



**waiting**

- [Red] [Black] [01] [€]
- [Red] [Green] [€] [01]
- [Blue] [Green] [10] [€]



**visited**

**visited**

- [Red] [Black] [€] [1]
- [Blue] [Black] [1] [€]
- [Blue] [Black] [€] [10]
- [Blue] [Green] [€] [0]
- [Red] [Green] [0] [€]



# Lossy Backward Reachability

waiting



waiting

- Red circle, Black circle, 01, €
- Red circle, Green circle, €, 01
- Blue circle, Green circle, 10, €

visited

- Red circle, Black circle, €, 1
- Blue circle, Black circle, €, 10
- Blue circle, Green circle, €, 0
- Red circle, Green circle, 0, €

# Lossy Backward Reachability

**waiting**



**waiting**

● (red) ● (black) 01 €
● (red) ● (green) € 01

● (blue) ● (green) 10 €

**visited**

● (red) ● (black) € 1
● (blue) ● (black) 1 €

● (blue) ● (black) € 10

● (blue) ● (green) € 0
● (red) ● (green) 0 €



# Lossy Backward Reachability

waiting



0001 €

0010 €

00€1

001 €

00€10

00€01

00€0

0000 €

visited

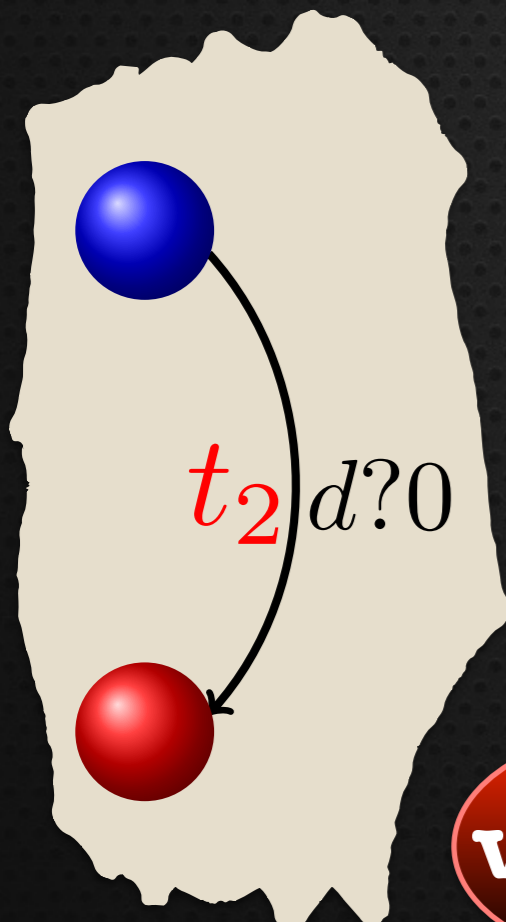
# Lossy Backward Reachability

**waiting**



Waiting state (blue bubble):

- Top row:  $\bullet$   $\bullet$  01  $\epsilon$
- Bottom row:  $\bullet$   $\bullet$  10  $\epsilon$



**visited**

Visited state (red bubble):

- Top row:  $\bullet$   $\bullet$   $\epsilon$  1
- Bottom row:  $\bullet$   $\bullet$  1  $\epsilon$
- Middle row:  $\bullet$   $\bullet$   $\epsilon$  10     $\bullet$   $\bullet$   $\epsilon$  01
- Bottom row:  $\bullet$   $\bullet$   $\epsilon$  0     $\bullet$   $\bullet$  0  $\epsilon$



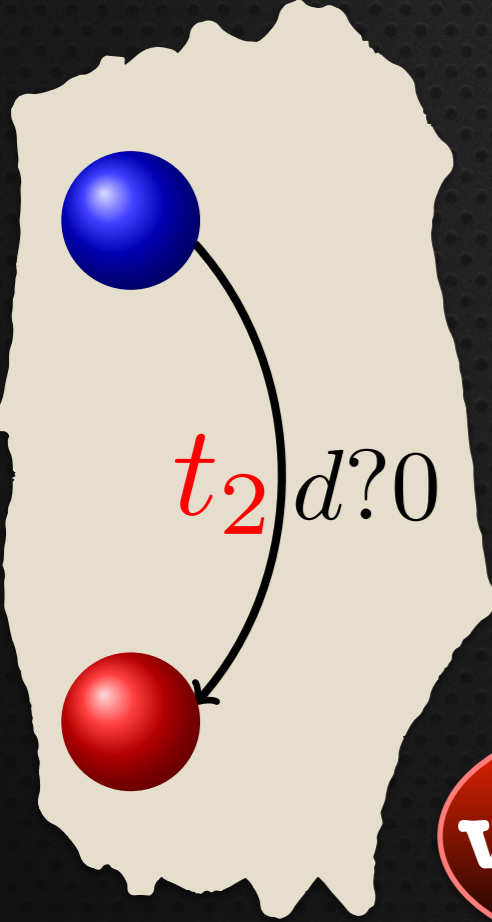
# Lossy Backward Reachability

**waiting**



Waiting state visualization:

- Top row:  $\text{Red} \text{ Black } 01 \text{ €}$
- Middle row (circled):  $\text{Blue} \text{ Green } 10 \text{ €}$
- Bottom row:  $\text{Blue} \text{ Green } \text{€} 010$



**visited**

Visited state visualization:

- Top row:  $\text{Red} \text{ Black } \text{€} 1$
- Second row:  $\text{Blue} \text{ Black } \text{€} 10$  and  $\text{Red} \text{ Green } \text{€} 01$
- Bottom row:  $\text{Blue} \text{ Green } \text{€} 0$  and  $\text{Red} \text{ Green } 0 \text{ €}$

# Lossy Backward Reachability

waiting



0001 €

0010 €

00€1

001 €

00€10

00€01

00€0

0000 €

visited



Lossy Backward Reachability

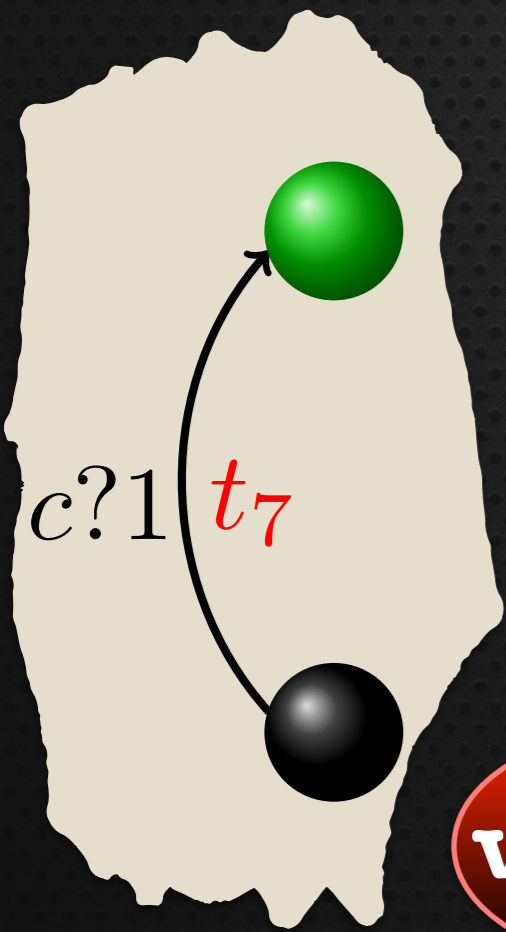
waiting



waiting

● ● 01 €

● ● 10 €



visited

● ● € 1

● ● 1 €

● ● € 10

● ● € 01

● ● € 0

● ● 0 €

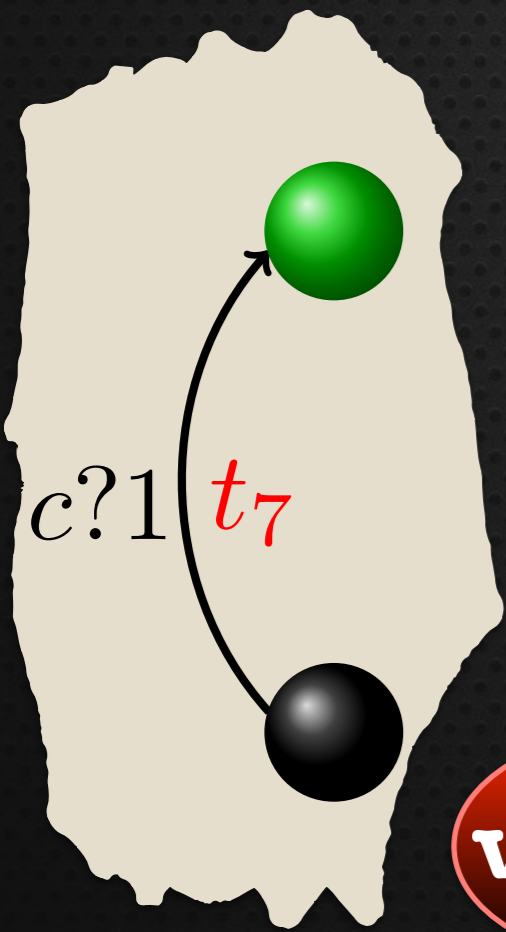
# Lossy Backward Reachability

**waiting**



Waiting state configurations:

- [Red] [Black] 01 €
- [Red] [Black] 1 01
- [Blue] [Green] 10 €



**visited**

Visited state configurations:

- [Red] [Black] € 1
- [Blue] [Black] 1 €
- [Blue] [Black] € 10
- [Red] [Green] € 01
- [Blue] [Green] € 0
- [Red] [Green] 0 €



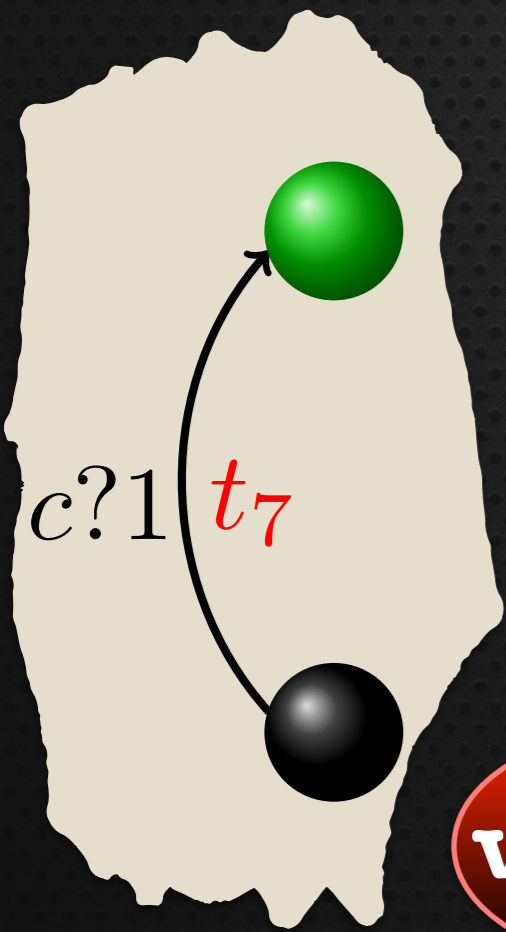
# Lossy Backward Reachability

**waiting**



**waiting**

- [Red] [Black] 01 €
- [Red] [Black] 1 01
- [Blue] [Green] 10 €



**visited**

**visited**

- [Red] [Black] € 1
- [Blue] [Black] 1 €
- [Blue] [Black] € 10
- [Red] [Green] € 01
- [Blue] [Green] € 0
- [Red] [Green] 0 €

# Lossy Backward Reachability

waiting



waiting

● ● 01 €

● ● 10 €

visited

● ● € 1

● ● 1 €

● ● € 10

● ● € 01

● ● € 0

● ● 0 €



# Lossy Backward Reachability

waiting



waiting

● ● 01 €

● ● 10 €

visited

● ● € 1

● ● 1 €

● ● € 10

● ● € 01

● ● € 0

● ● 0 €

# Lossy Backward Reachability

**waiting**



Blue bubble containing a sequence of four items: a blue circle, a green circle, the number 10, and the Euro symbol (€).

Red bubble containing several sequences of four items:

- Red circle, black circle, €, 1
- Blue circle, black circle, 1, €
- Blue circle, black circle, €, 10
- Red circle, green circle, €, 01
- Blue circle, green circle, €, 0
- Red circle, green circle, 0, €

One sequence (Red circle, black circle, 01, €) is circled in white.

**visited**

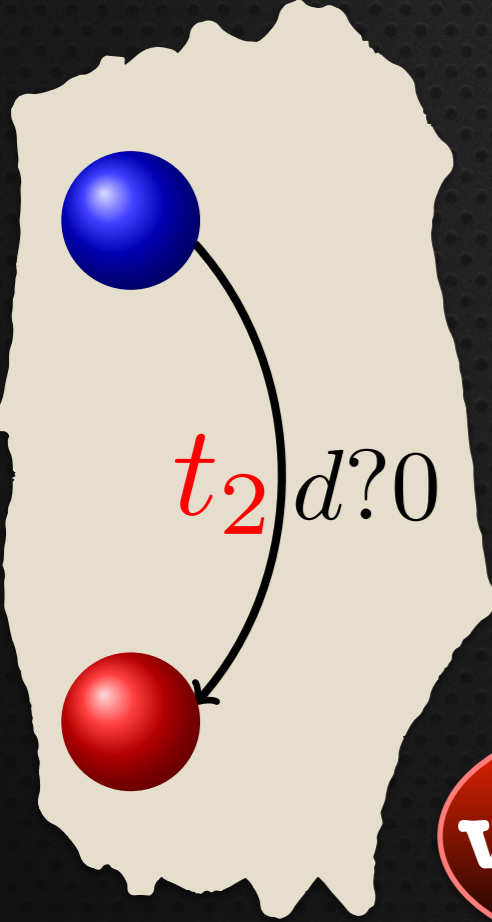


# Lossy Backward Reachability

**waiting**



Blue bubble containing a stack of four elements: a blue circle, a green circle, the number 10, and the Euro symbol (€).



Red bubble containing a stack of seven elements: a red circle, a black circle, the Euro symbol (€), the number 1, a blue circle, a black circle, the Euro symbol (€), the number 10, a red circle, a green circle, the Euro symbol (€), the number 01, a blue circle, a green circle, the Euro symbol (€), the number 0, a red circle, a green circle, the Euro symbol (€), the number 0.

**visited**

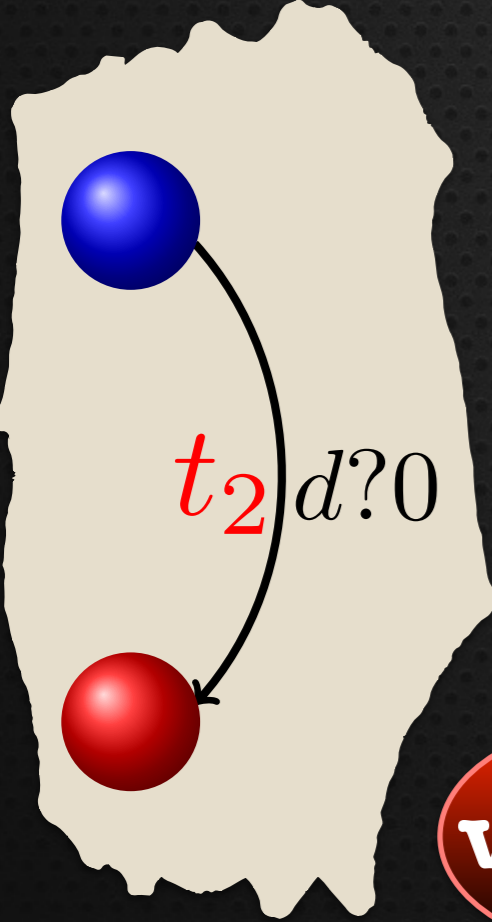
Lossy Backward Reachability

waiting



Blue oval containing two rows of four elements each:

- Row 1: Blue circle, Black circle, 01, 0
- Row 2: Blue circle, Green circle, 10, €



Red oval containing several rows of four elements each:

- Row 1: Red circle, Black circle, €, 1
- Row 2: Blue circle, Black circle, €, 10
- Row 3: Red circle, Green circle, €, 01
- Row 4: Blue circle, Green circle, €, 0
- Row 5: Red circle, Green circle, 0, €

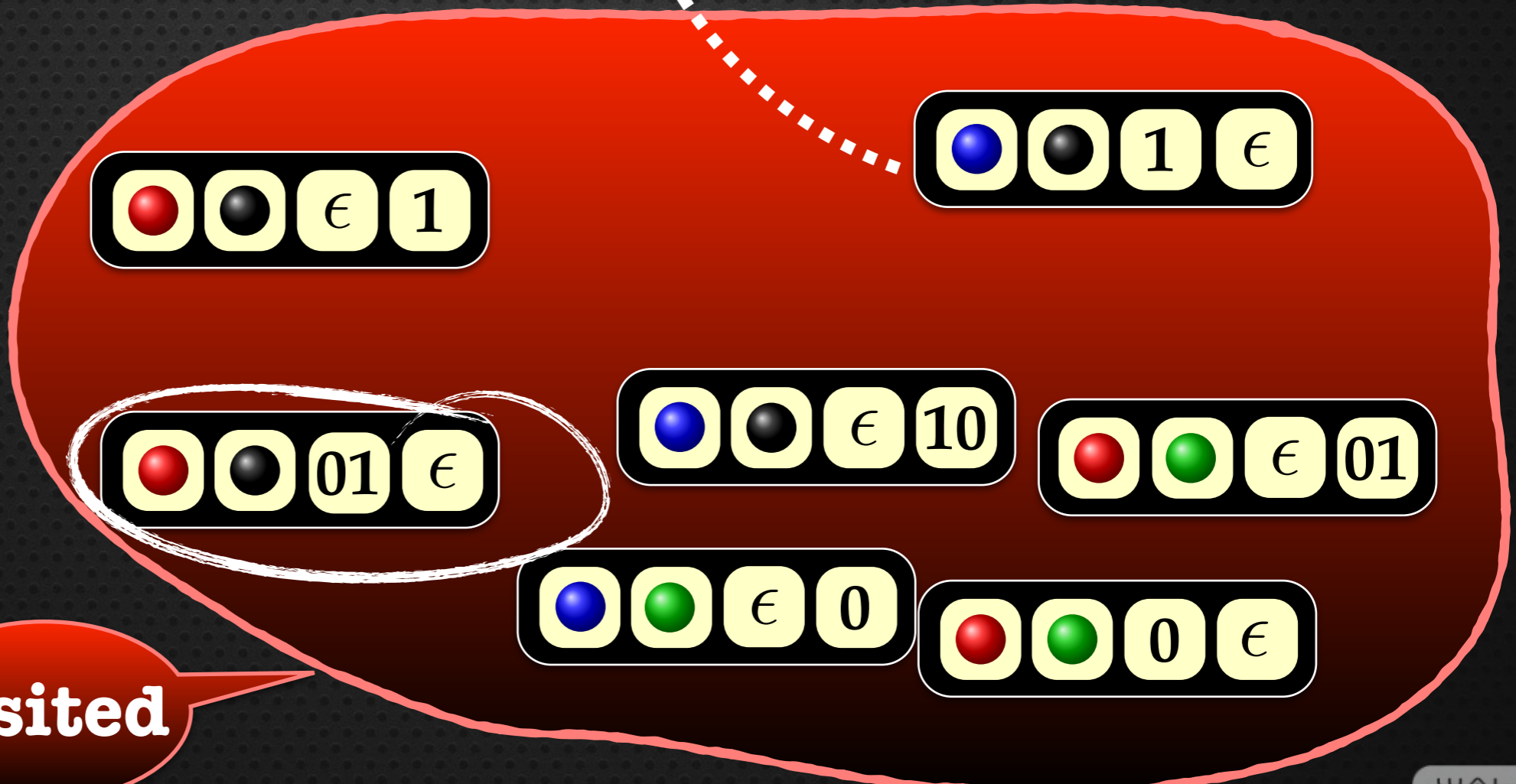
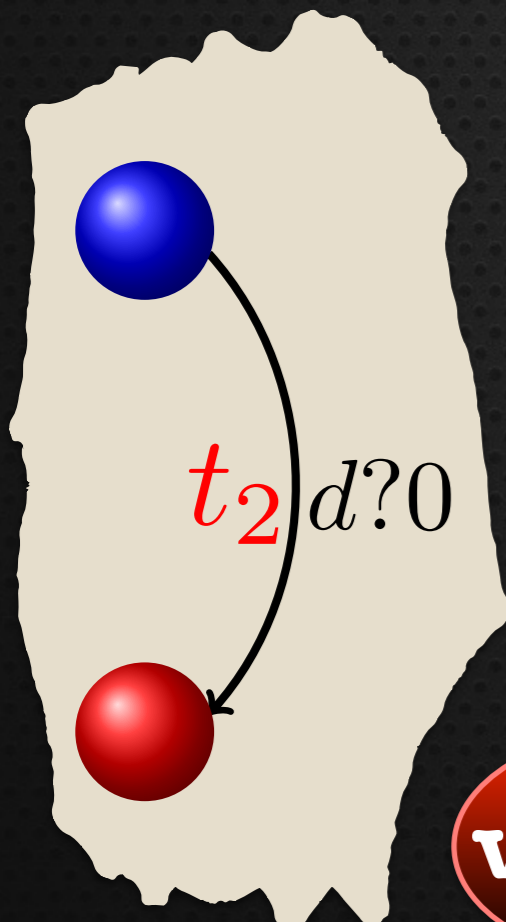
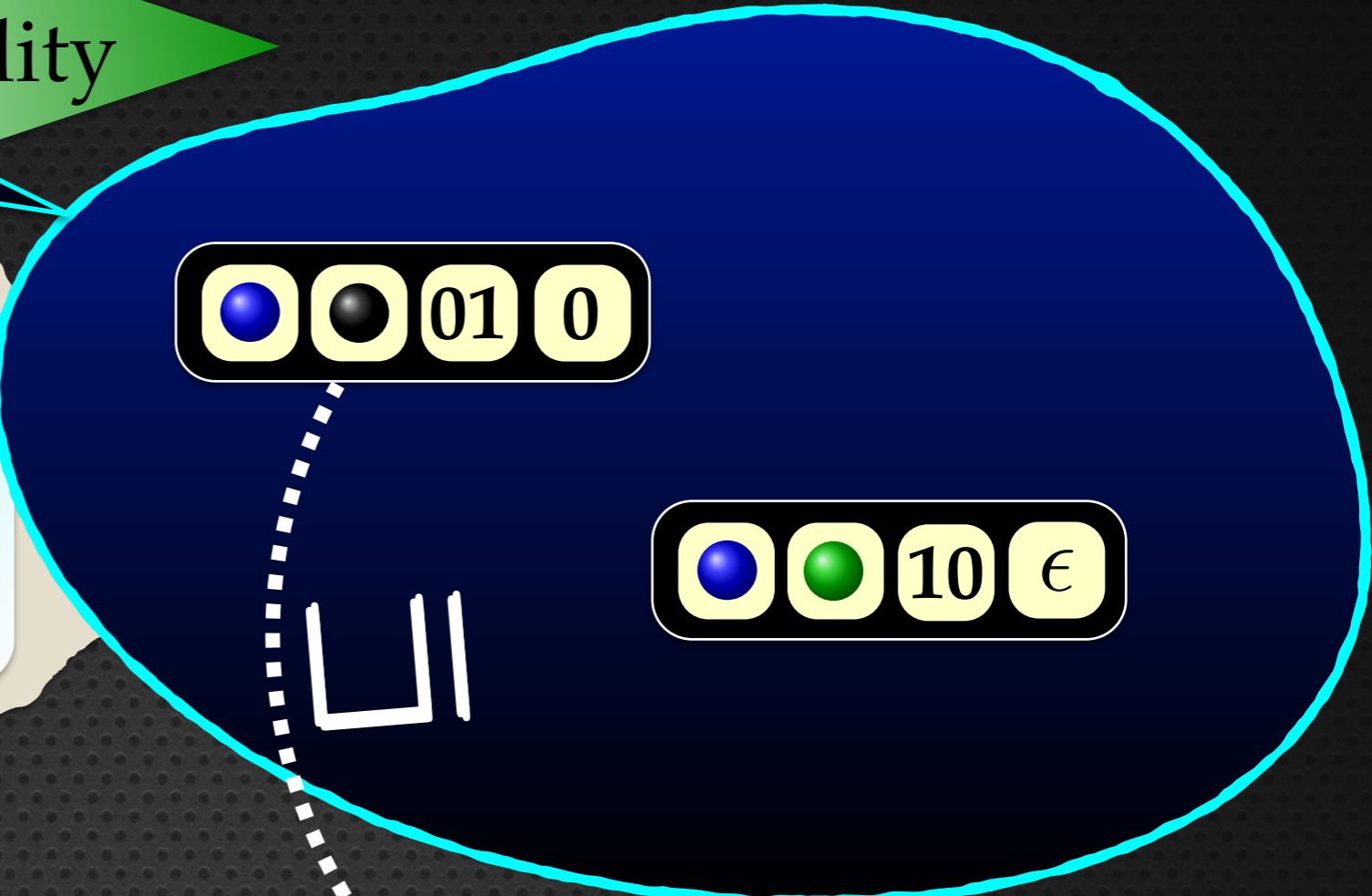
White oval highlights the row: Red circle, Black circle, 01, €

Red oval contains a red speech bubble: visited



# Lossy Backward Reachability

**waiting**



**visited**

# Lossy Backward Reachability

**waiting**



Blue bubble containing a sequence of four elements: a blue circle, a green circle, the number 10, and the Euro symbol (€).

Red bubble containing several sequences of four elements:

- Red circle, black circle, €, 1
- Blue circle, black circle, 1, €
- Blue circle, black circle, €, 10
- Red circle, green circle, €, 01
- Blue circle, green circle, €, 0
- Red circle, green circle, 0, €

One sequence (Red circle, black circle, 01, €) is circled in white.

**visited**

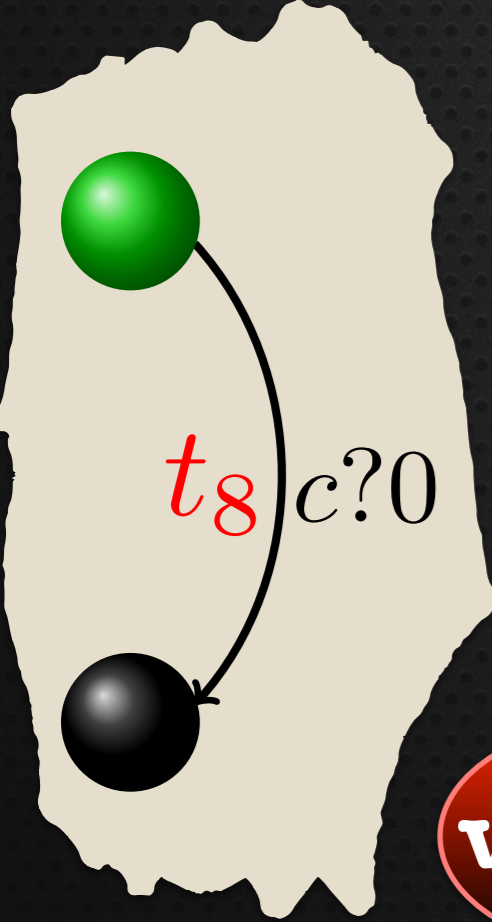


Lossy Backward Reachability

waiting



Blue bubble containing a stack of four items: a blue circle, a green circle, the number 10, and the Euro symbol (€).



Red bubble containing a stack of seven items: a red circle, a black circle, the Euro symbol (€), the number 1, a blue circle, a black circle, the Euro symbol (€), the number 10, a red circle, a green circle, the Euro symbol (€), the number 01, a blue circle, a green circle, the Euro symbol (€), the number 0, a red circle, a green circle, the Euro symbol (€), the number 0.

visited

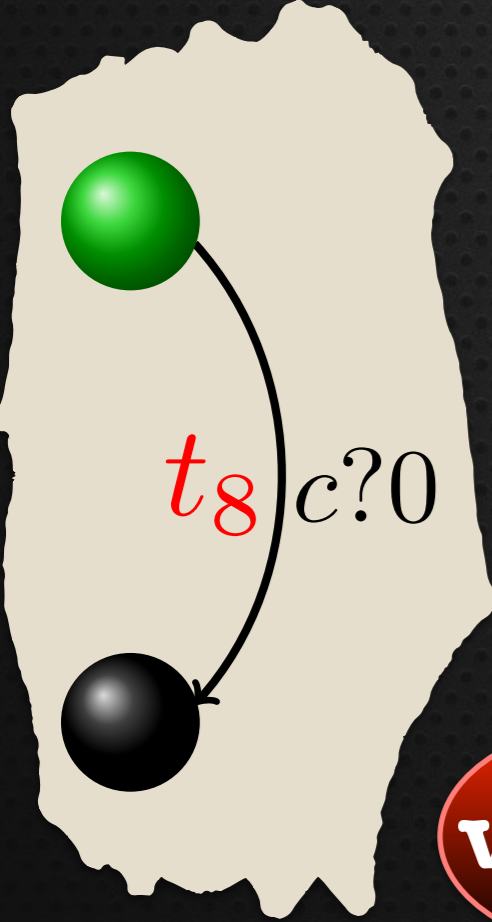
Lossy Backward Reachability

**waiting**



Red ● Green ● 010 €

Blue ● Green ● 10 €



Red ● Black ● € 1

Blue ● Black ● 1 € 1

Red ● Green ● € 01

Blue ● Green ● € 0

Red ● Green ● 0 €

Blue ● Black ● € 10

Red ● Green ● € 01

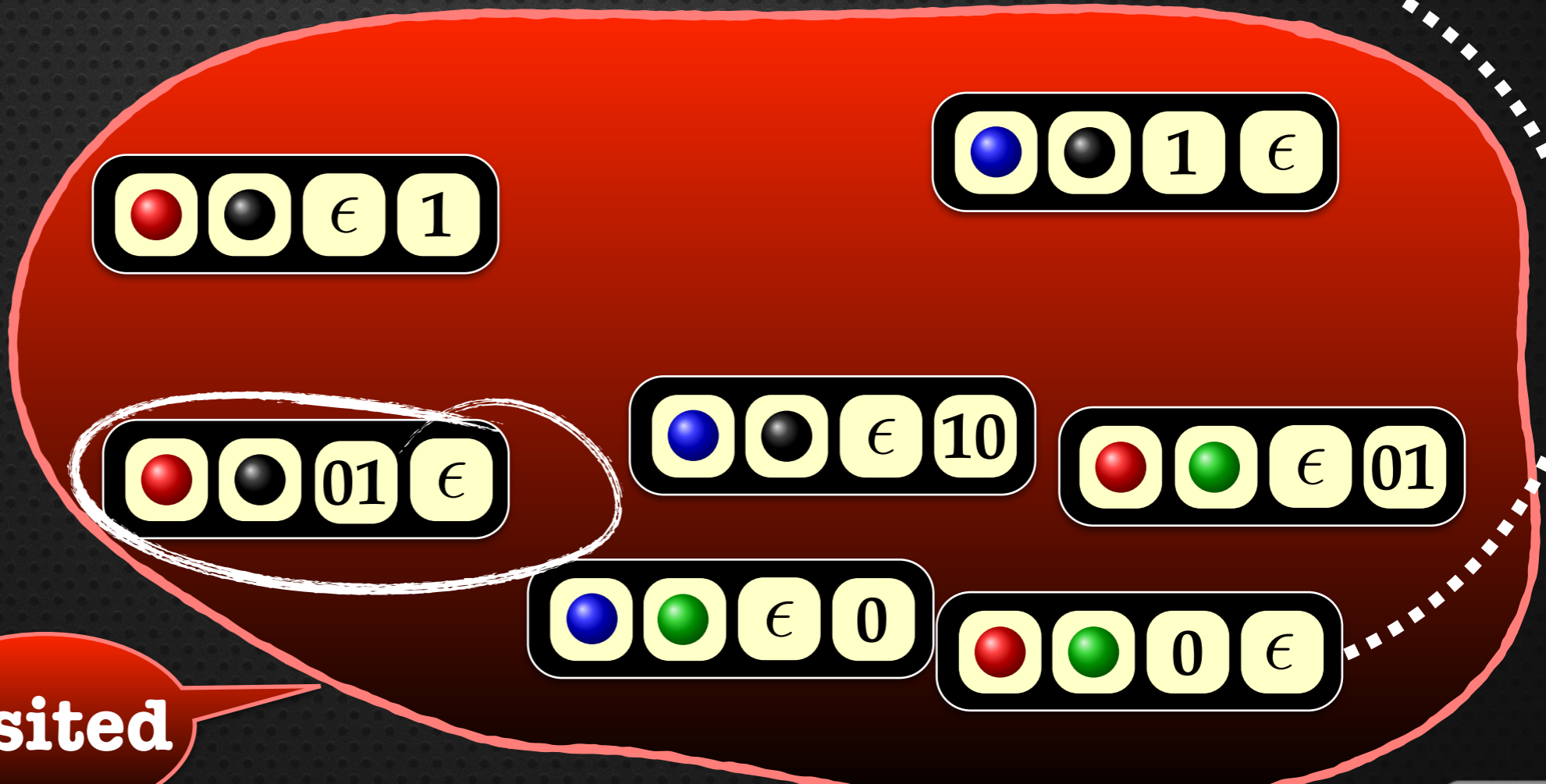
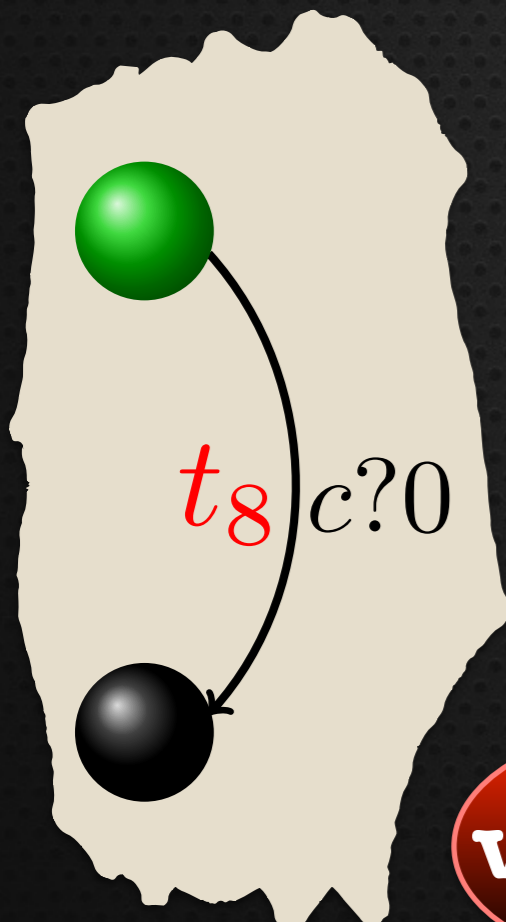
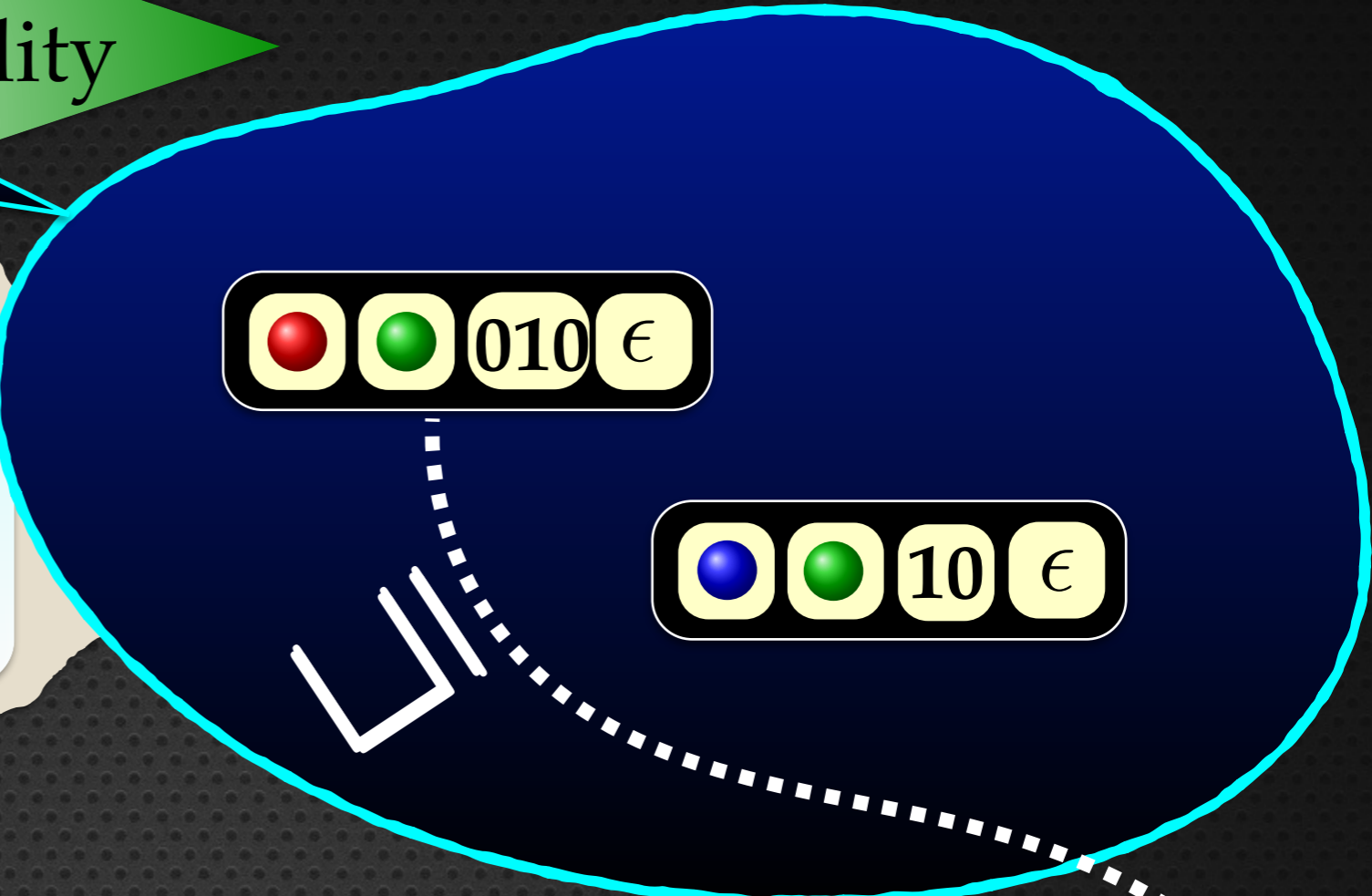
Red ● Black ● 01 €

**visited**



# Lossy Backward Reachability

**waiting**



# Lossy Backward Reachability

waiting



Blue bubble containing a display:  $\text{blue circle} \text{ green circle } 10 \text{ €}$

Red bubble containing several displays:

- $\text{red circle} \text{ black circle } \text{€} 1$
- $\text{blue circle} \text{ black circle } \text{€} 10$
- $\text{red circle} \text{ green circle } \text{€} 01$
- $\text{blue circle} \text{ green circle } \text{€} 0$
- $\text{red circle} \text{ green circle } 0 \text{ €}$
- $\text{blue circle} \text{ black circle } 1 \text{ €}$

visited



# Lossy Backward Reachability

waiting



waiting

● ● 10 €

visited

● ● 1 €

● ● € 10

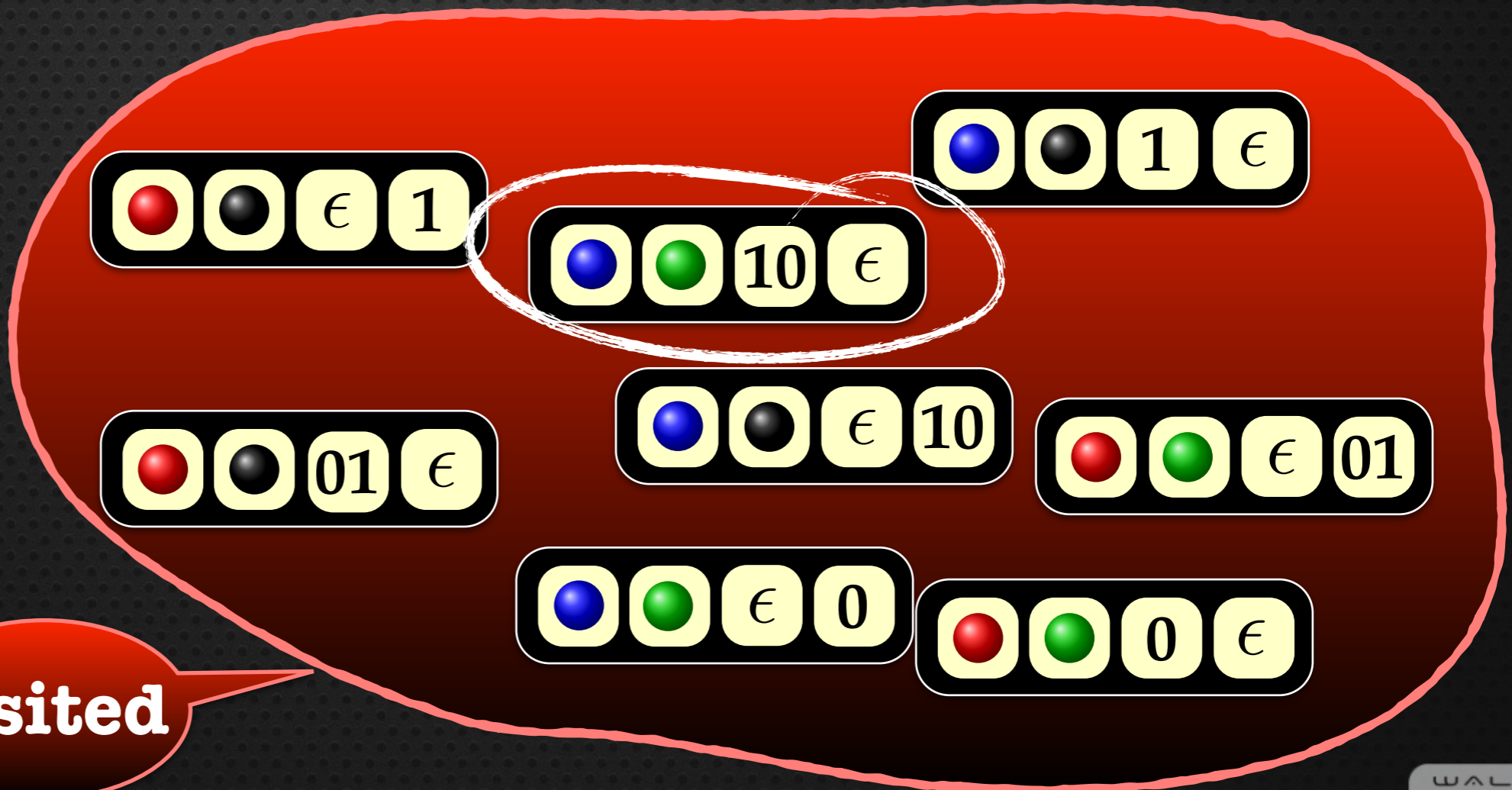
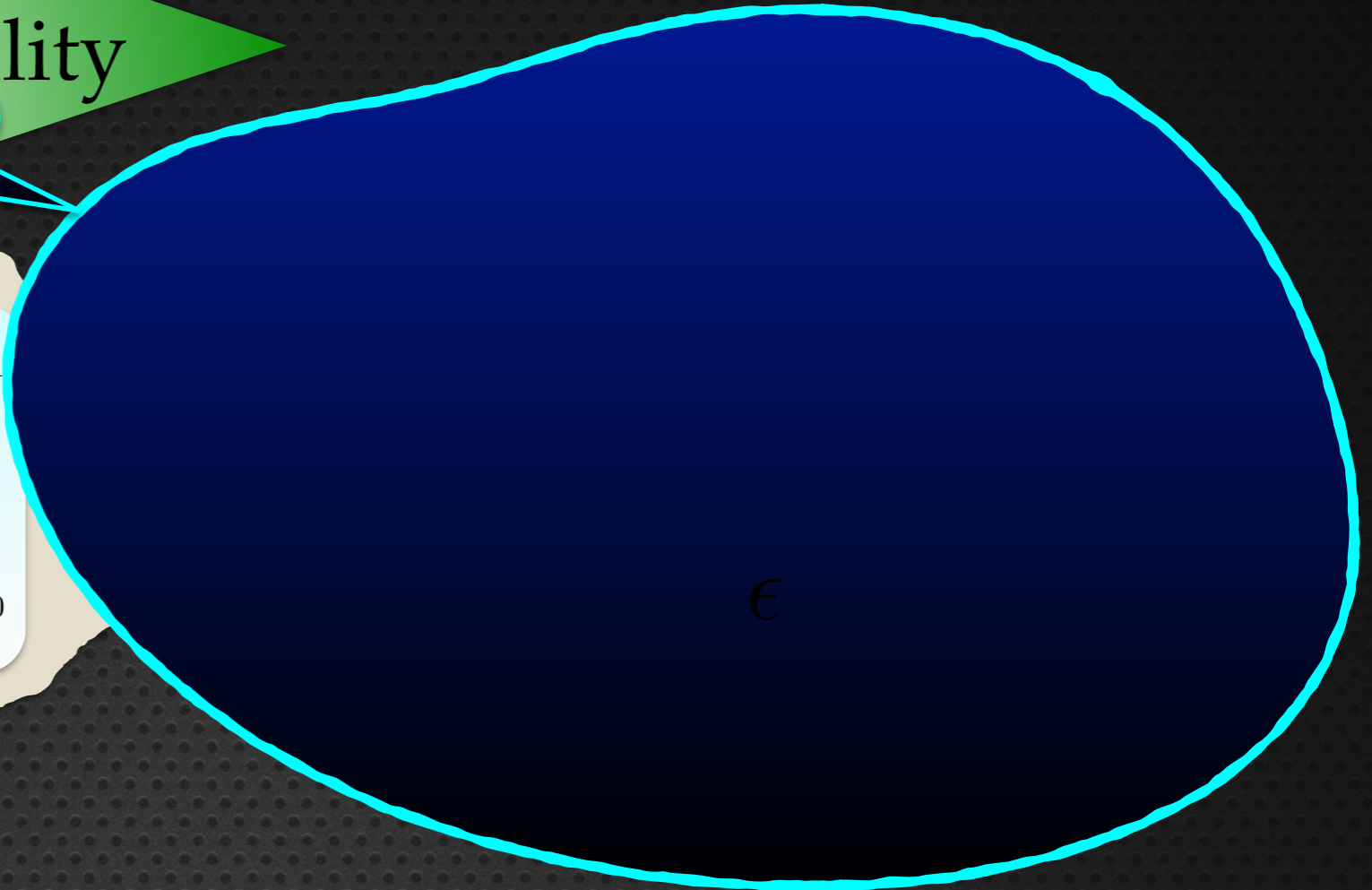
● ● 01 €

● ● € 0

● ● 0 €

# Lossy Backward Reachability

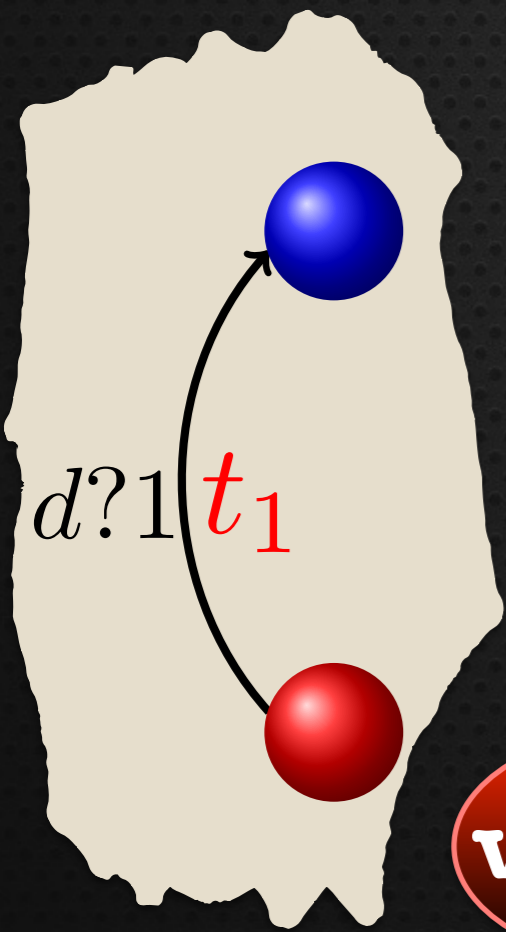
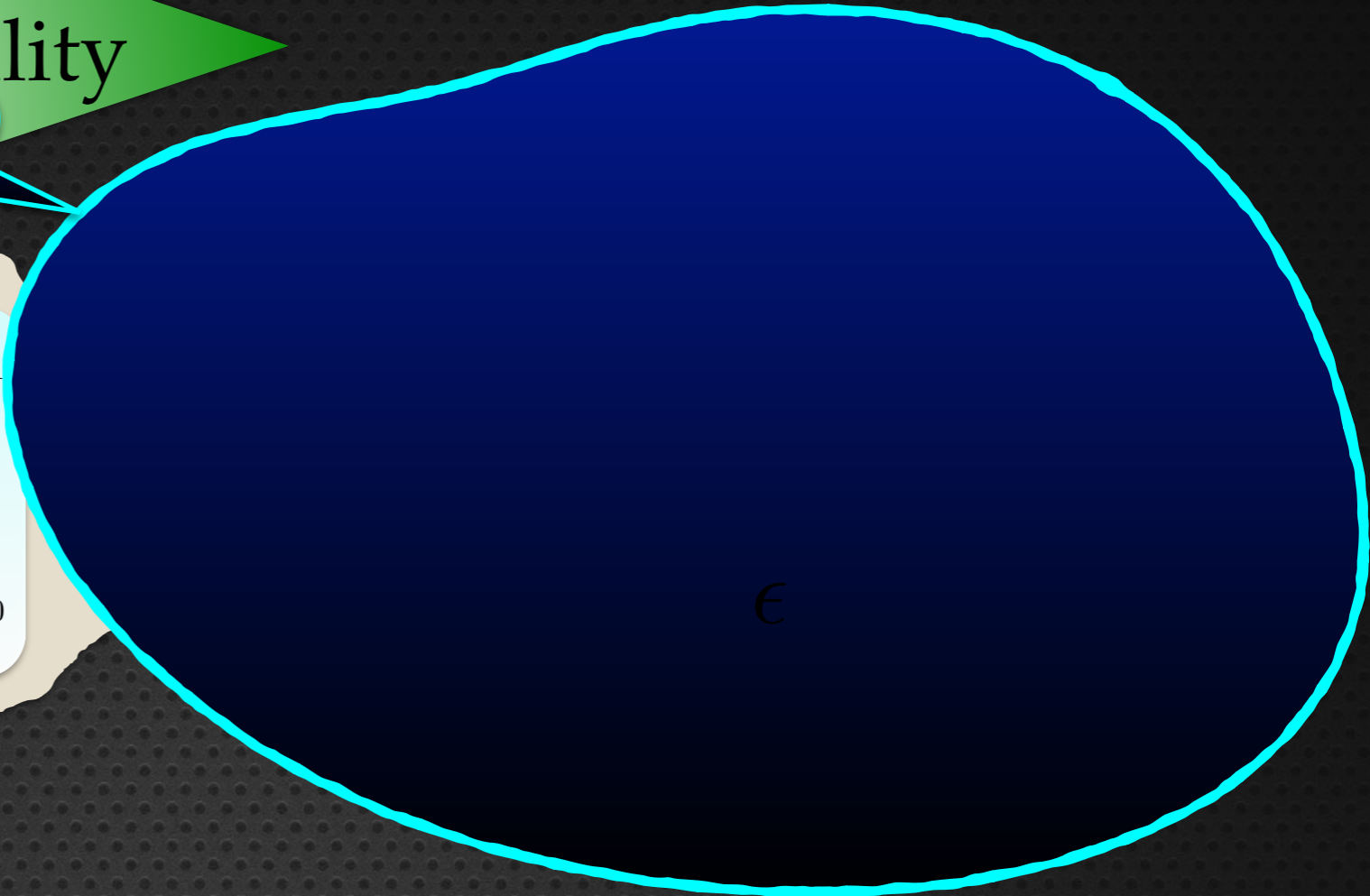
**waiting**



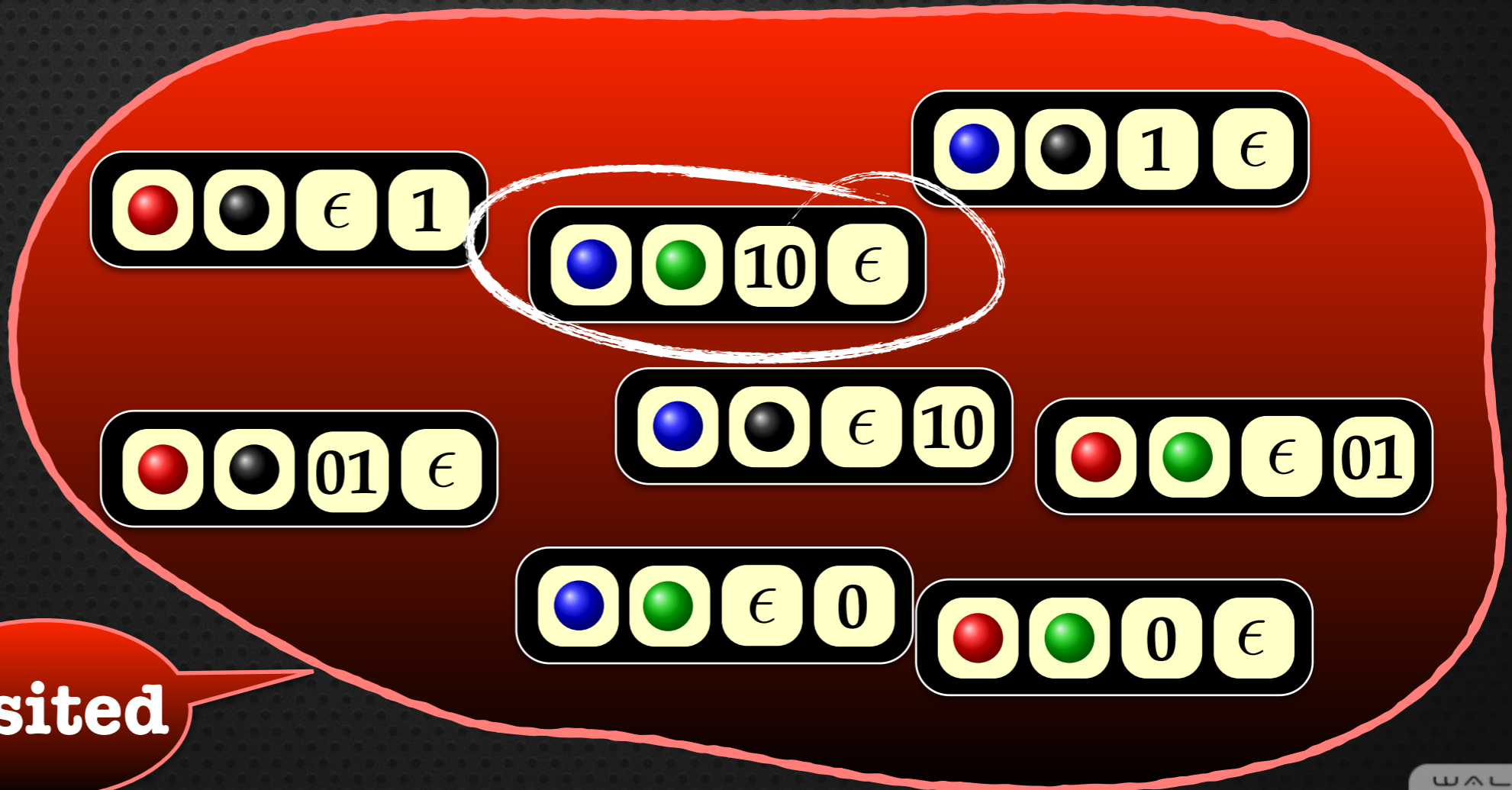


Lossy Backward Reachability

**waiting**



**visited**



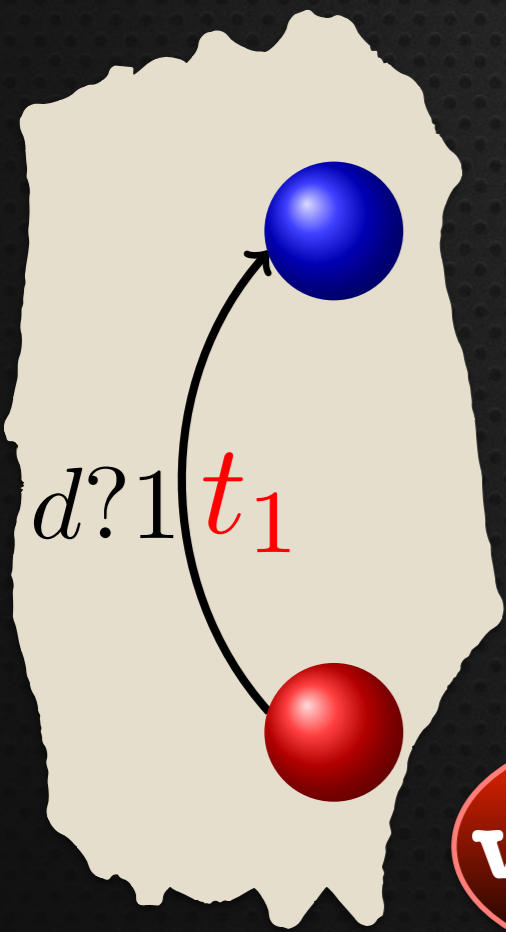
Lossy Backward Reachability

waiting



€

● ● 10 1



visited

● ● 1 €

● ● € 1

● ● 10 €

● ● € 10

● ● € 01

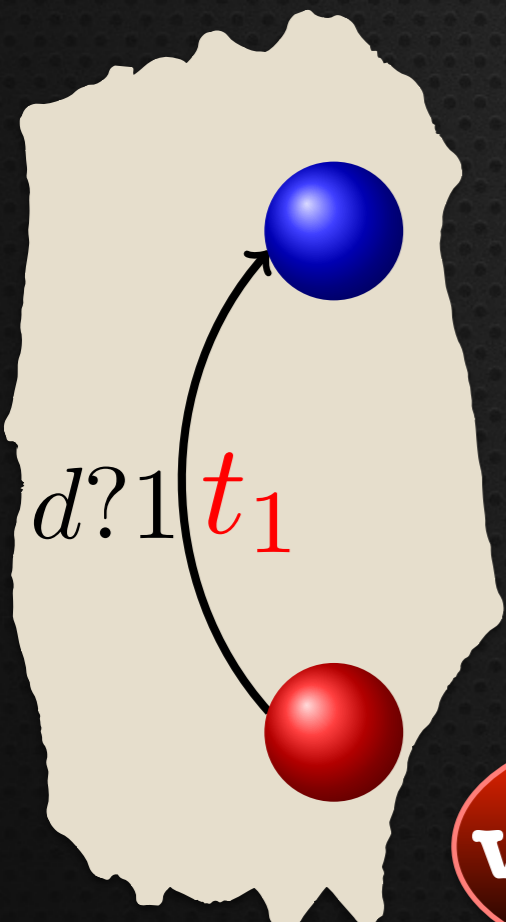
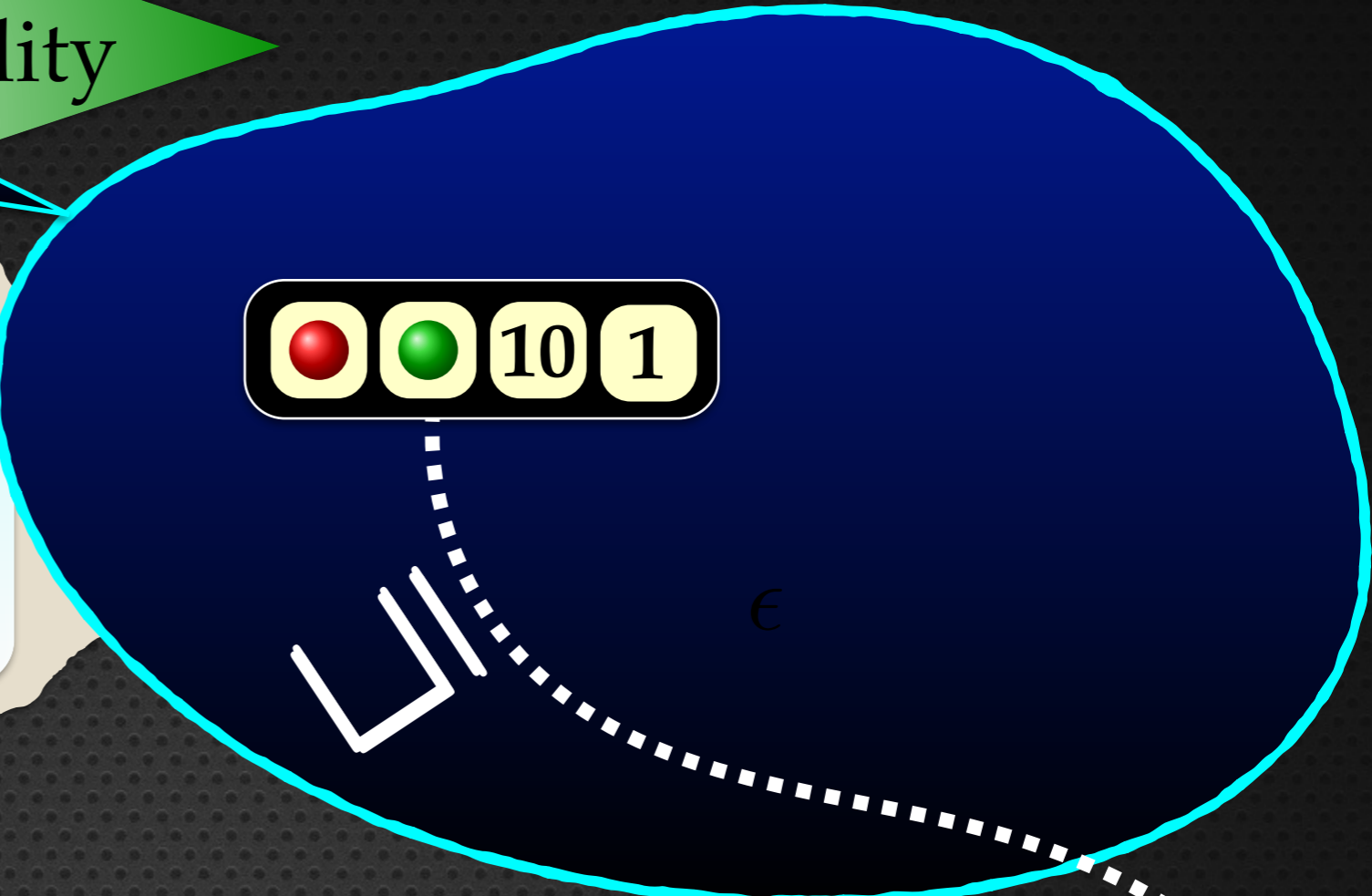
● ● € 0

● ● 0 €

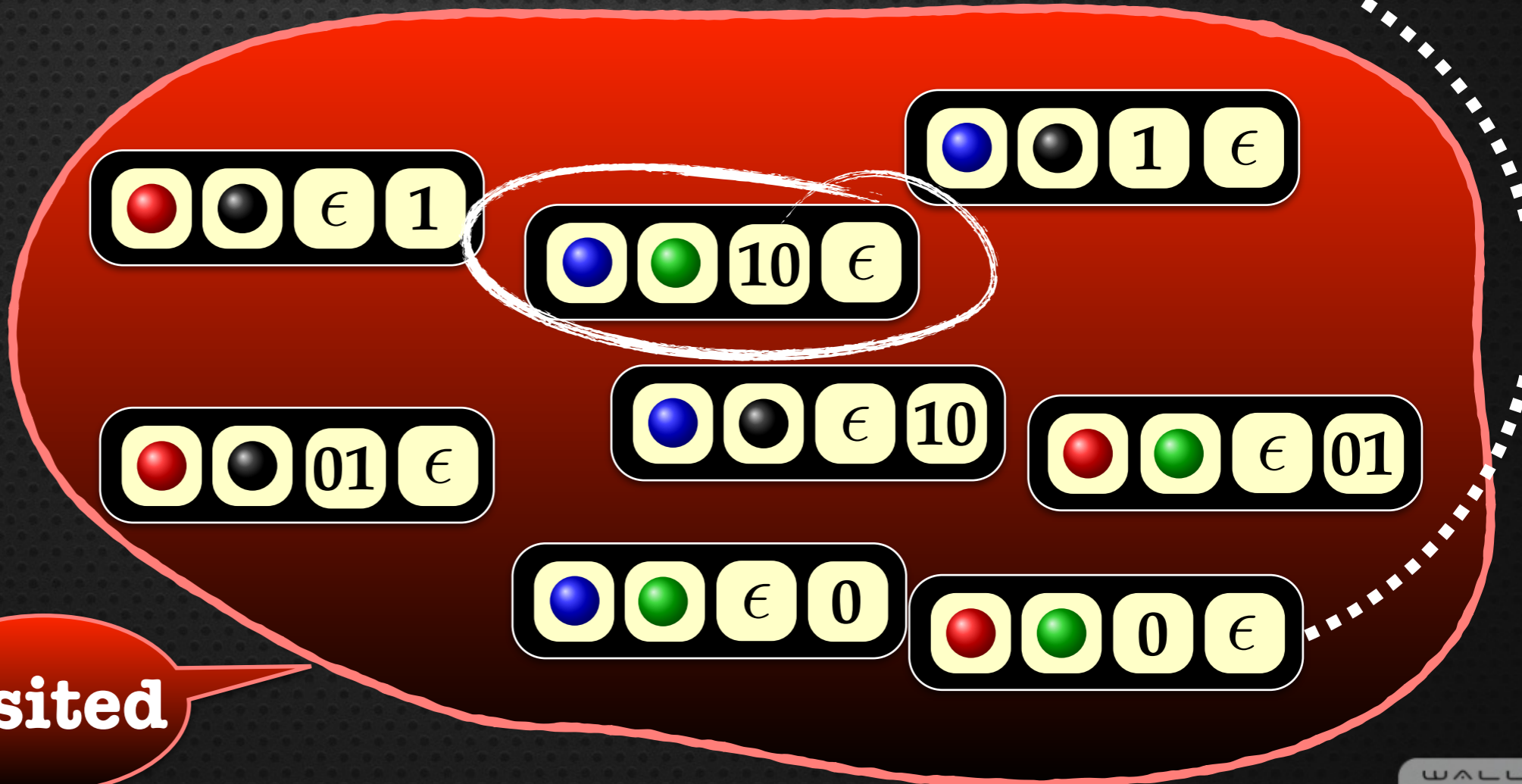


# Lossy Backward Reachability

**waiting**

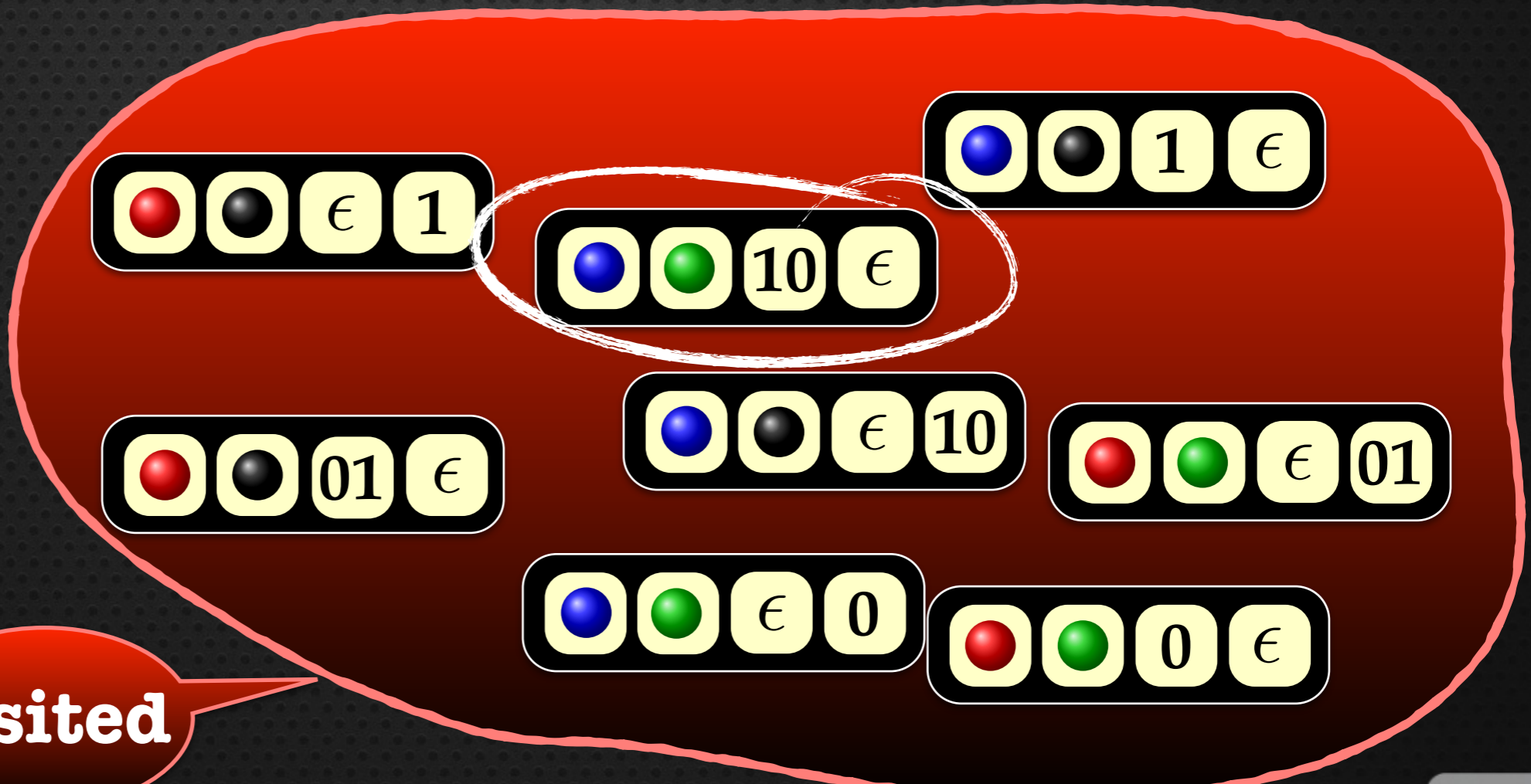
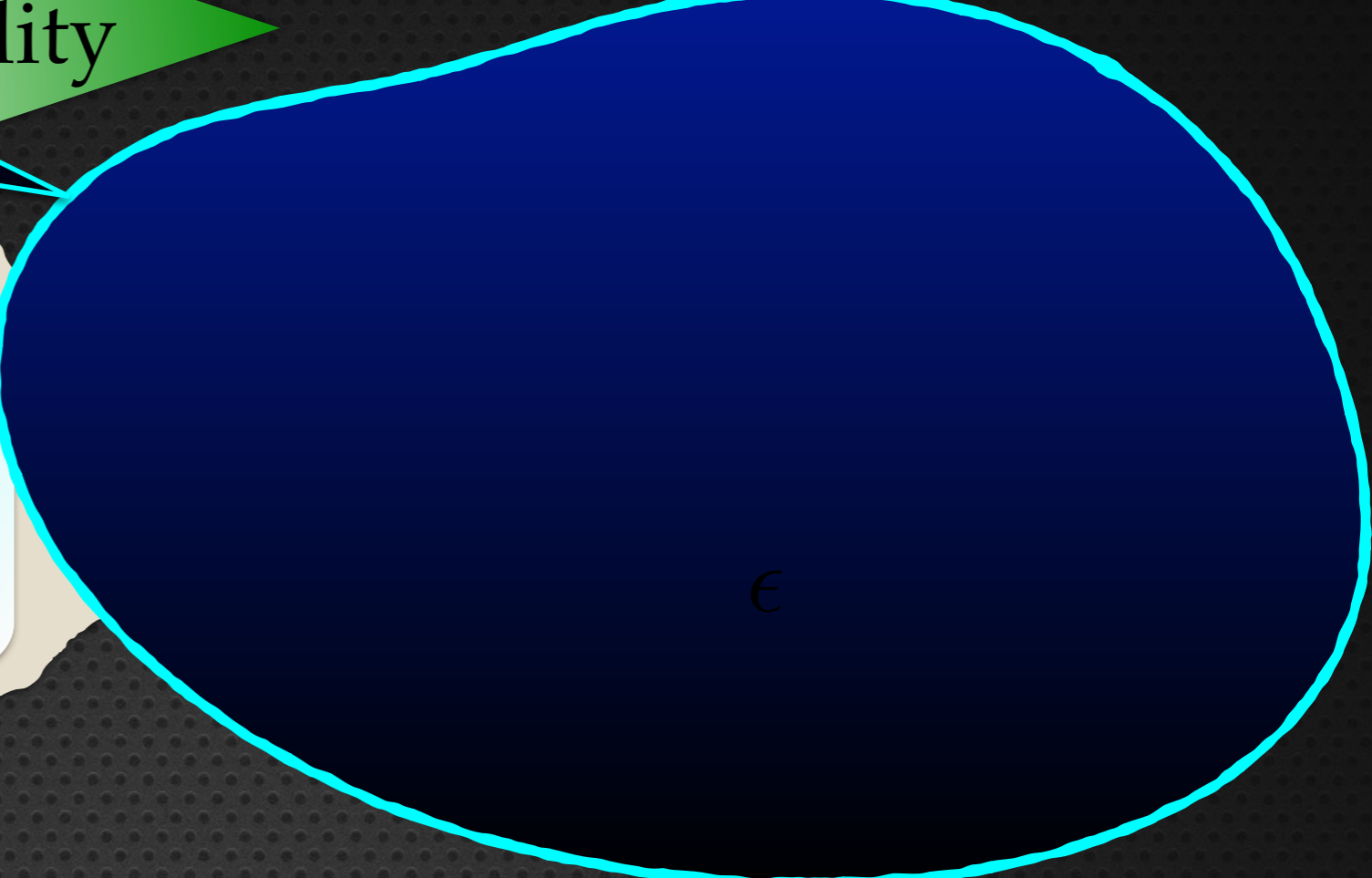


**visited**



# Lossy Backward Reachability

**waiting**

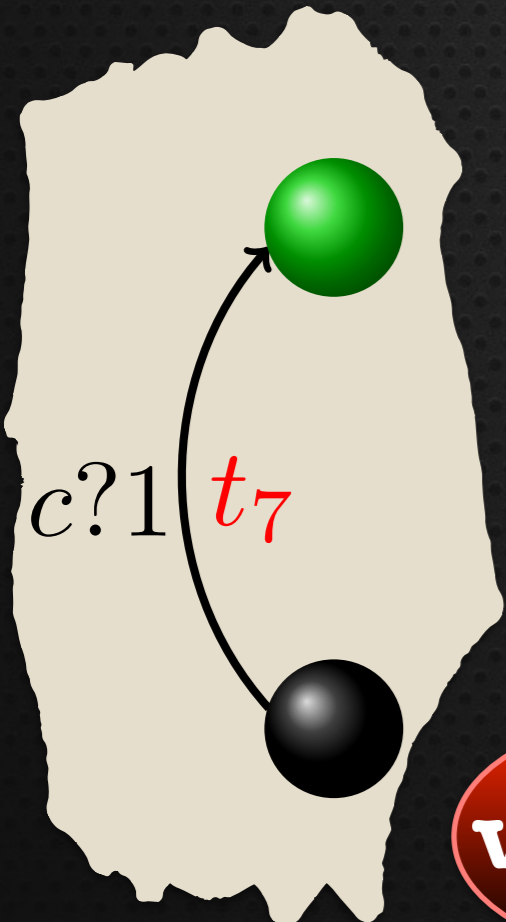
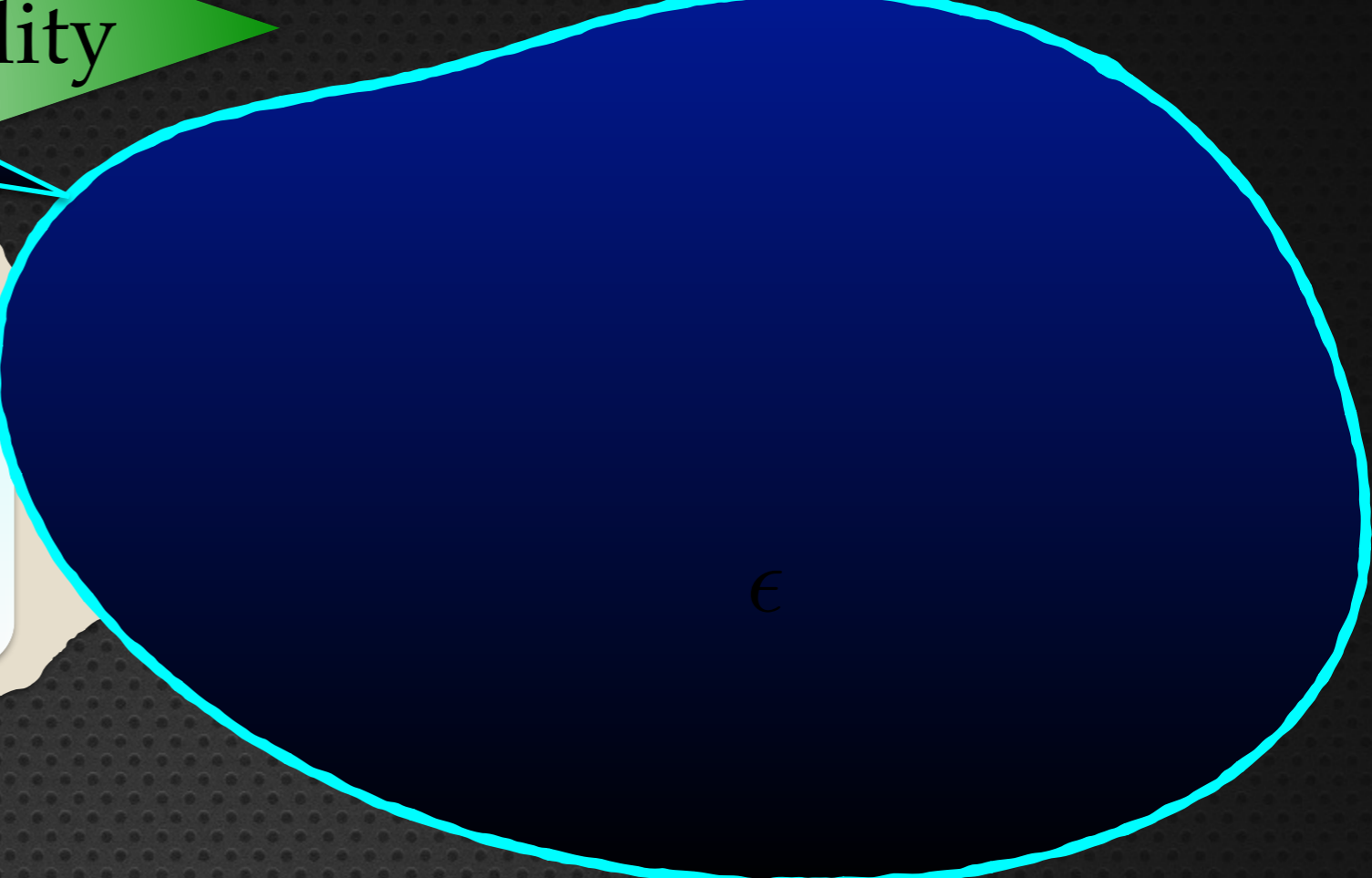


**visited**

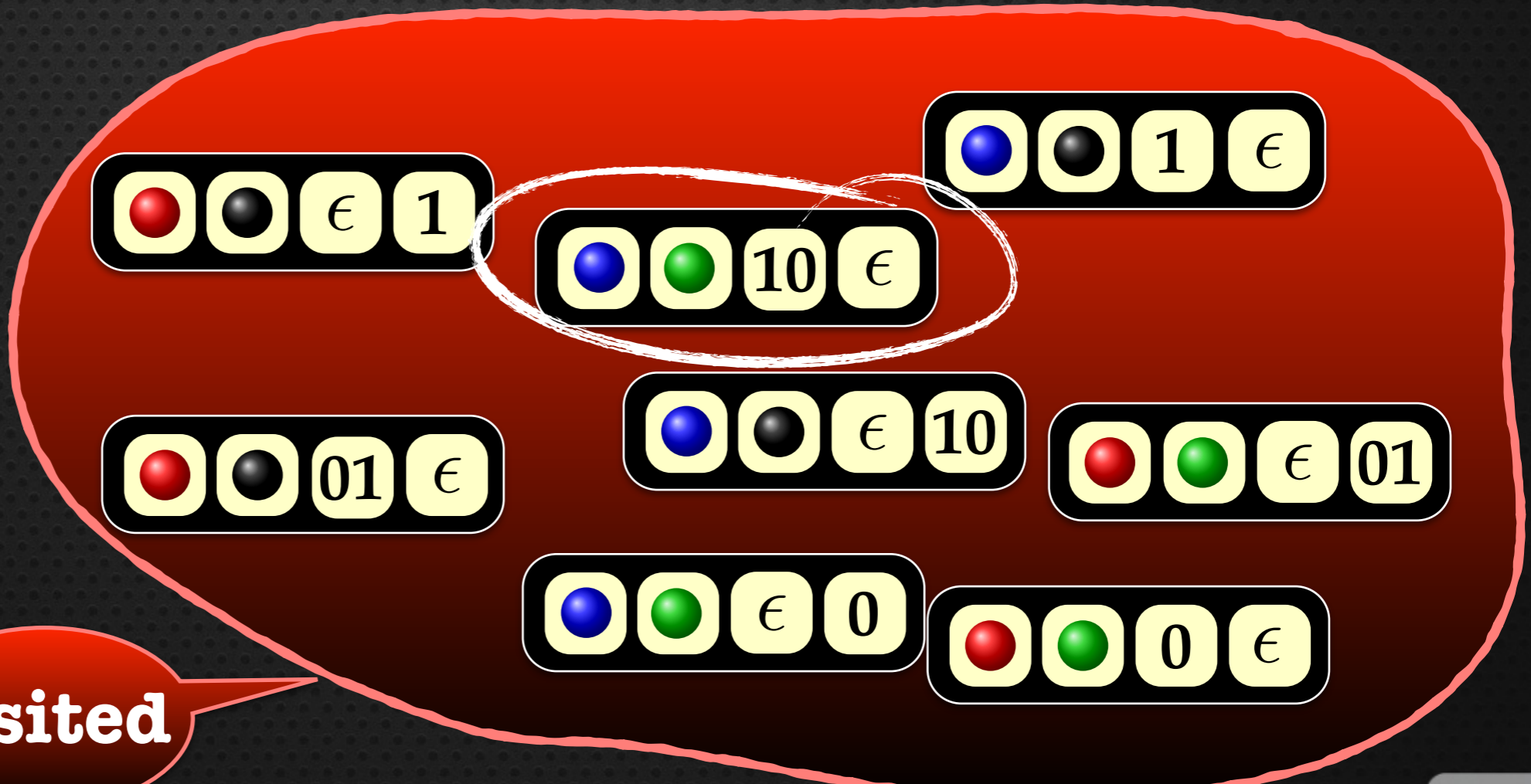


Lossy Backward Reachability

waiting



visited

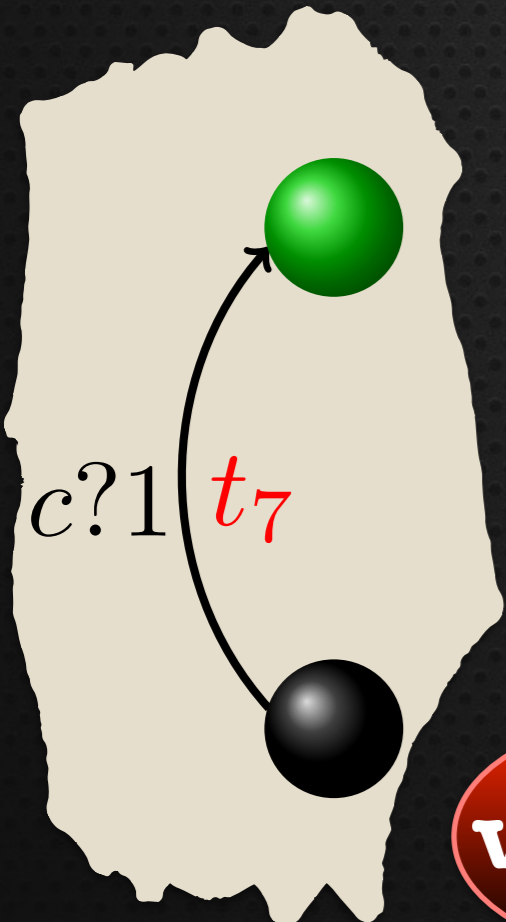
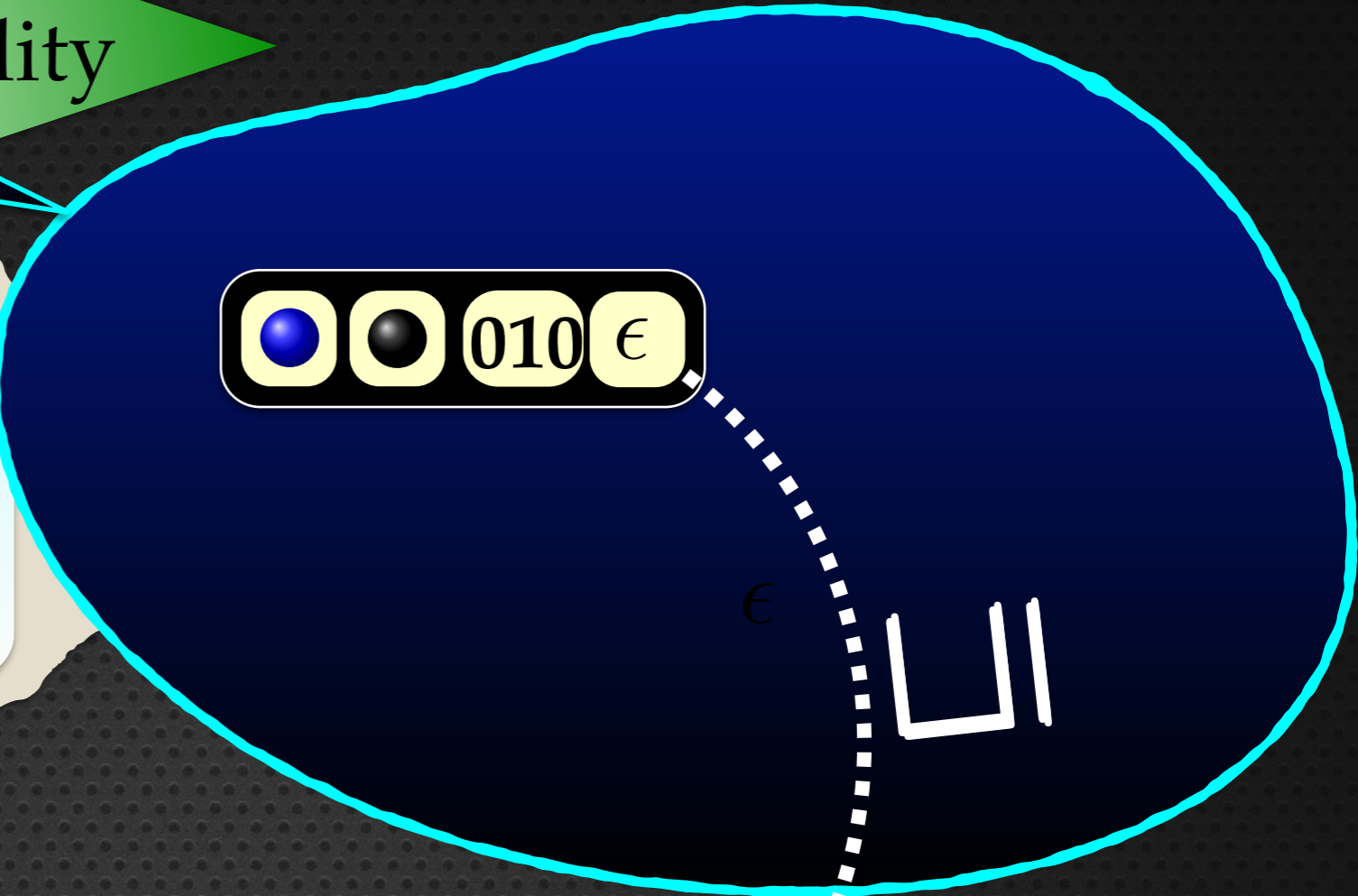




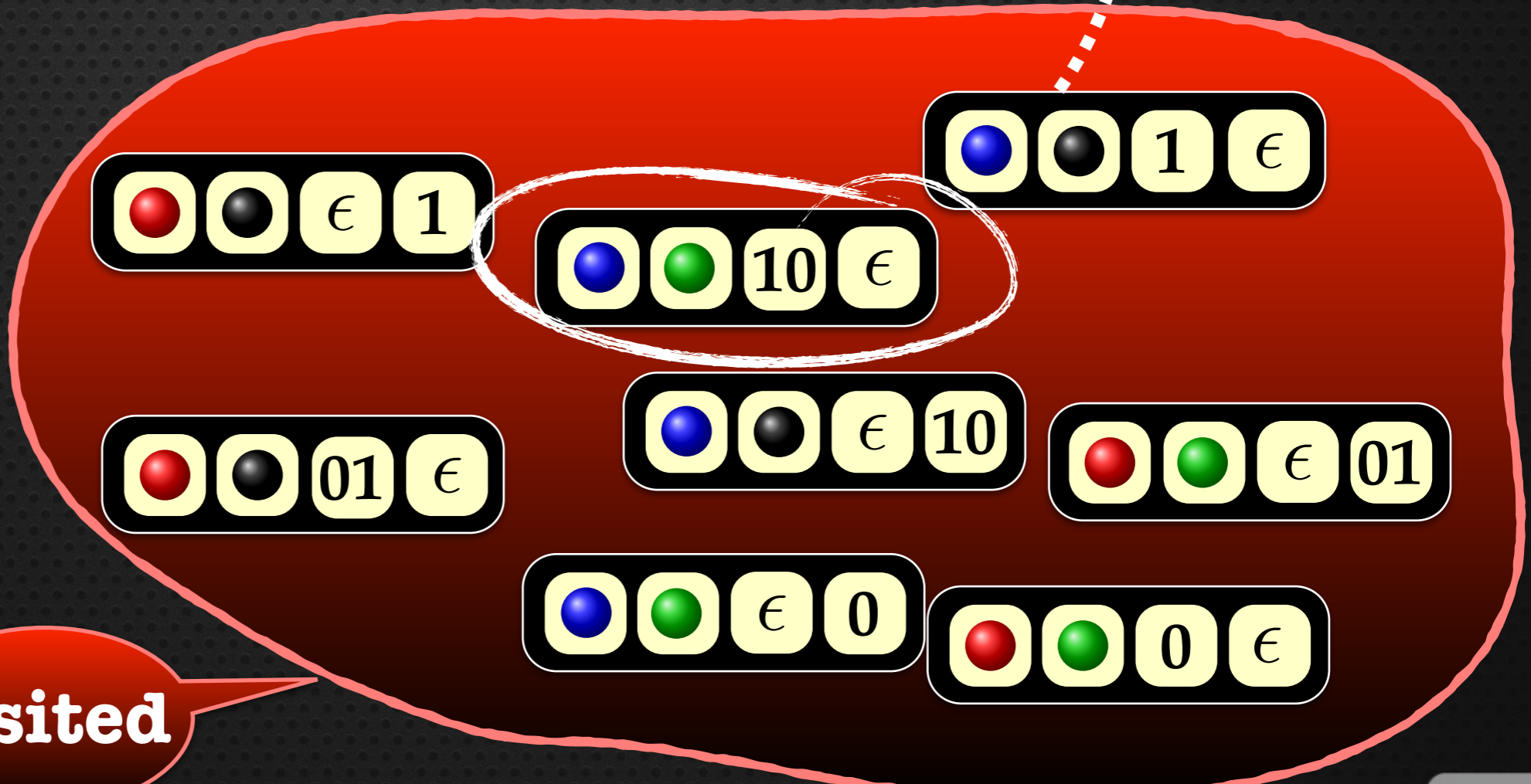


Lossy Backward Reachability

**waiting**

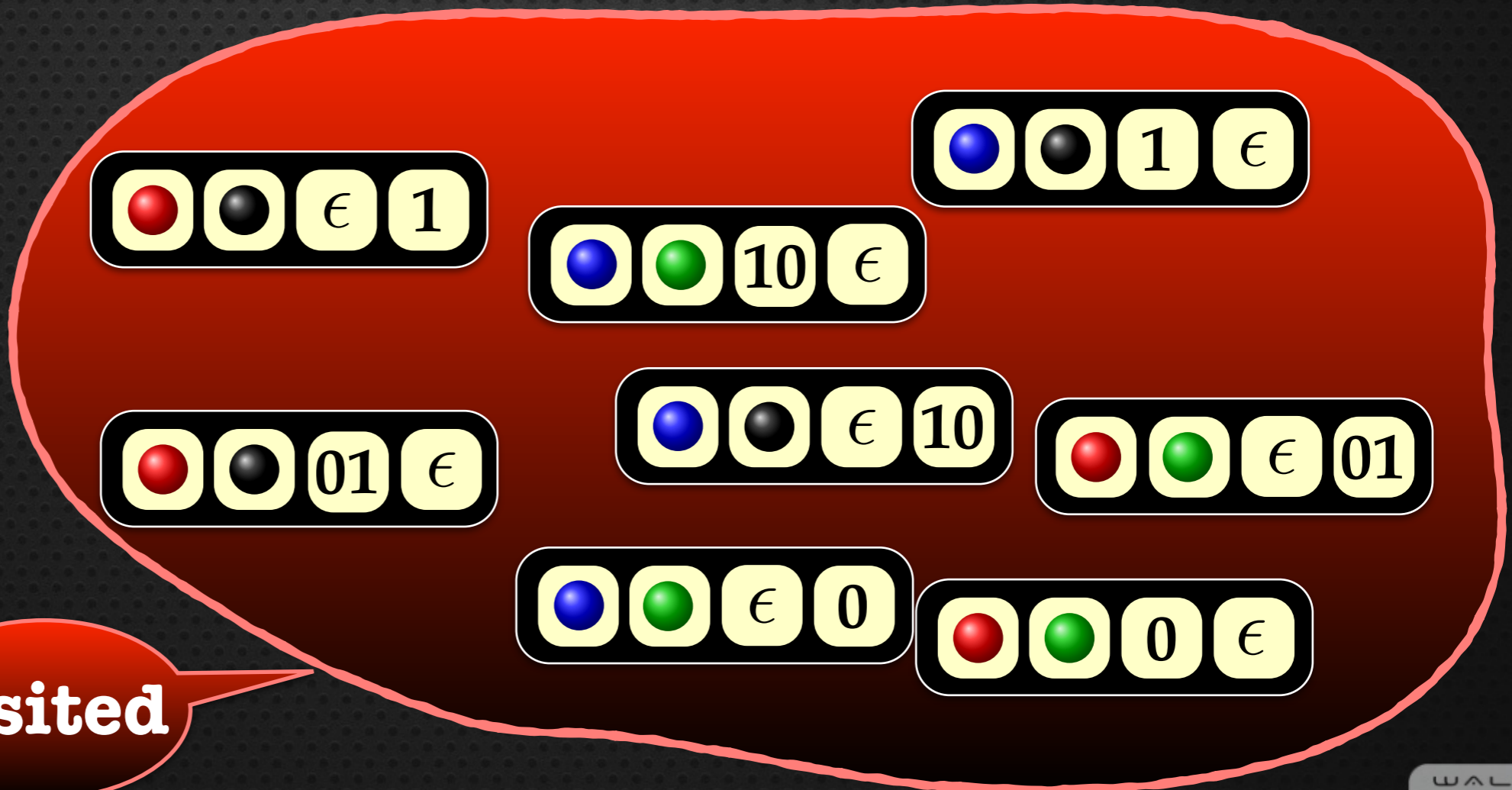
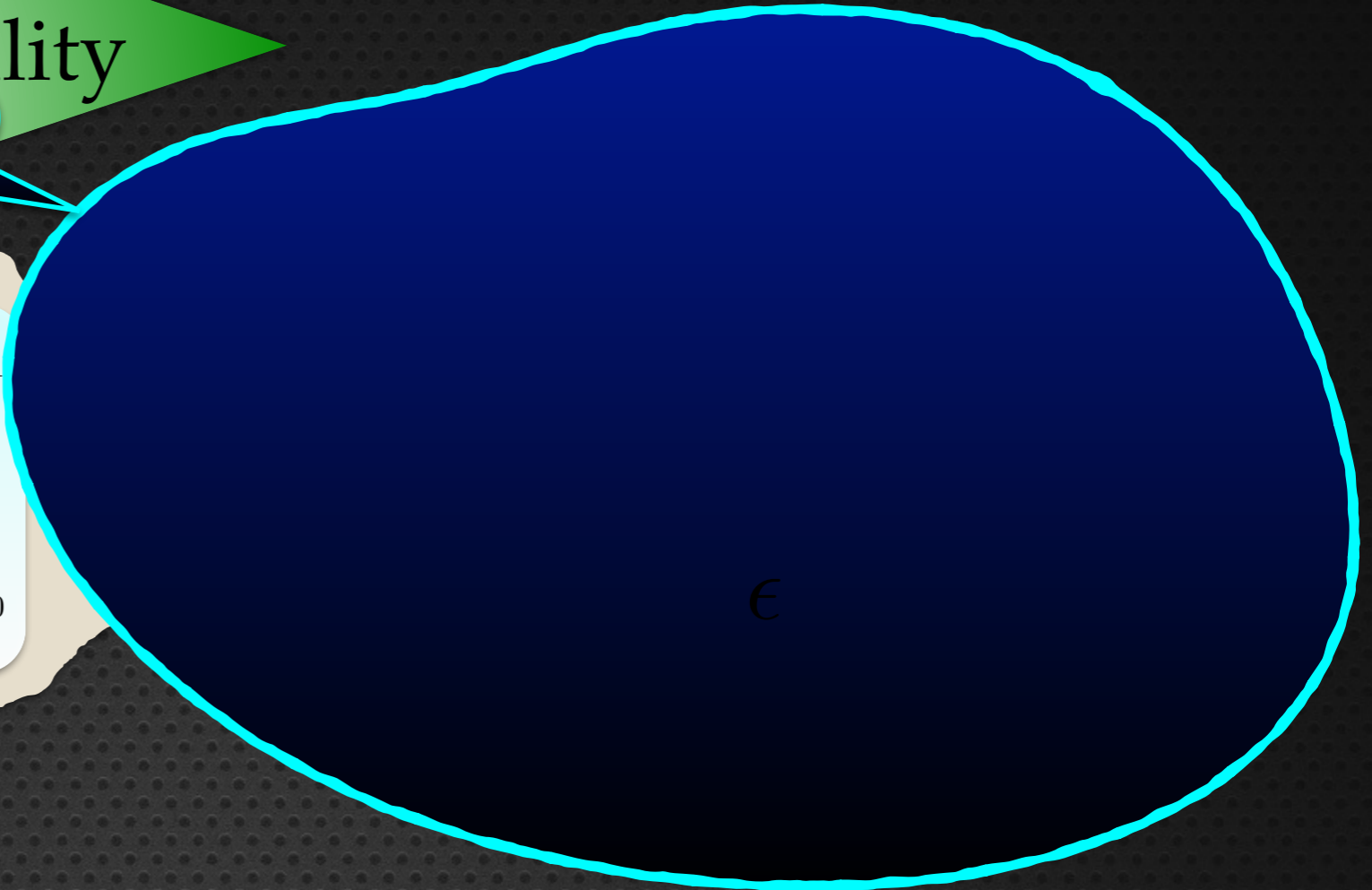


**visited**



Lossy Backward Reachability

waiting

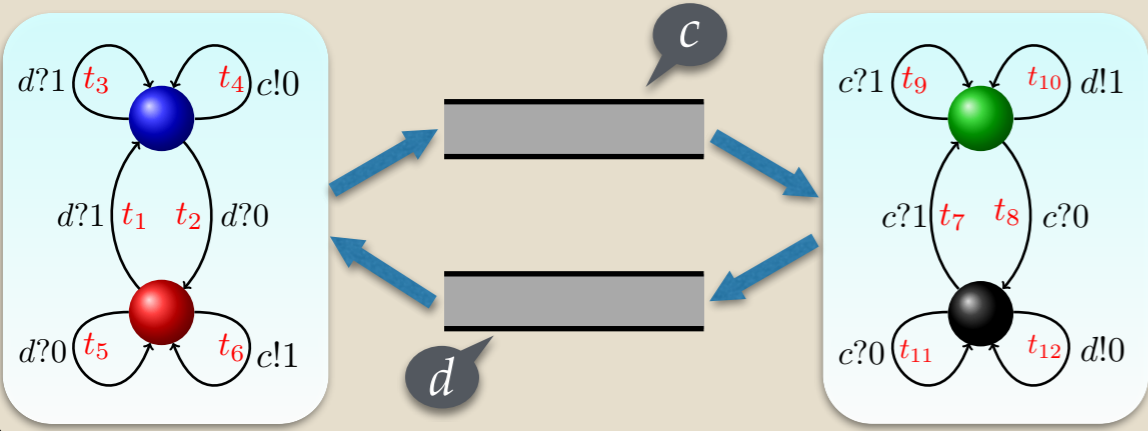


visited



# Lossy Backward Probability

**waiting**

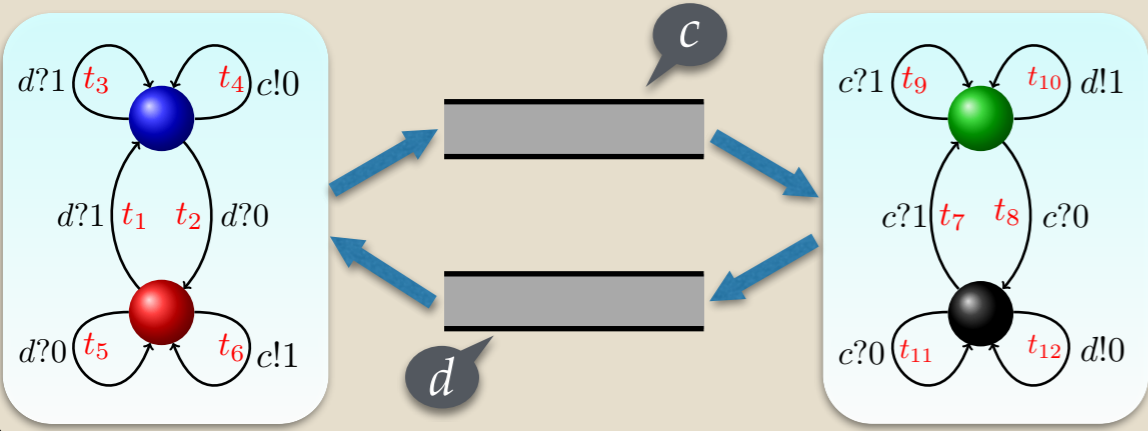


		€	0			10	€
		0	€			€	01
		€	1			01	€
		1	€			€	10



# Lossy Backward Reachability

**waiting**



● ● € 1

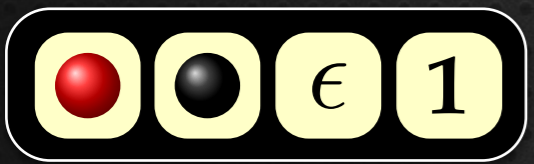
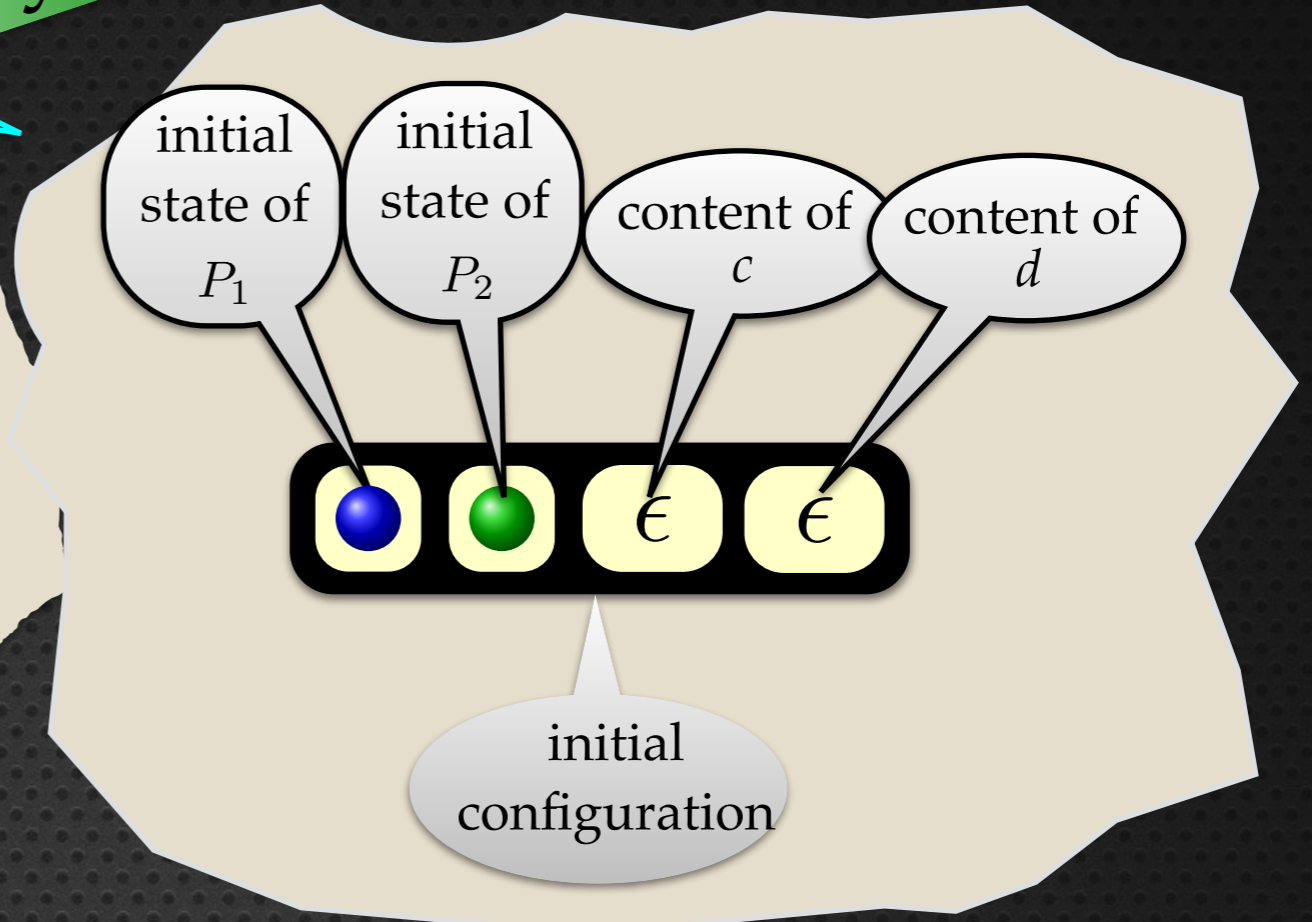
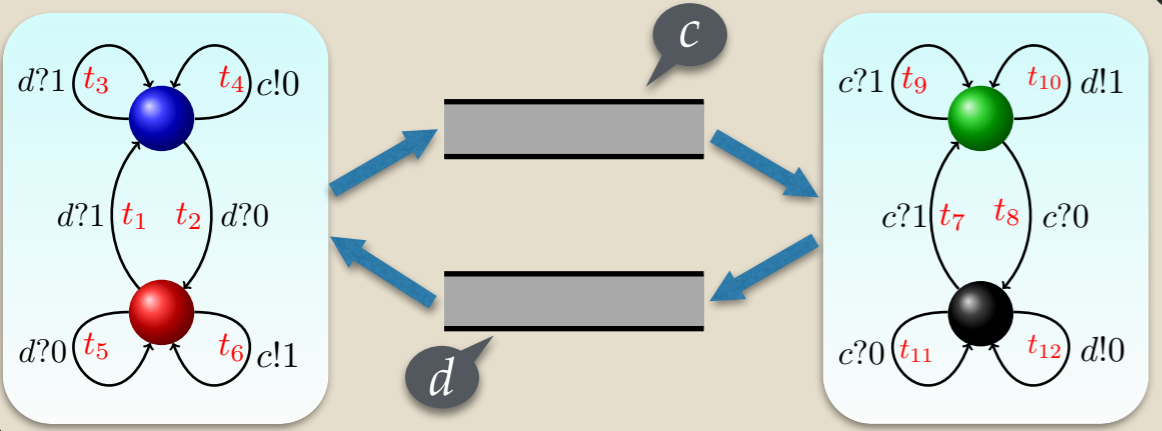
**T : target configurations**

● ● € 0	● ● 10 €
● ● 0 €	● ● € 01
● ● € 1	● ● 01 €
● ● 1 €	● ● € 10

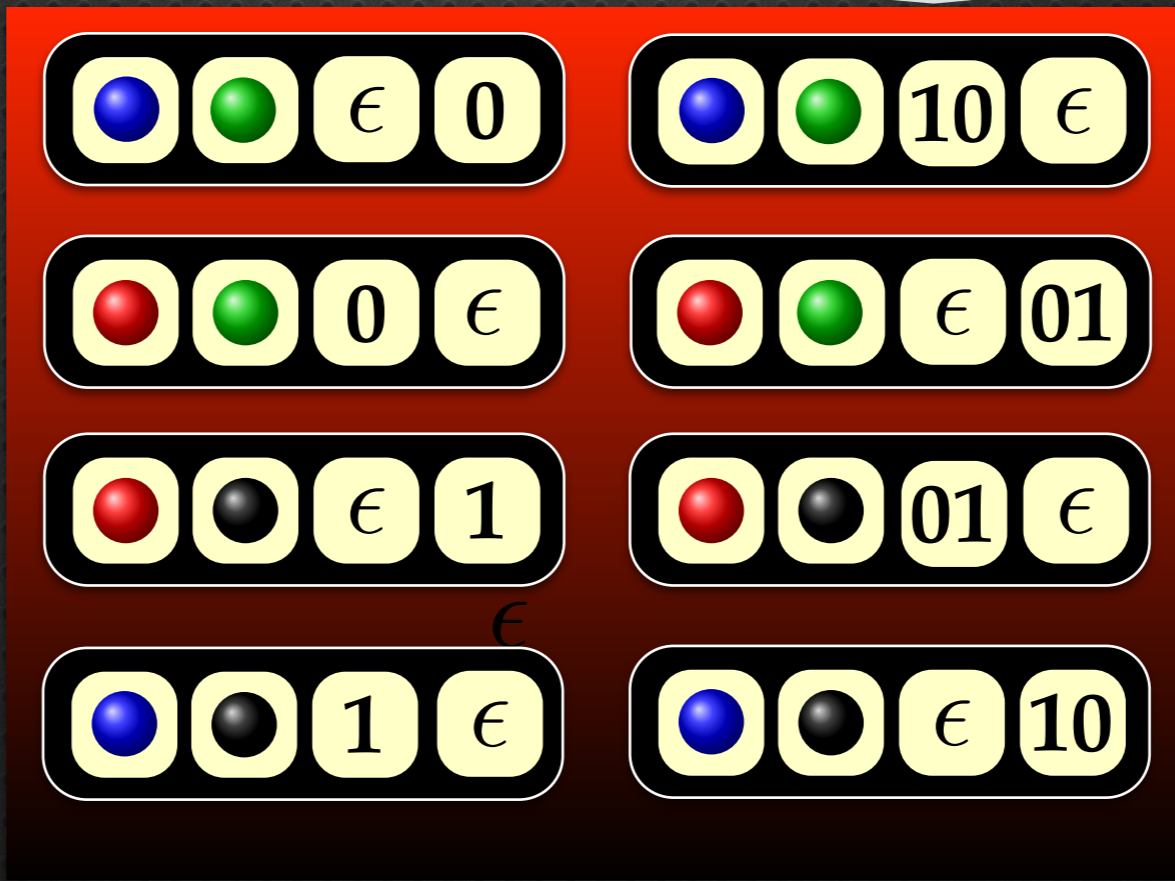


# Lossy Backward Reachability

**waiting**

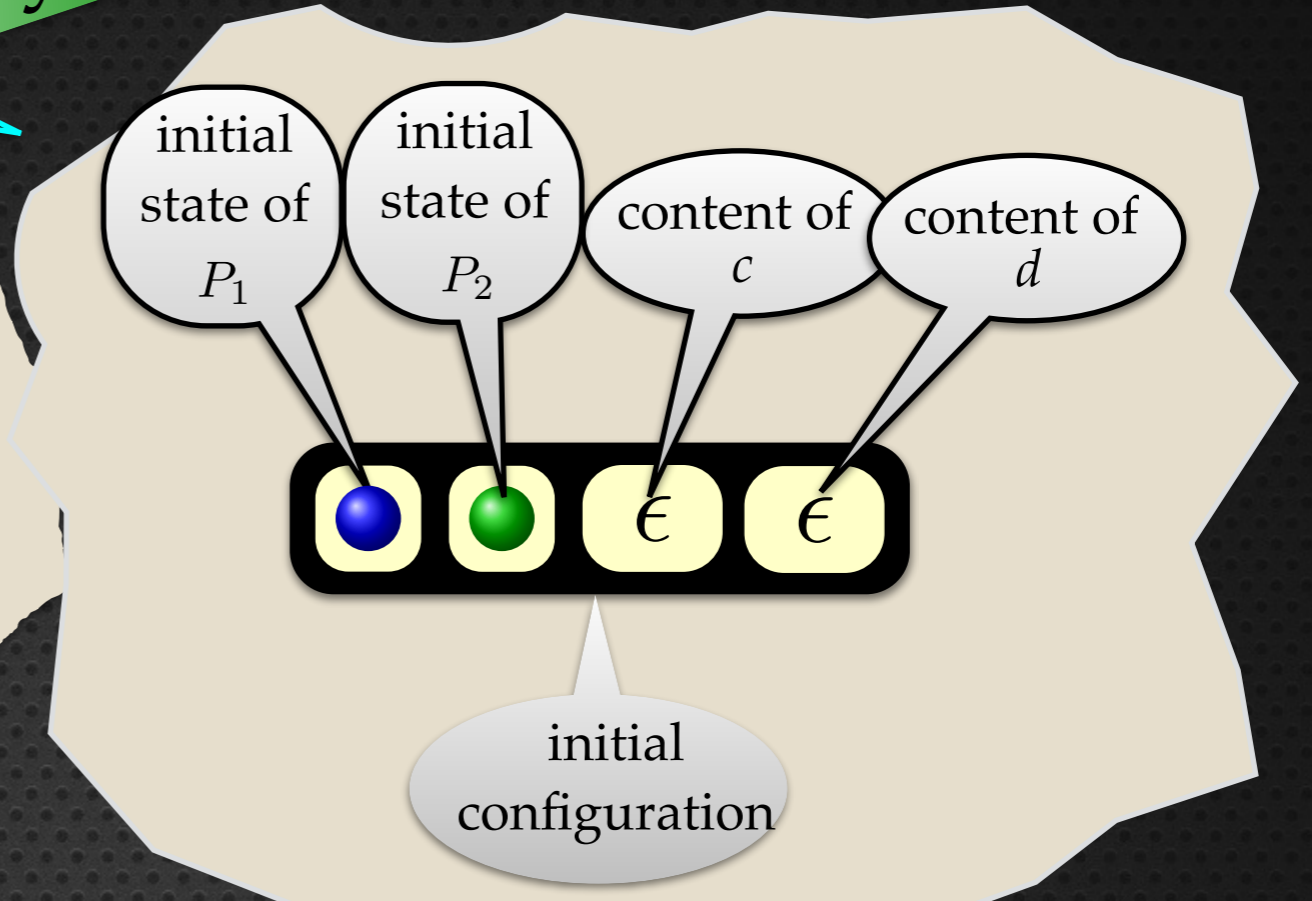
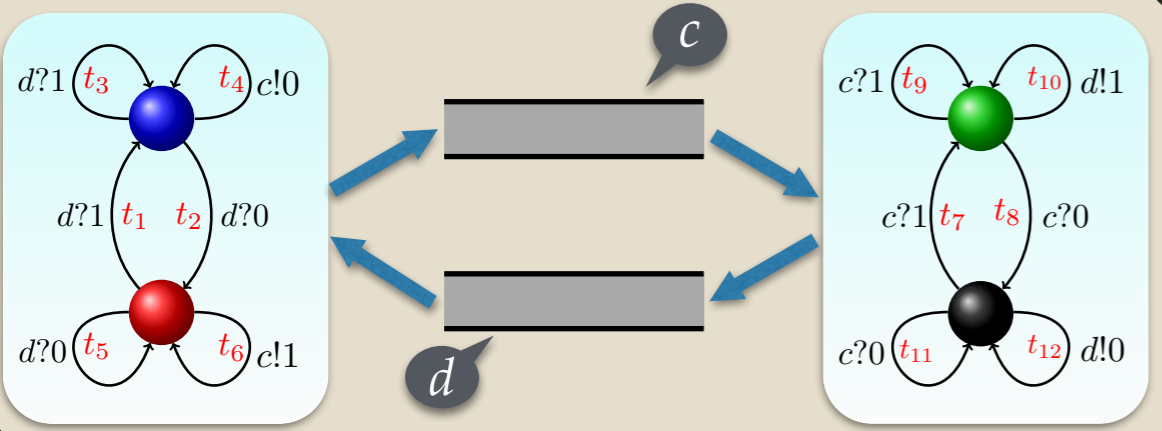


**T : target configurations**

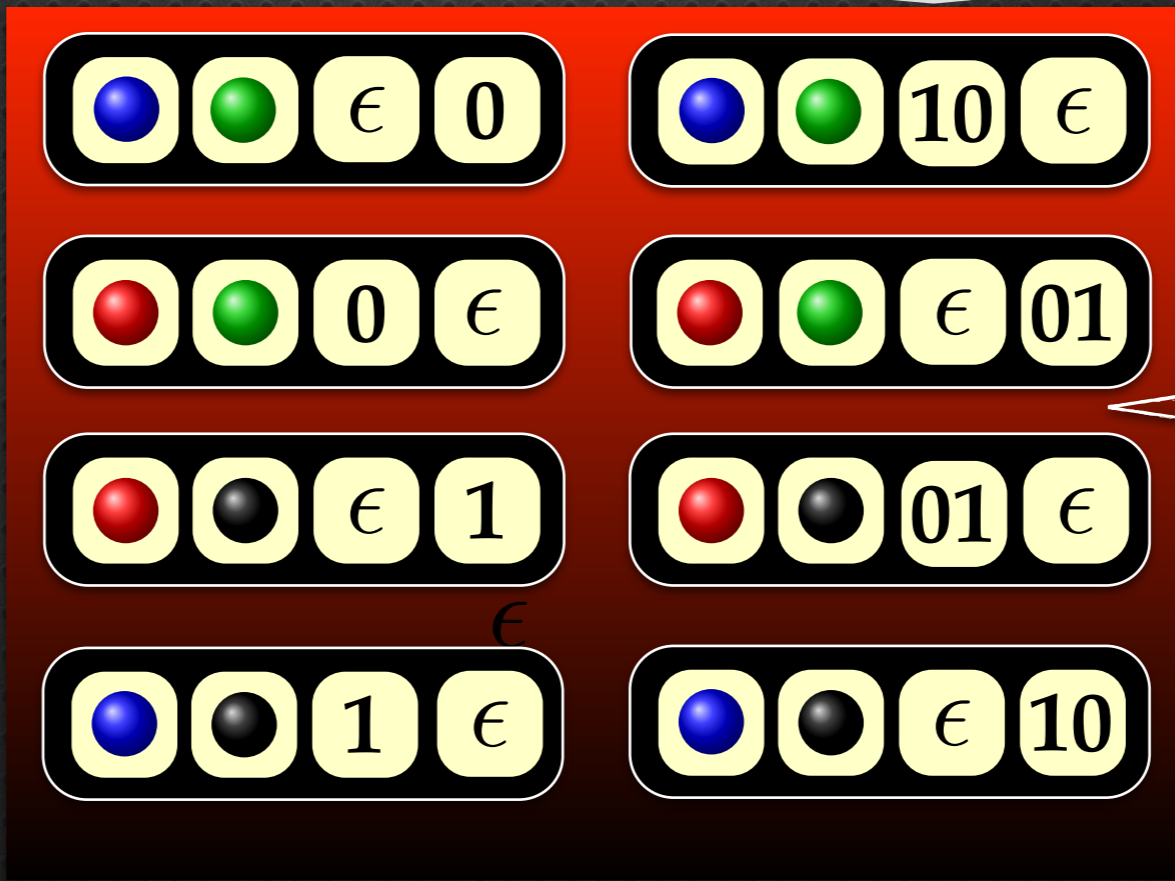


# Lossy Backward Reachability

**waiting**



**T : target configurations**

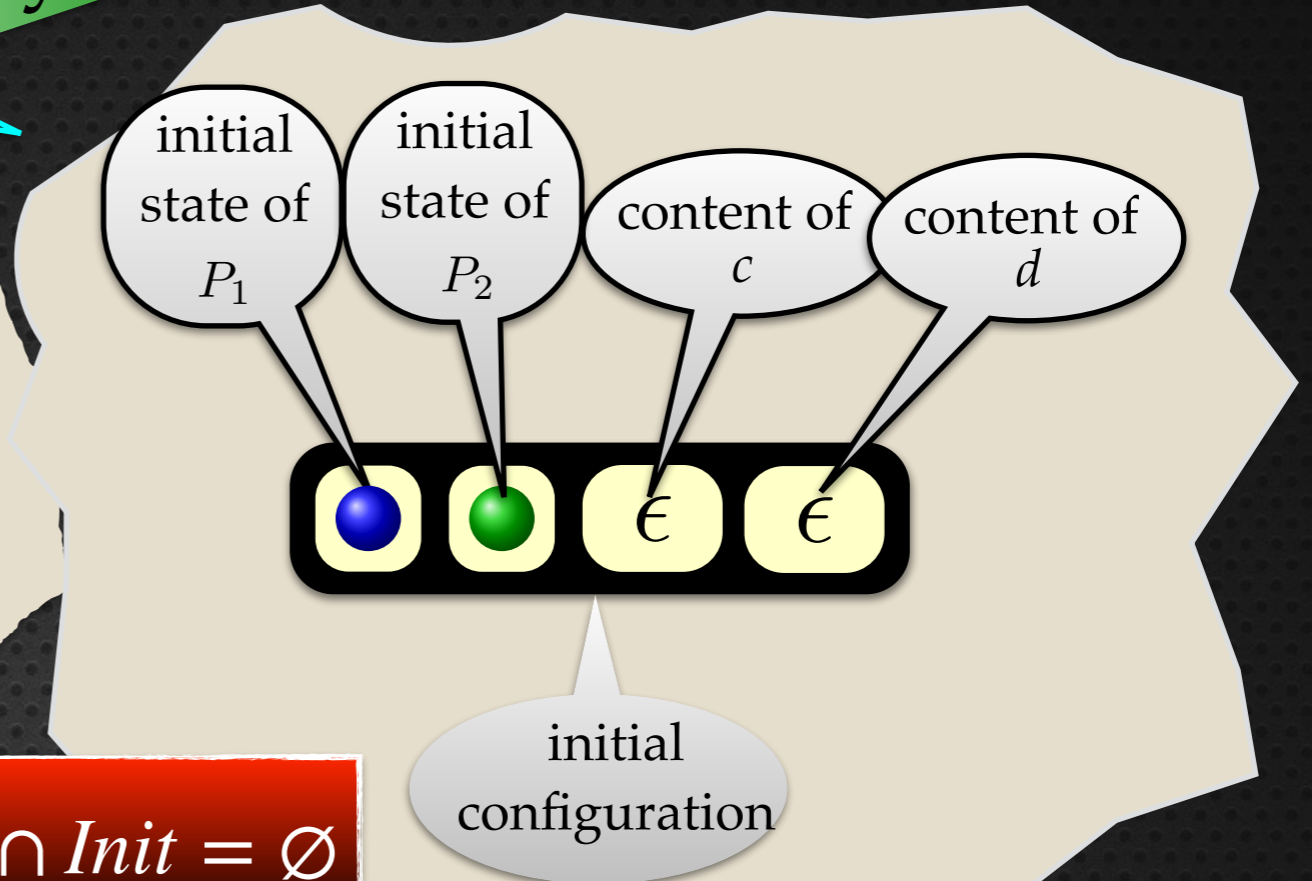
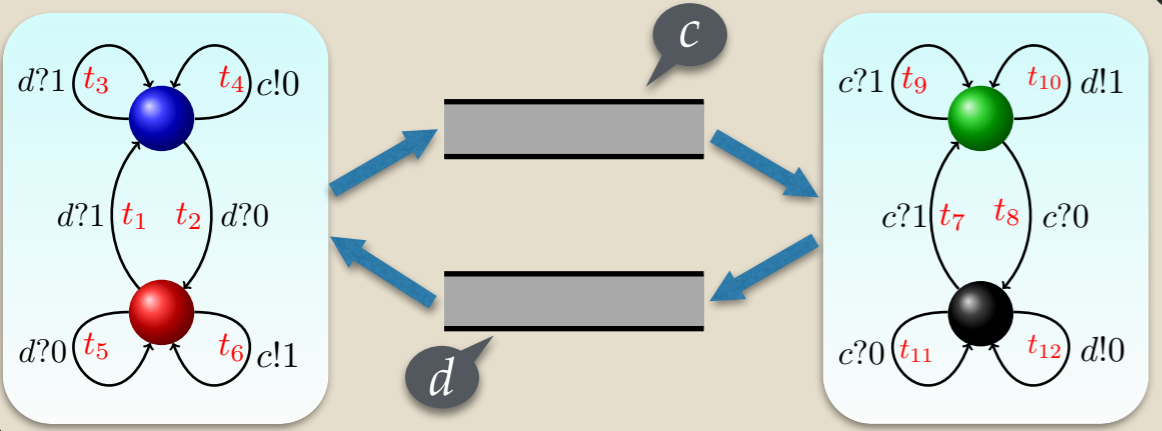


**Pre\*(T)**



# Lossy Backward Reachability

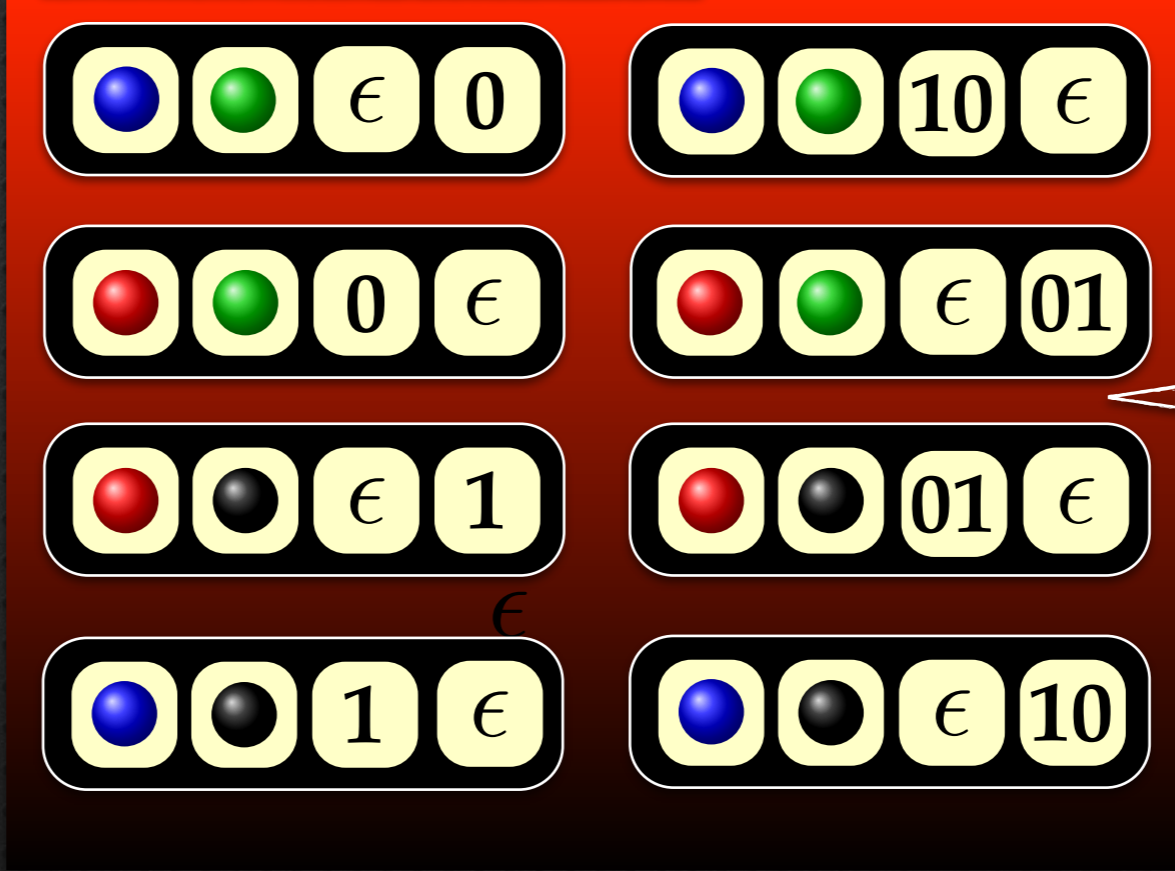
**waiting**



$$Pre^*(T) \cap Init = \emptyset$$



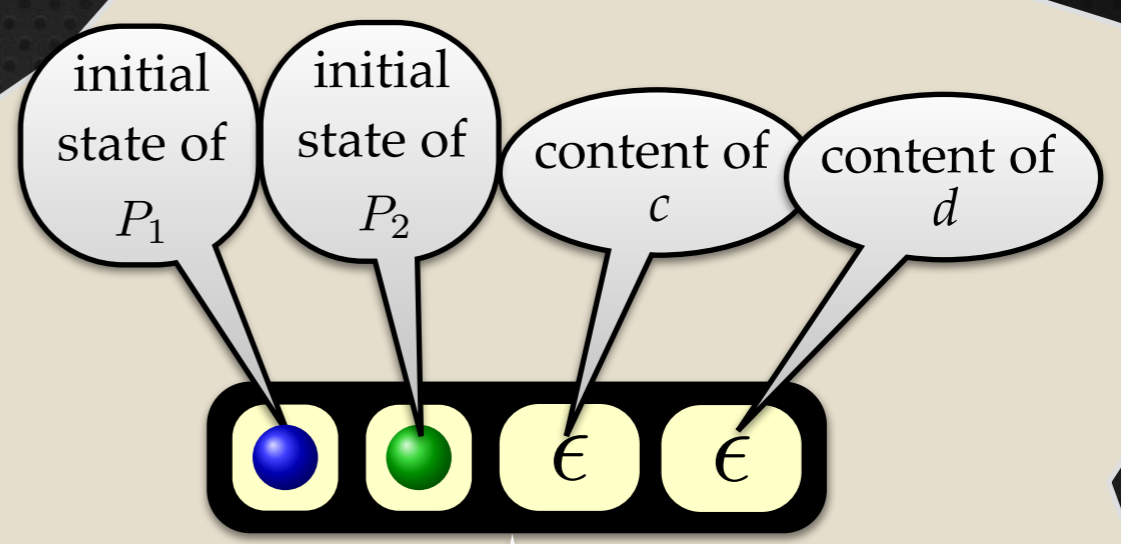
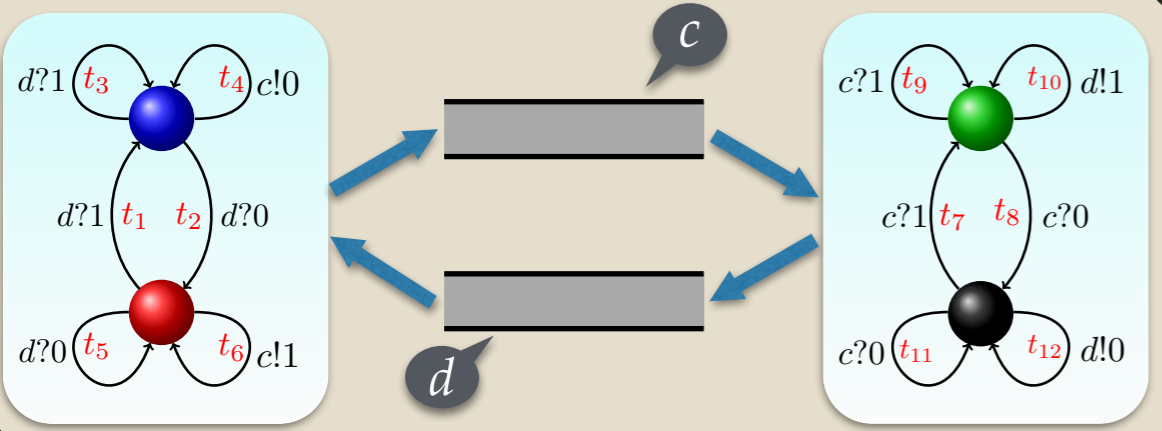
**$T$  : target configurations**



**$Pre^*(T)$**

# Lossy Backward Reachability

**waiting**

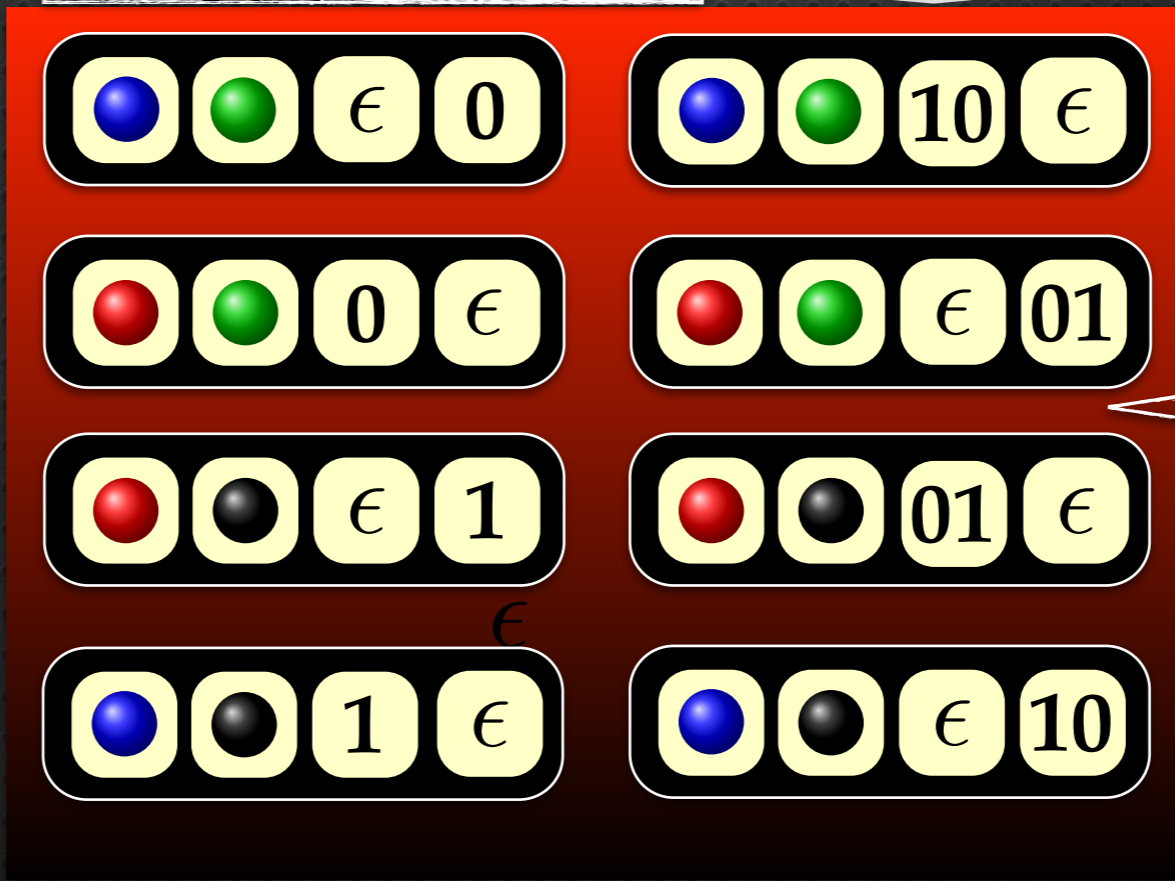


$$Pre^*(T) \cap Init = \emptyset$$

**“target configurations not reachable from initial configuration”**



**T : target configurations**



**Pre\*(T)**



## Well Quasi-Ordering

infinite sequence of words

$w_0, w_1, w_2, \dots, w_i, \dots, w_j, \dots$

$$\exists i < j : w_i \sqsubseteq w_j$$

## Well Quasi-Ordering

infinite sequence of words

$w_0, w_1, w_2, \dots, w_i, \dots, w_j, \dots$

$\sqsubseteq$

$$\exists i < j : w_i \sqsubseteq w_j$$



# Loss Well Quasi-Ordering

## Well Quasi-Ordering

infinite sequence of words

$w_0, w_1, w_2, \dots, w_i, \dots, w_j, \dots$

$\sqsubseteq$

$$\exists i < j : w_i \sqsubseteq w_j$$

## Well Quasi-Ordering

infinite sequence of configurations

$c_0, c_1, c_2, \dots, c_i, \dots, c_j, \dots$

$$\exists i < j : c_i \sqsubseteq c_j$$

## Well Quasi-Ordering

infinite sequence of words

$w_0, w_1, w_2, \dots, w_i, \dots, w_j, \dots$

$\sqsubseteq$

$$\exists i < j : w_i \sqsubseteq w_j$$

## Well Quasi-Ordering

infinite sequence of configurations

$c_0, c_1, c_2, \dots, c_i, \dots, c_j, \dots$

$\sqsubseteq$

$$\exists i < j : c_i \sqsubseteq c_j$$



# Lossy Channel Systems

## Ordering:

- monotonicity
- computing predecessors
- well quasi-ordering