Beaconless Geocast Protocols are Interesting, Even in 1D

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Maarten Löffler, Tobias Müller,
Vera Sacristán, Rodrigo I. Silveira

Beaconless Geocast Routing

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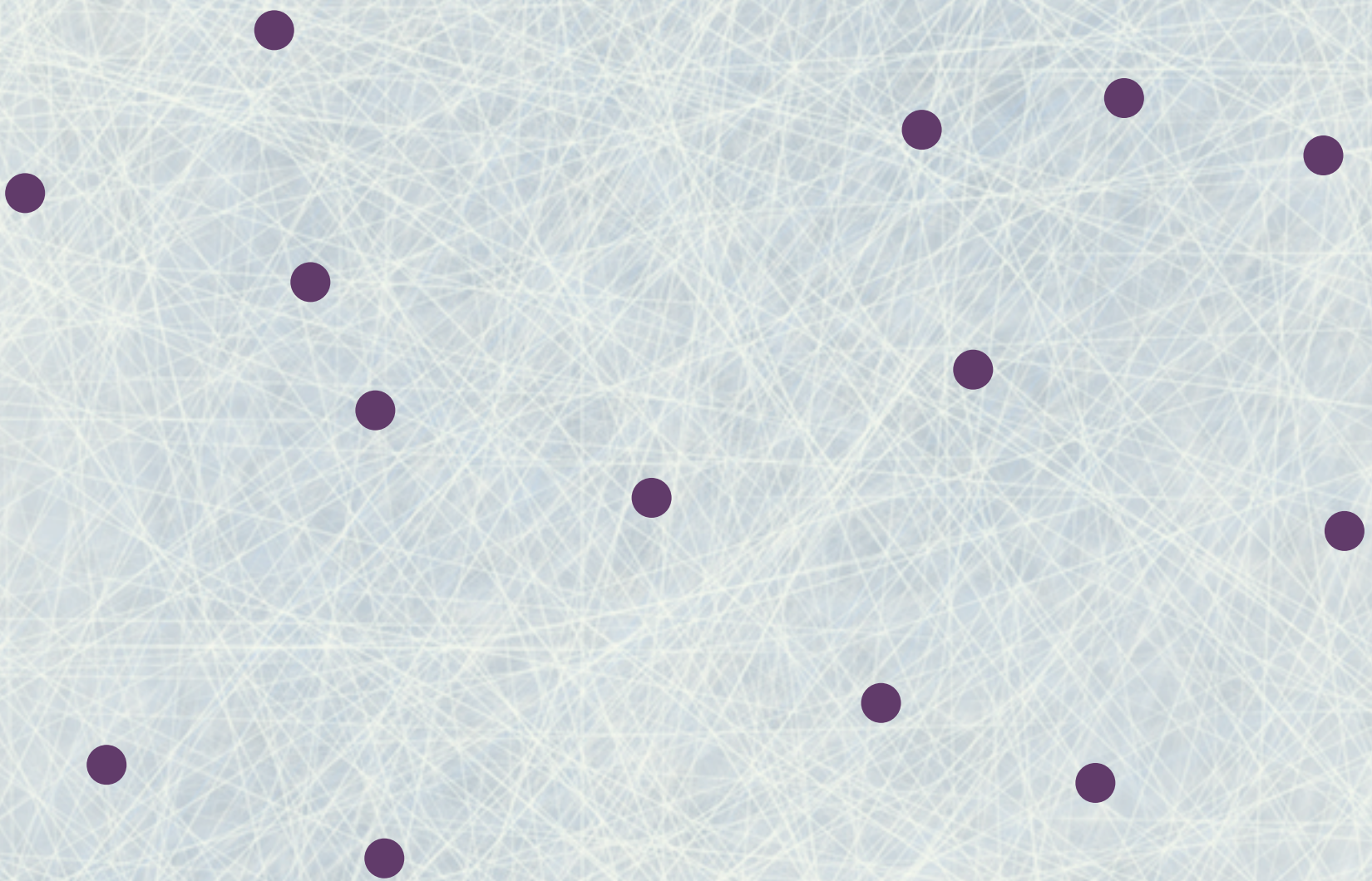

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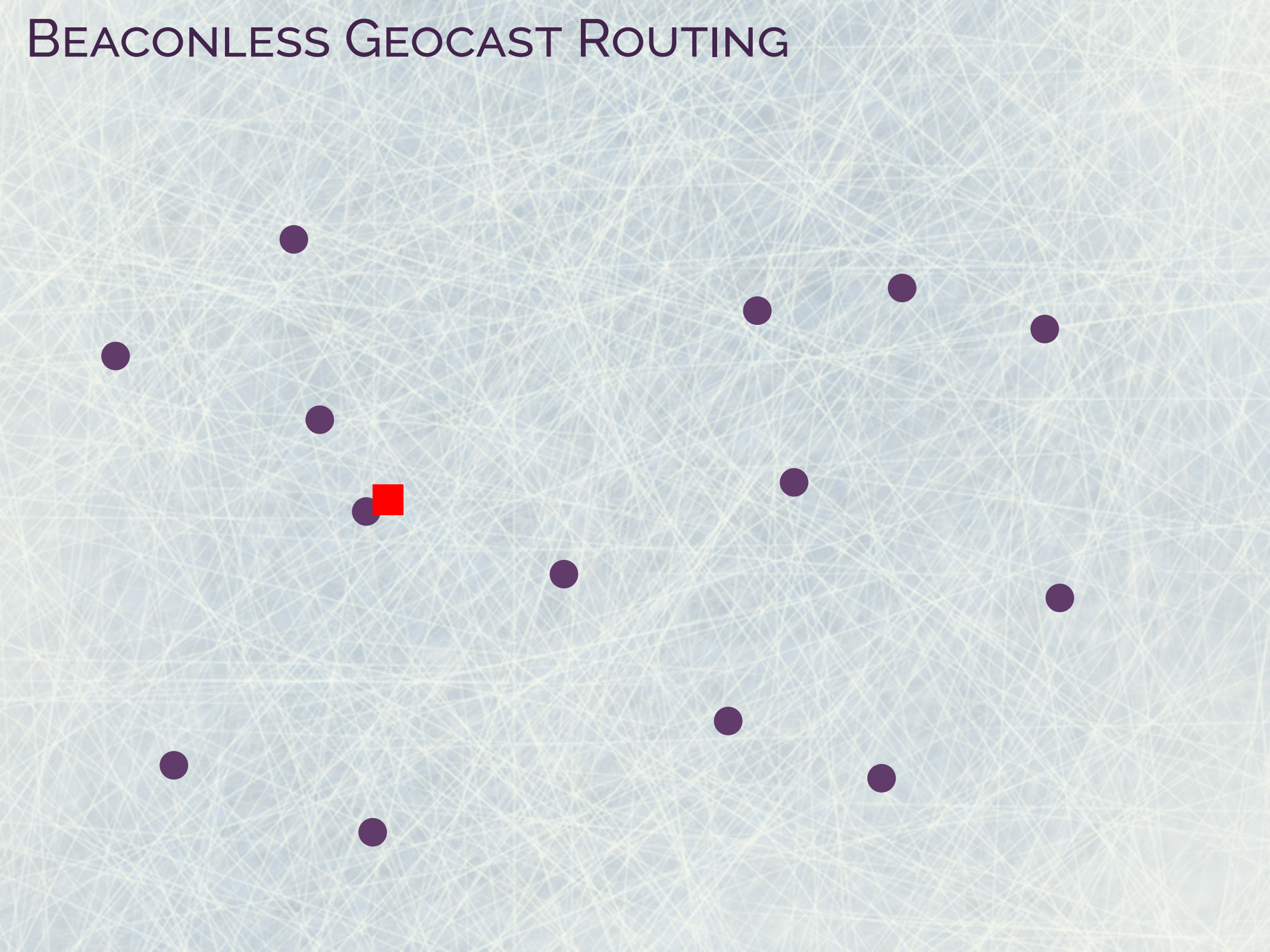

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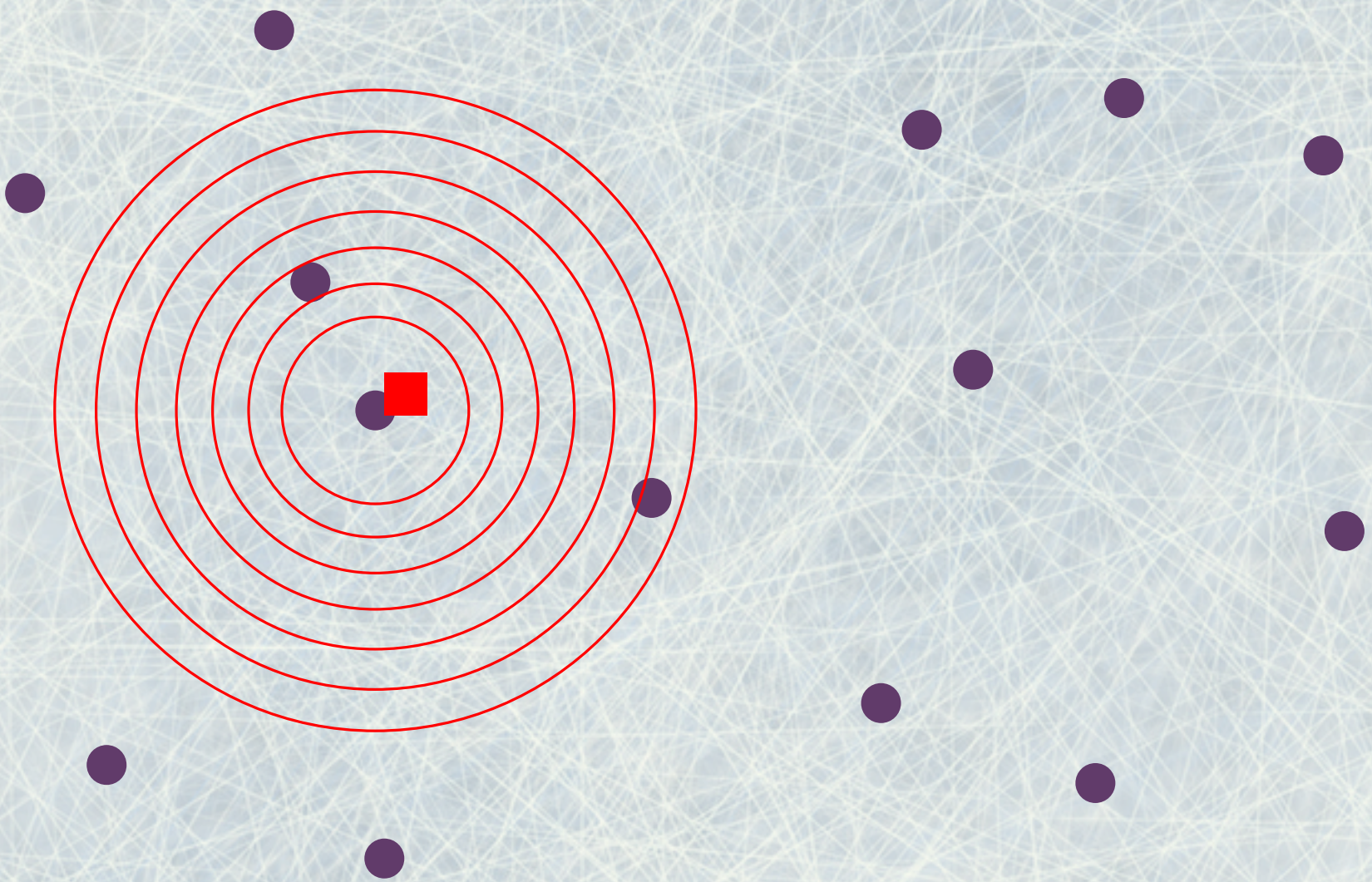

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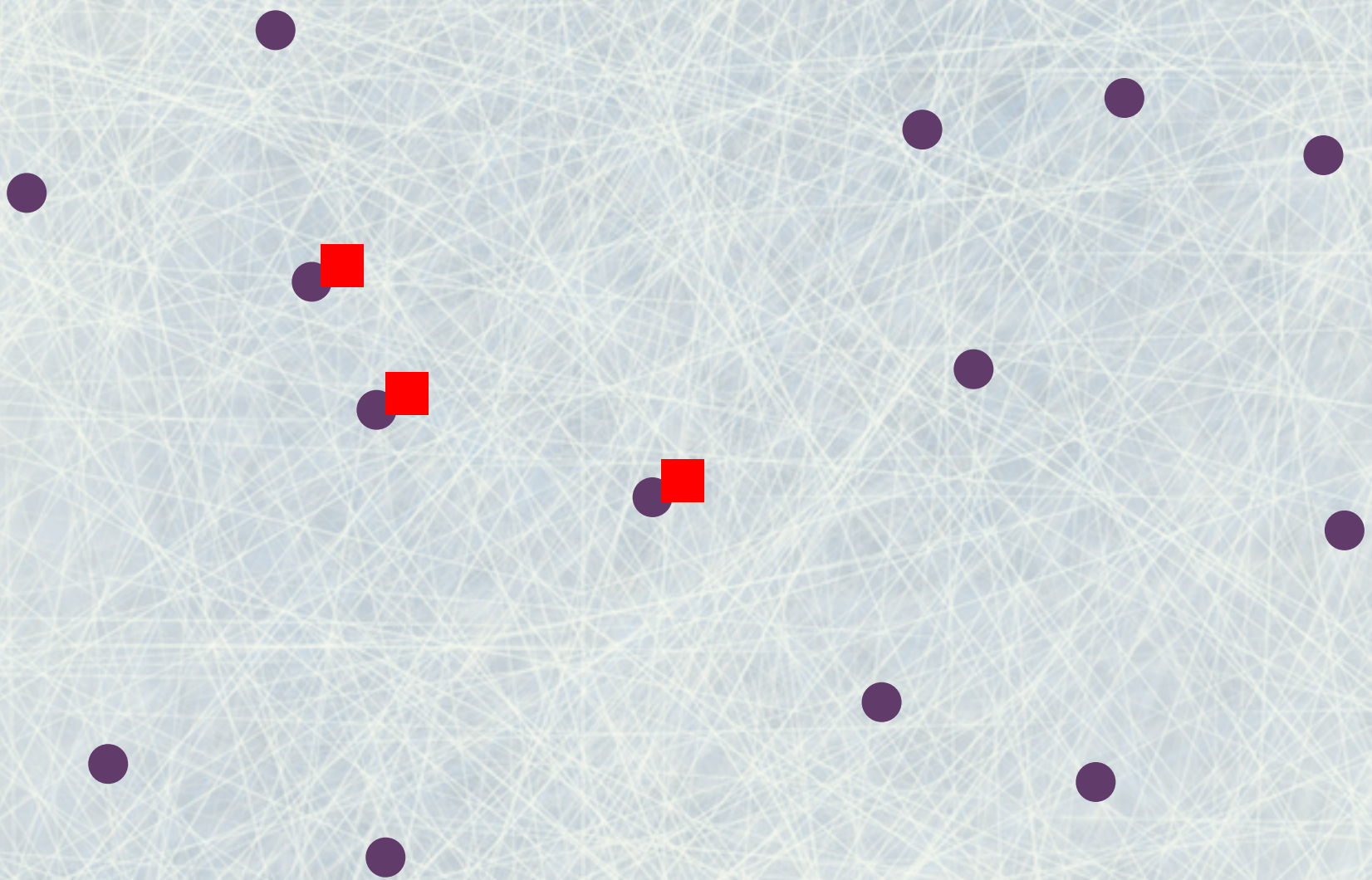

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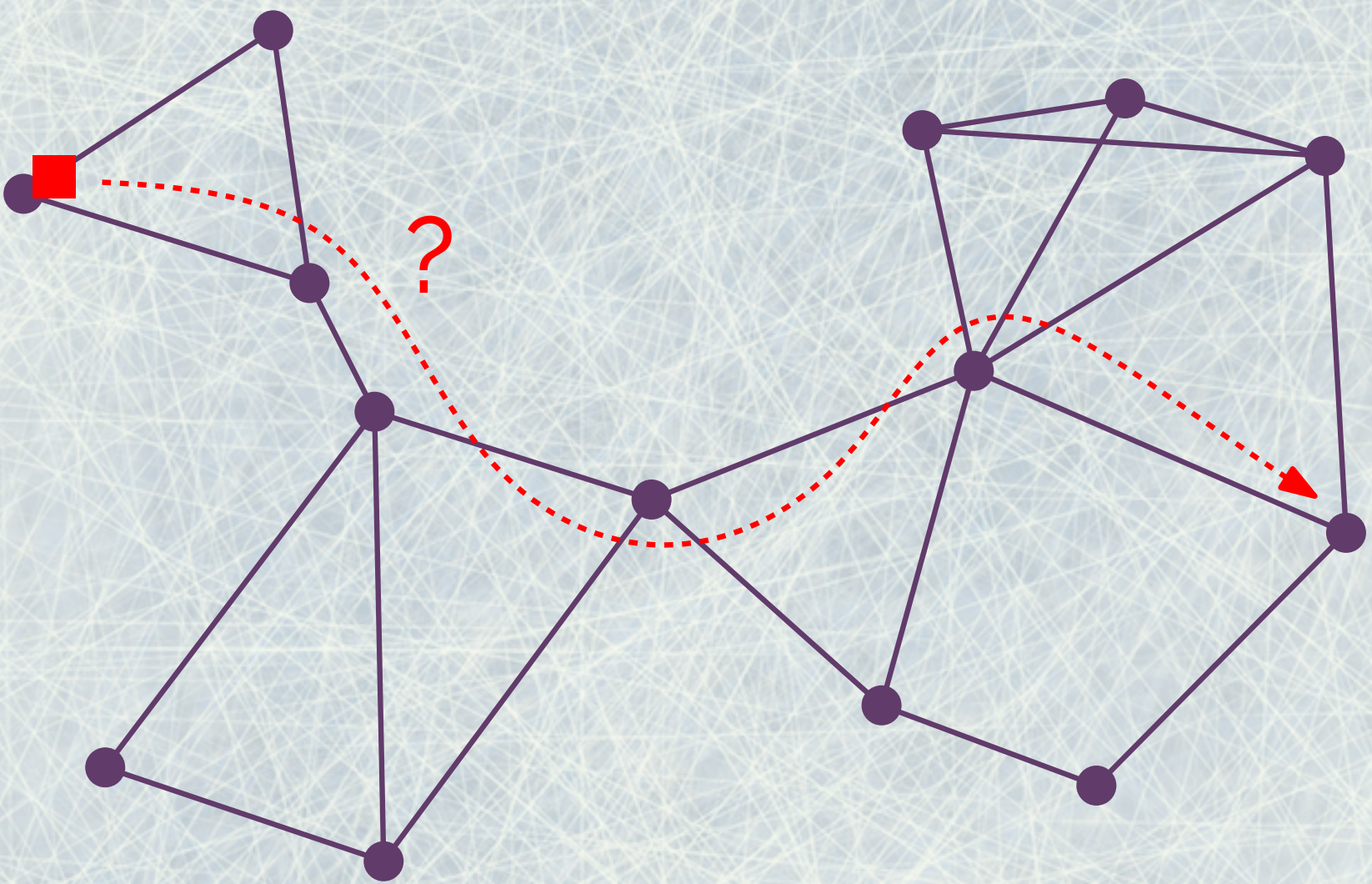

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But remember: nodes do not know the graph structure!

Beaconless Geocast Protocols

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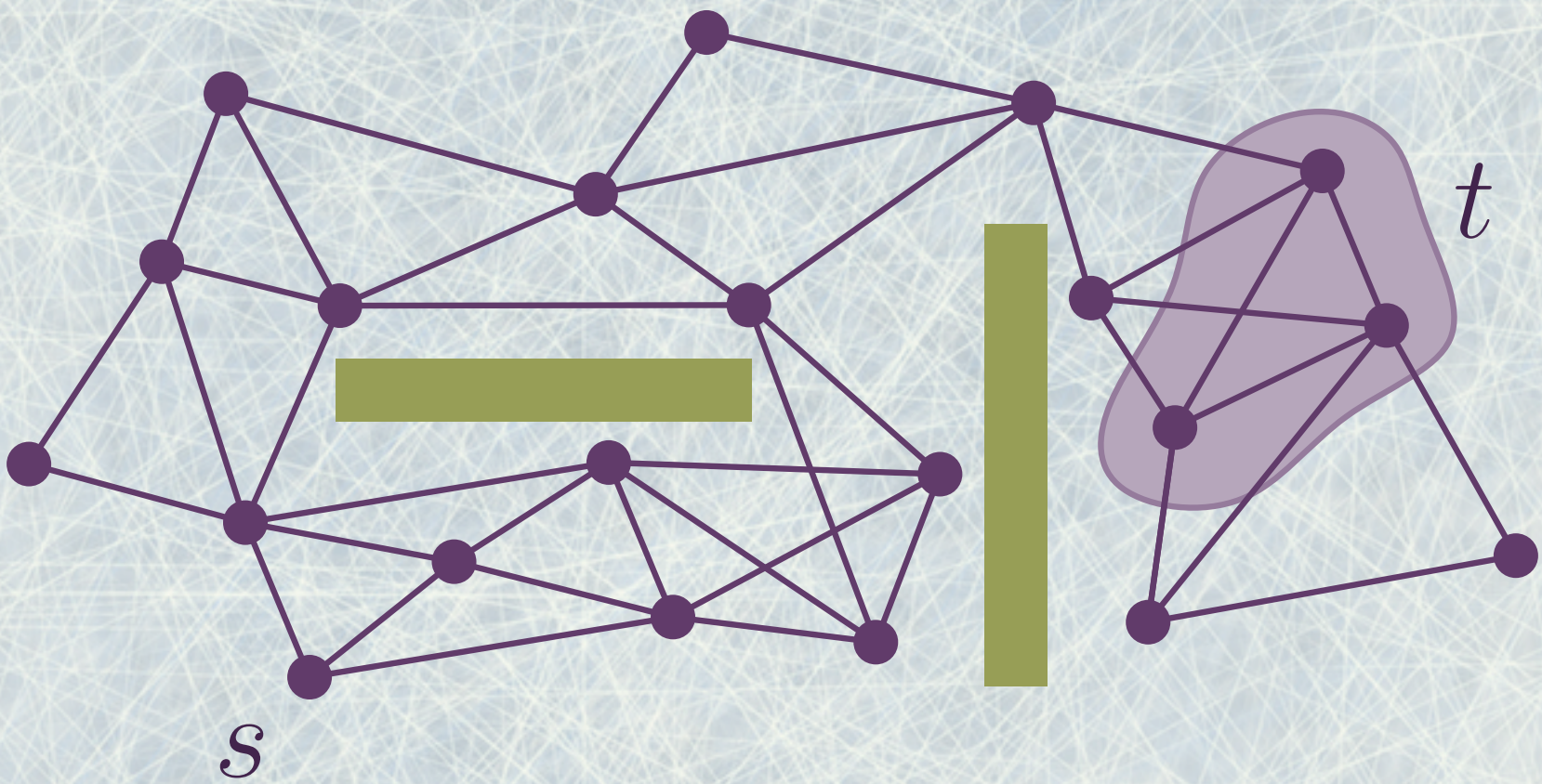

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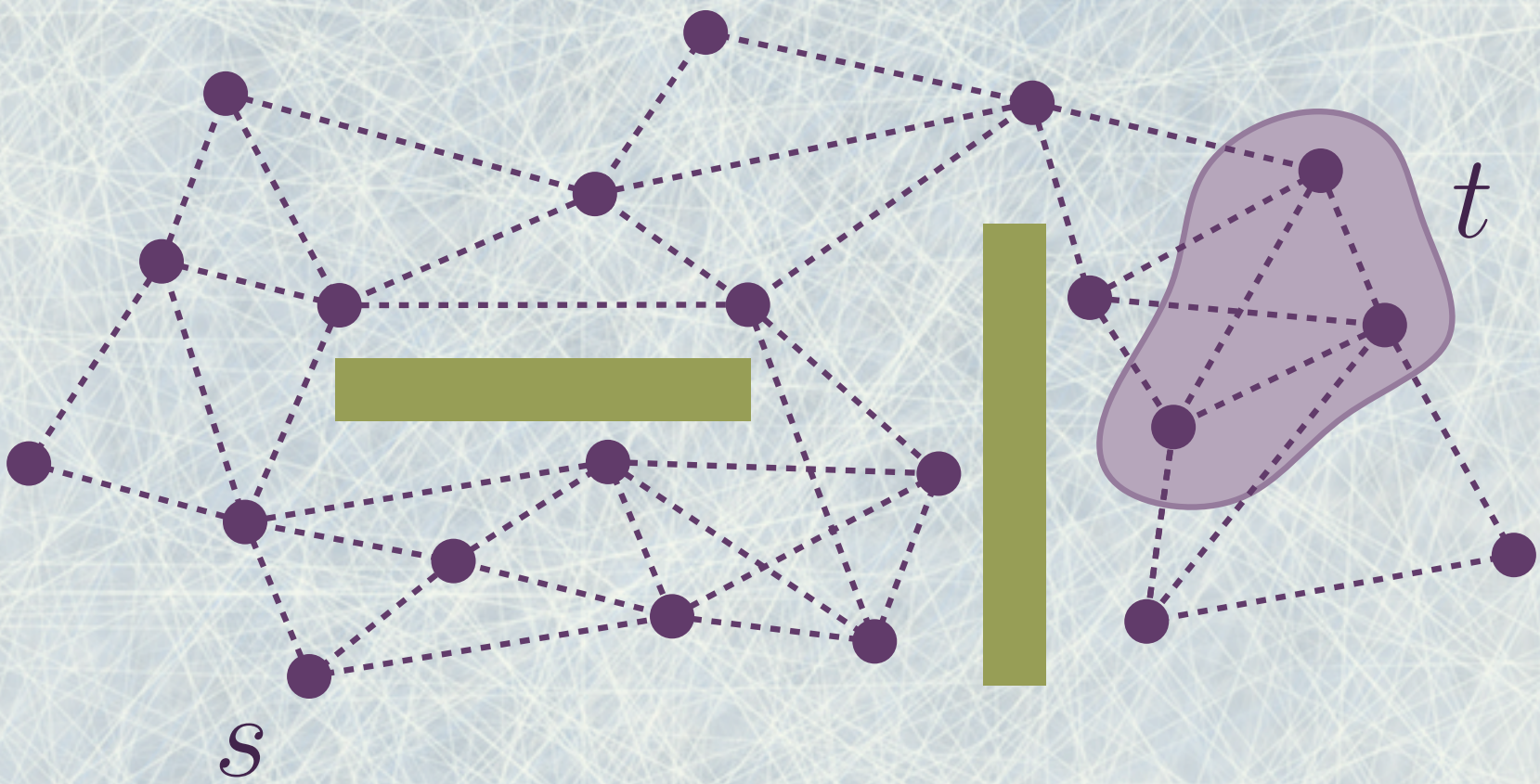

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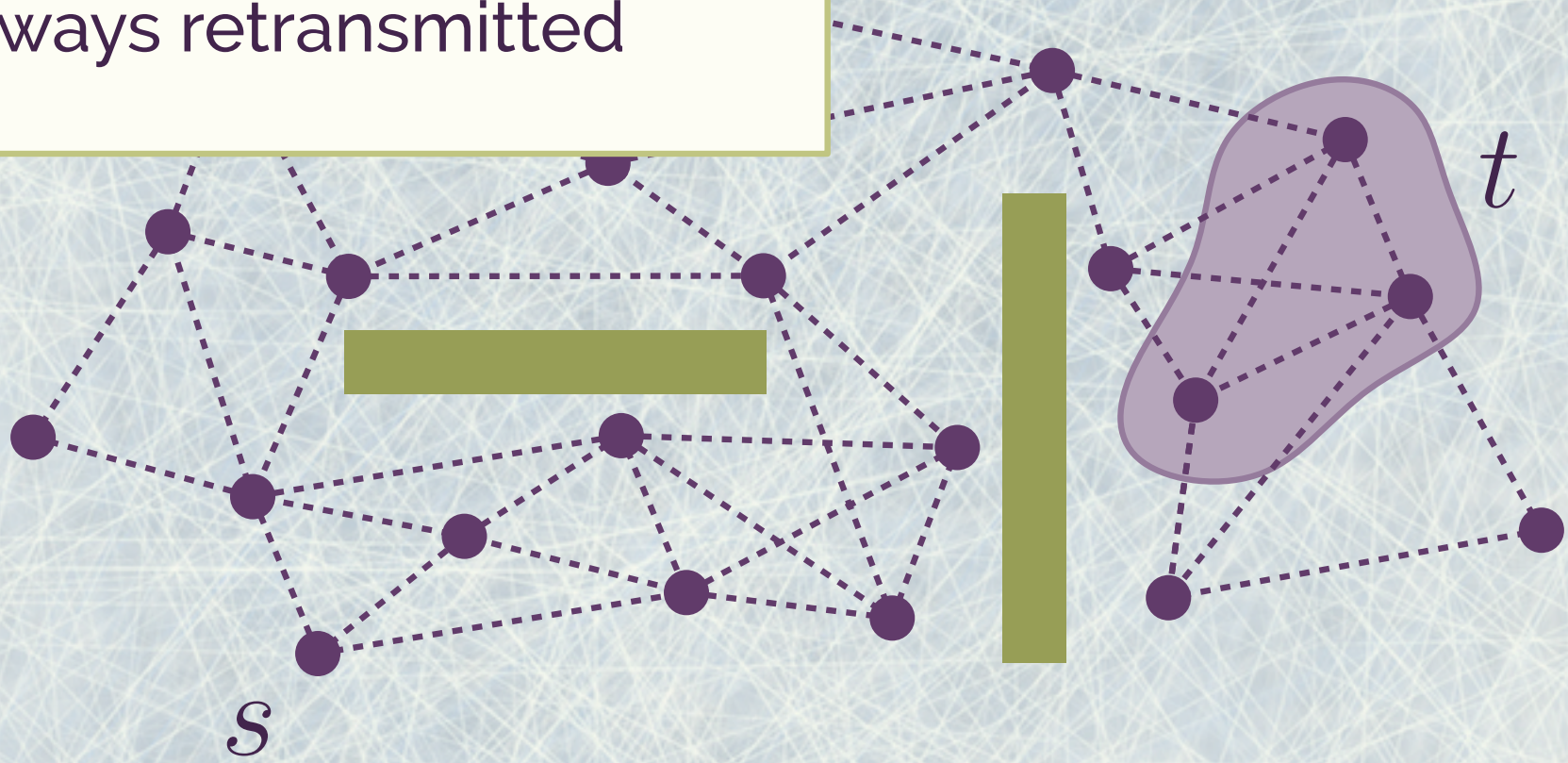
Simple flooding: all incoming packets are always retransmitted



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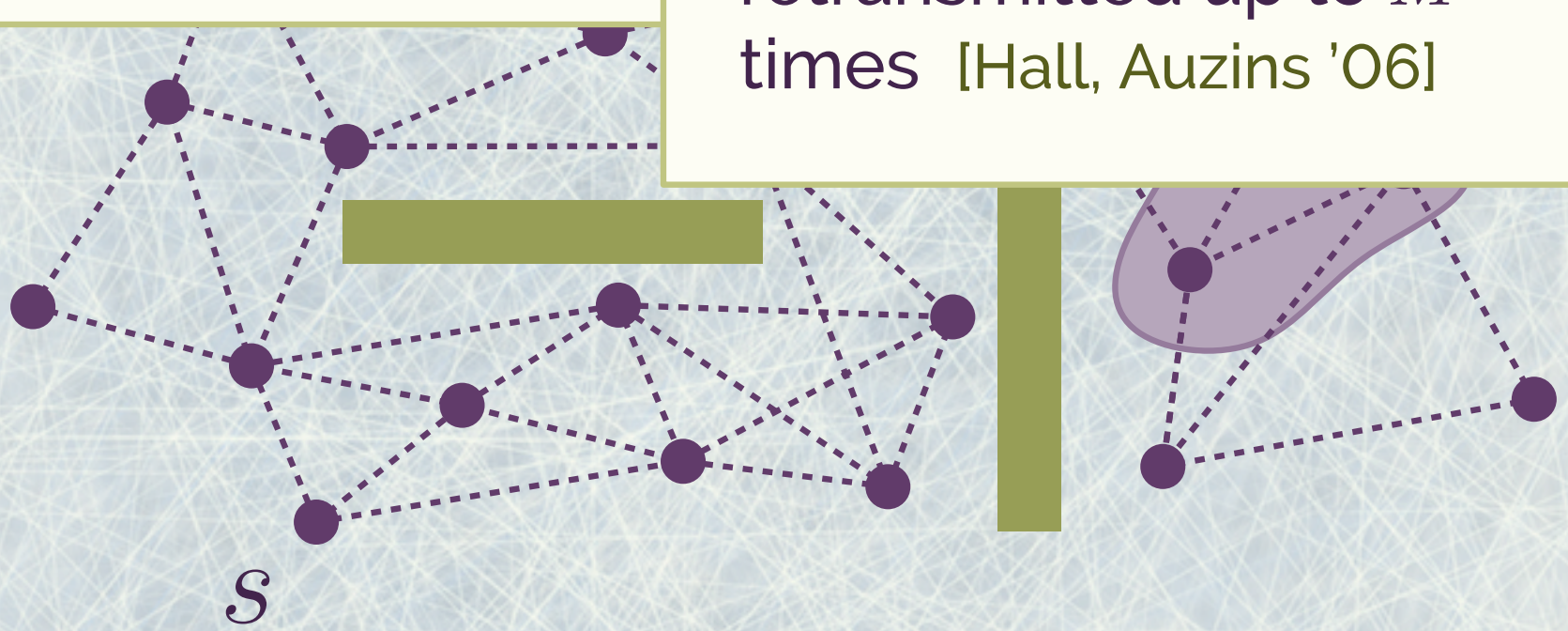

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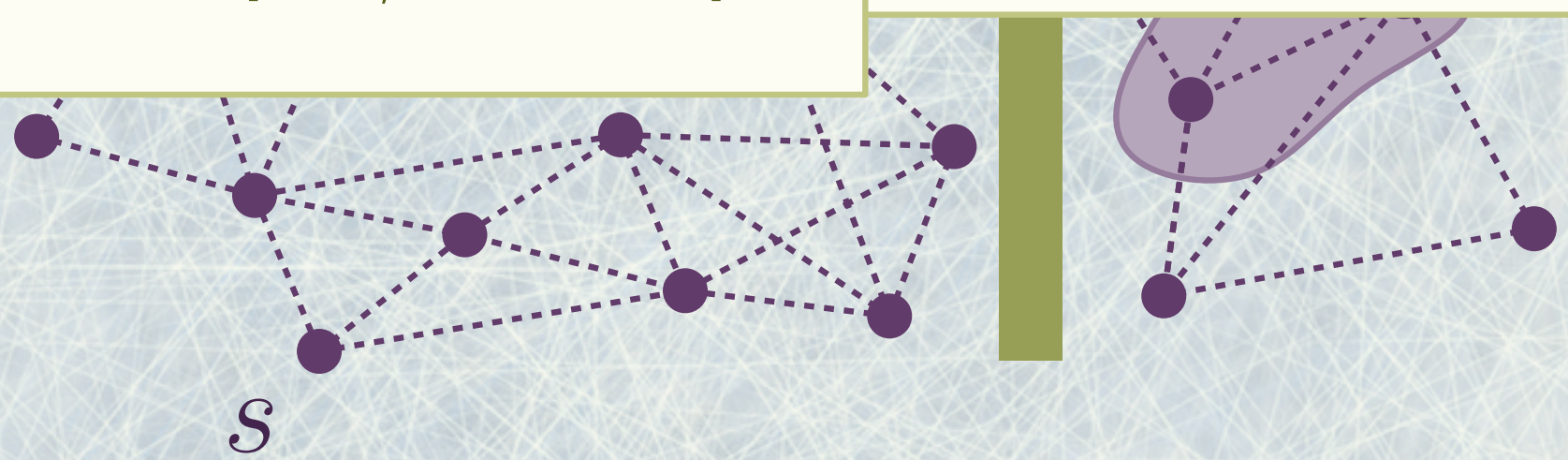

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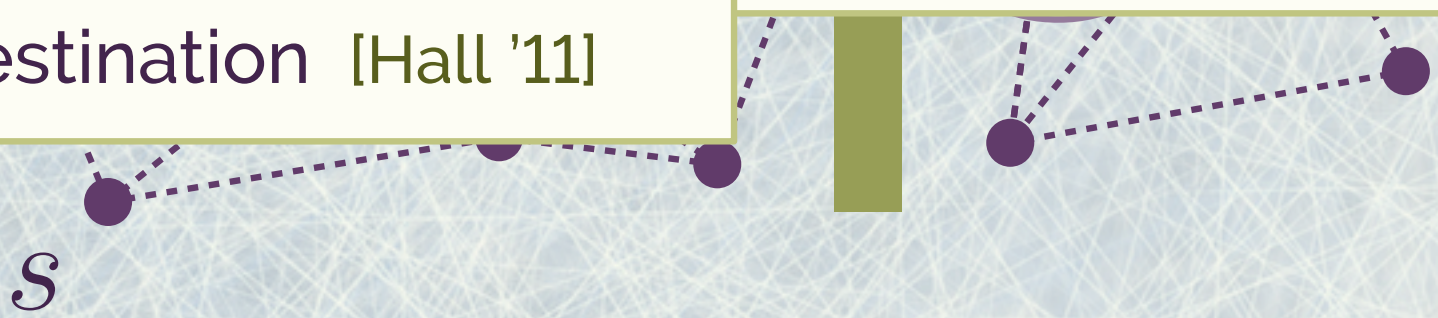

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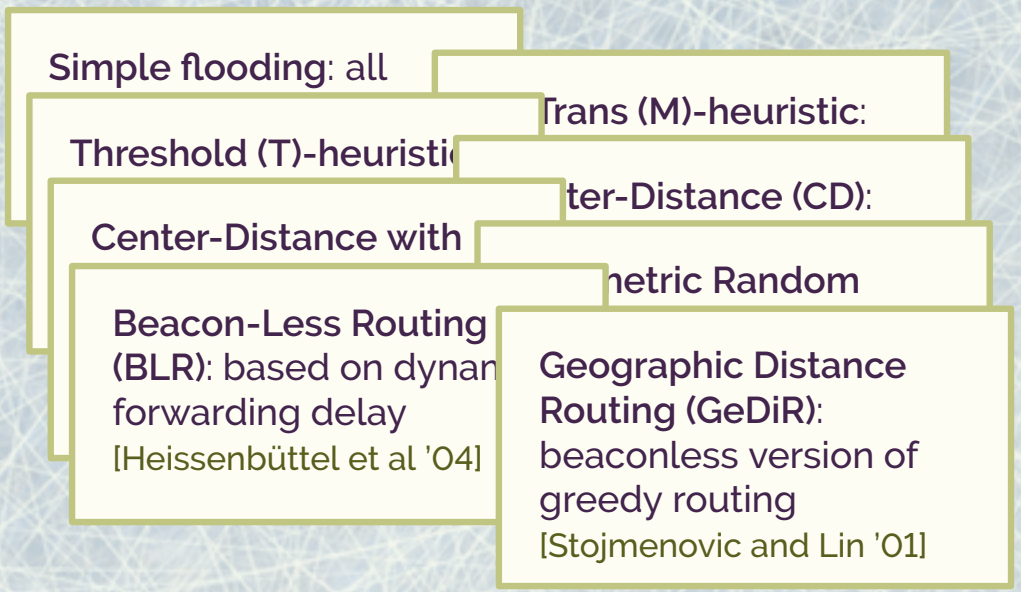

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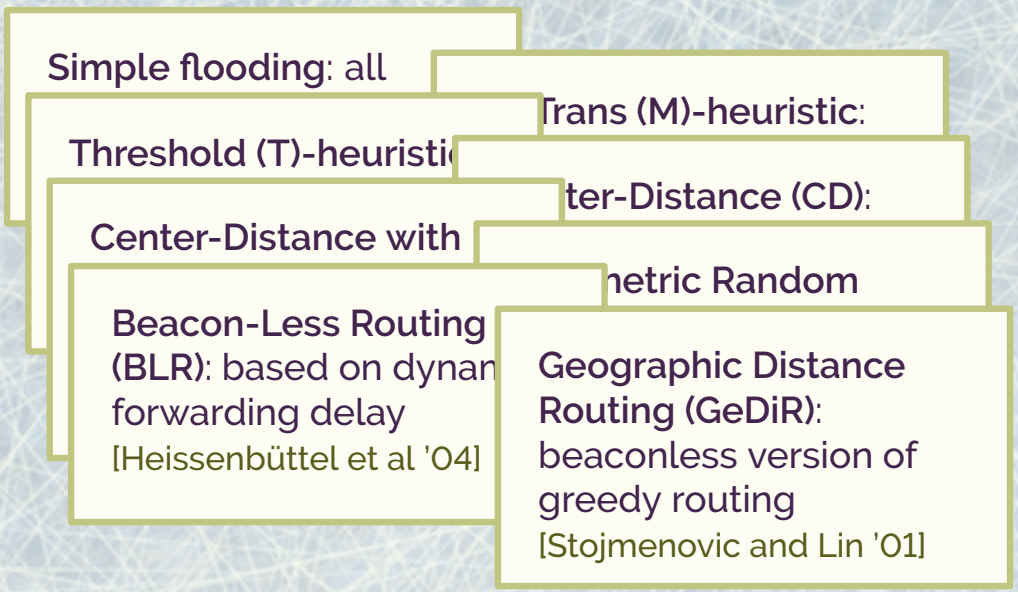

We wish to capture this phenomenon in mathematical language.

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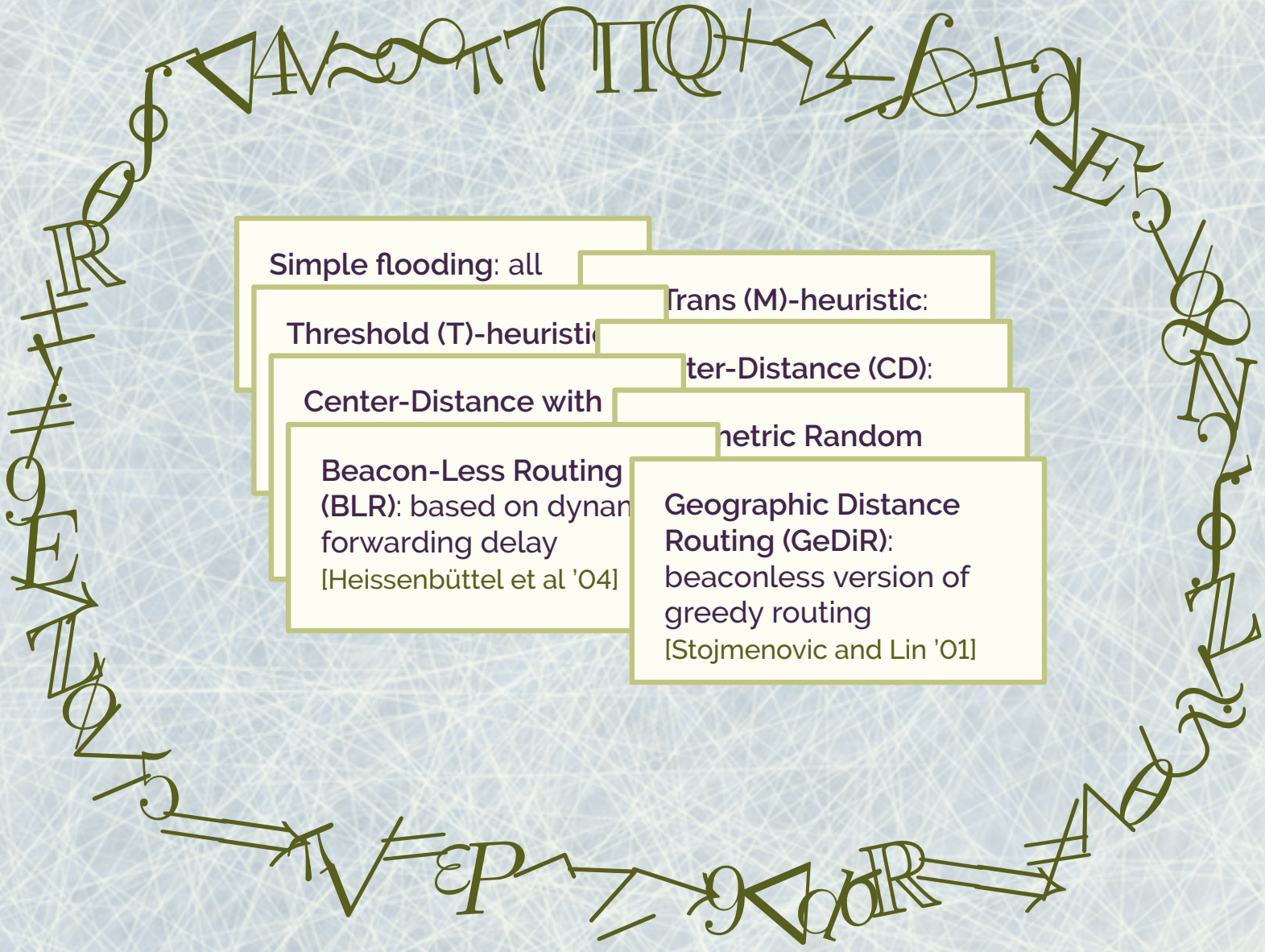

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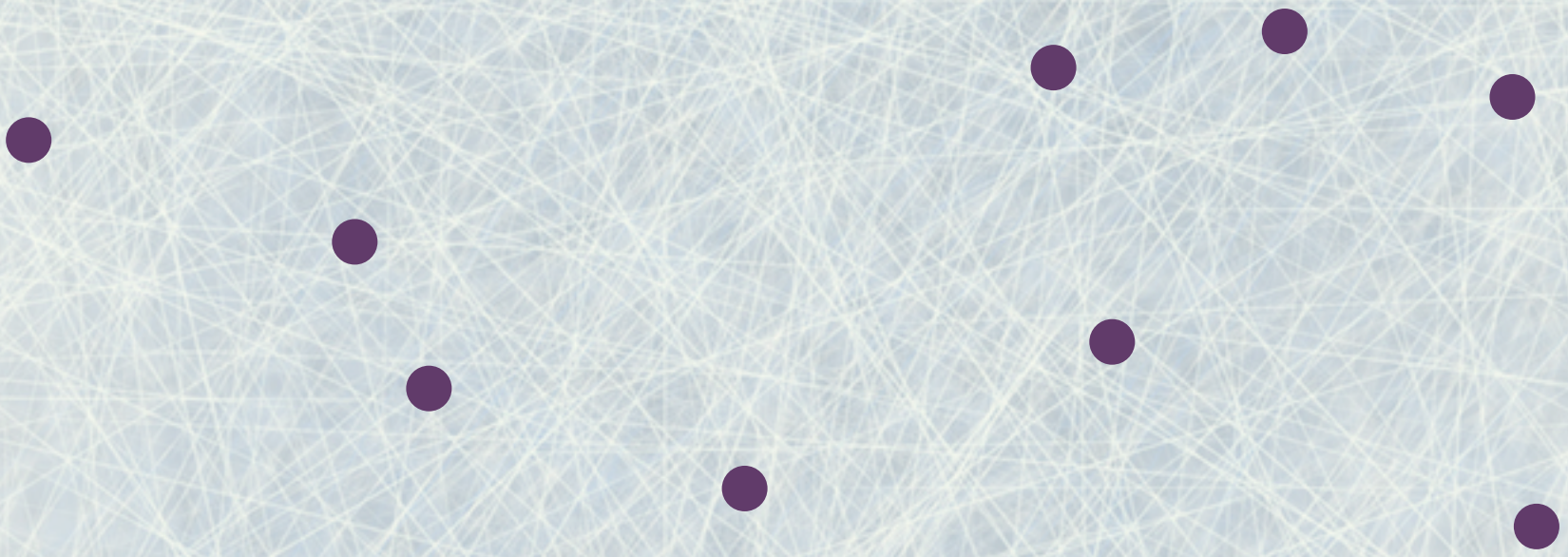

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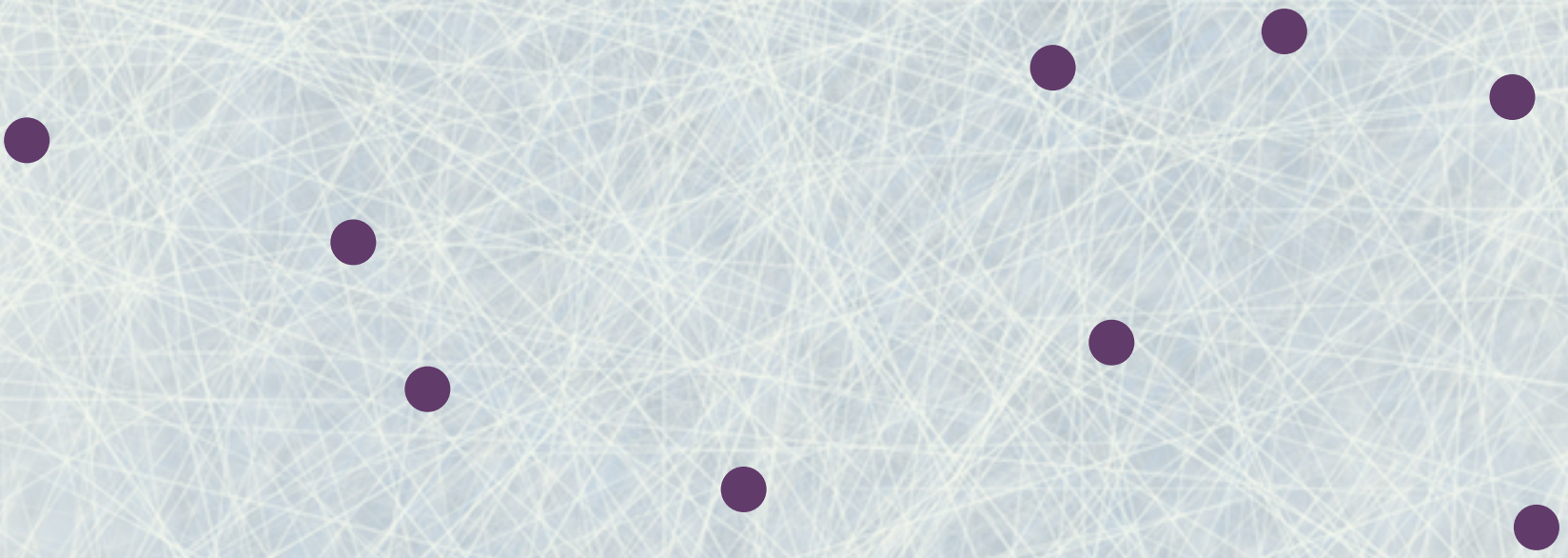

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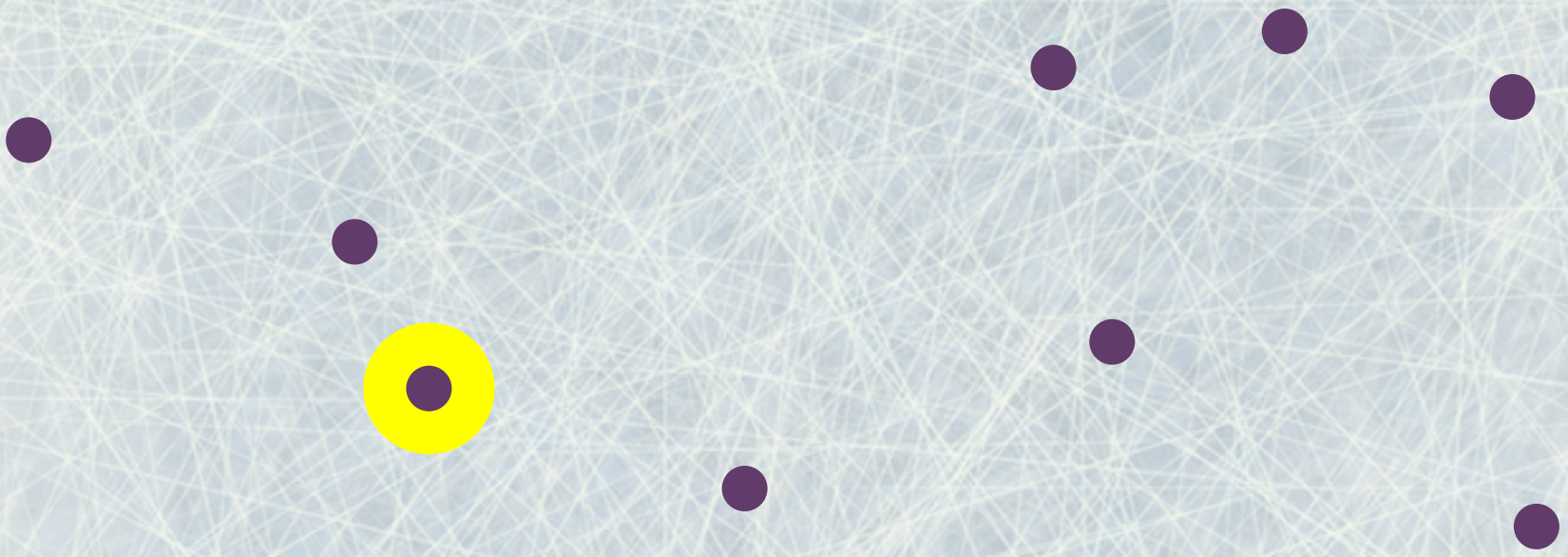

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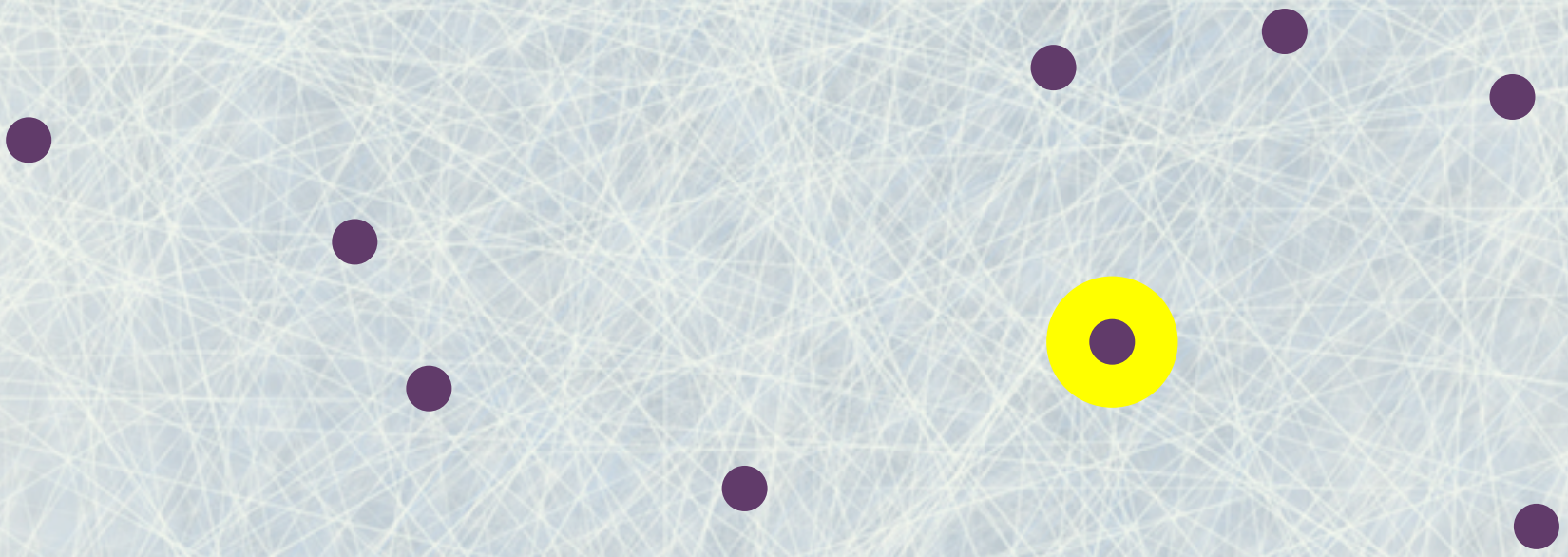

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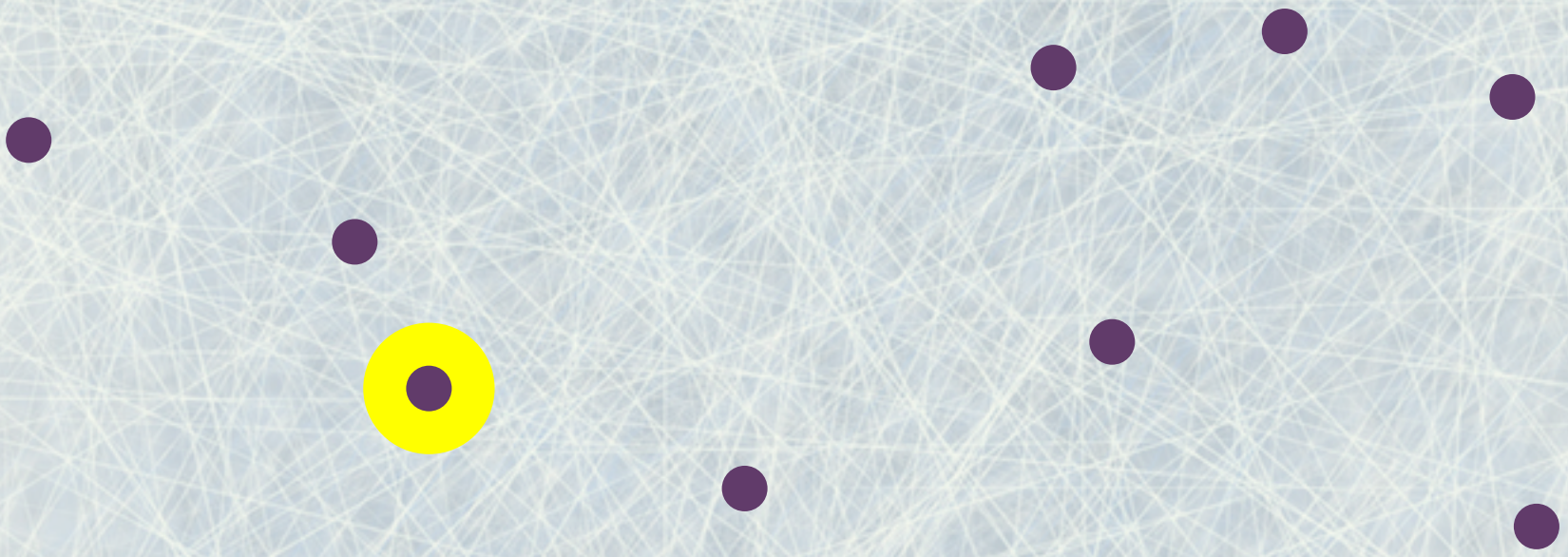

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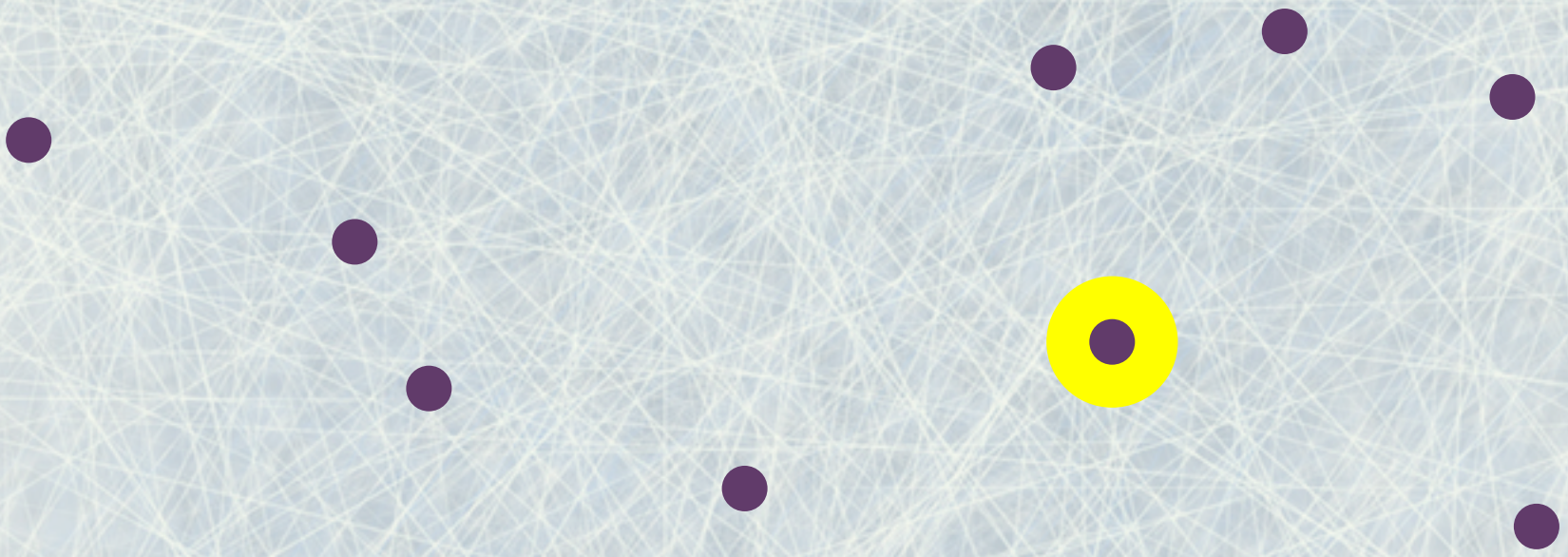

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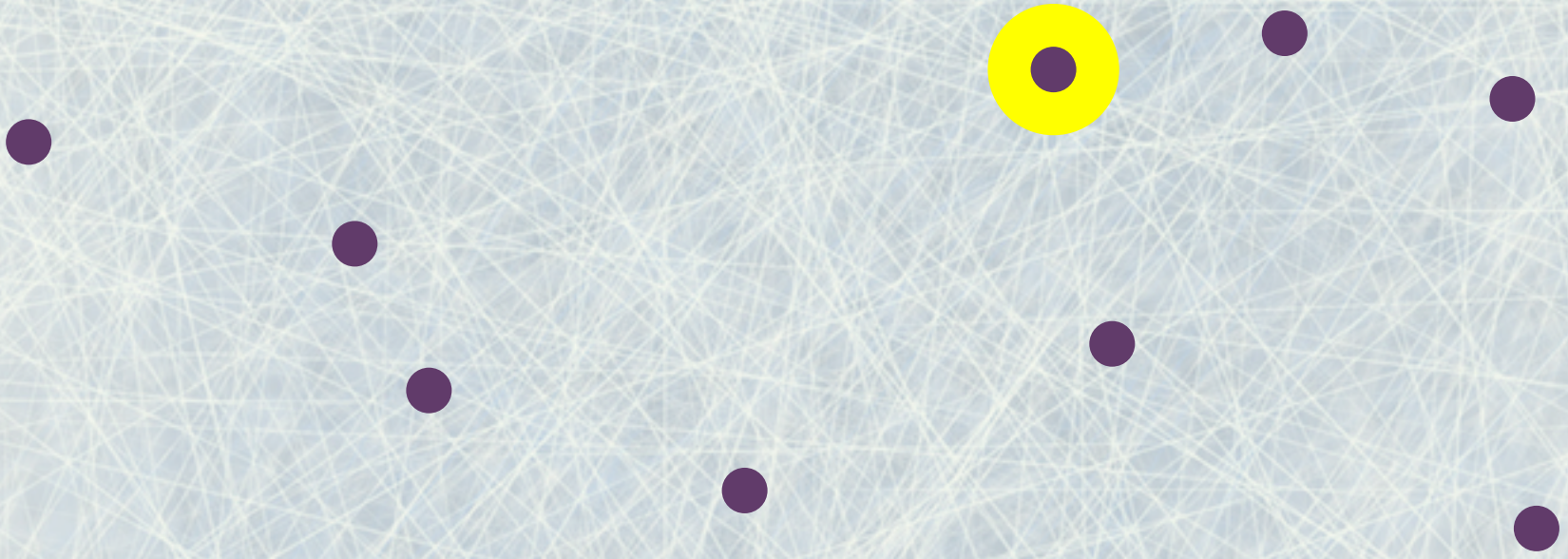

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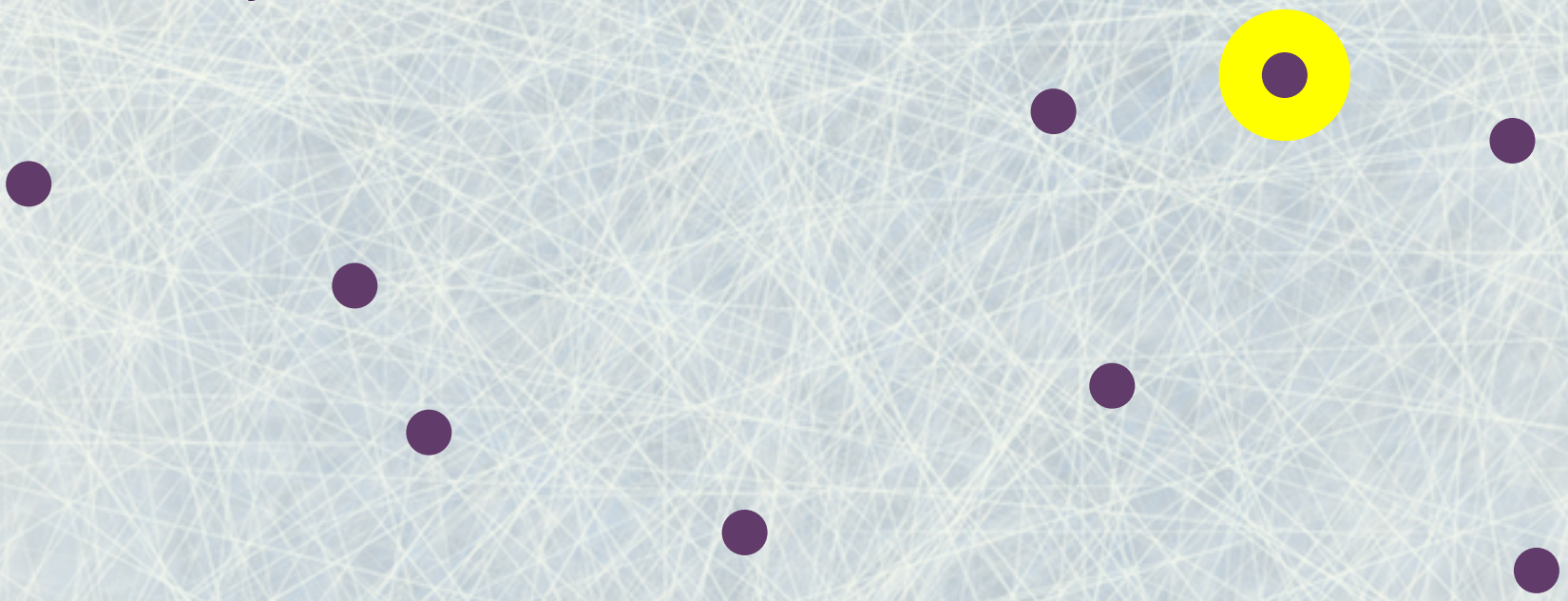

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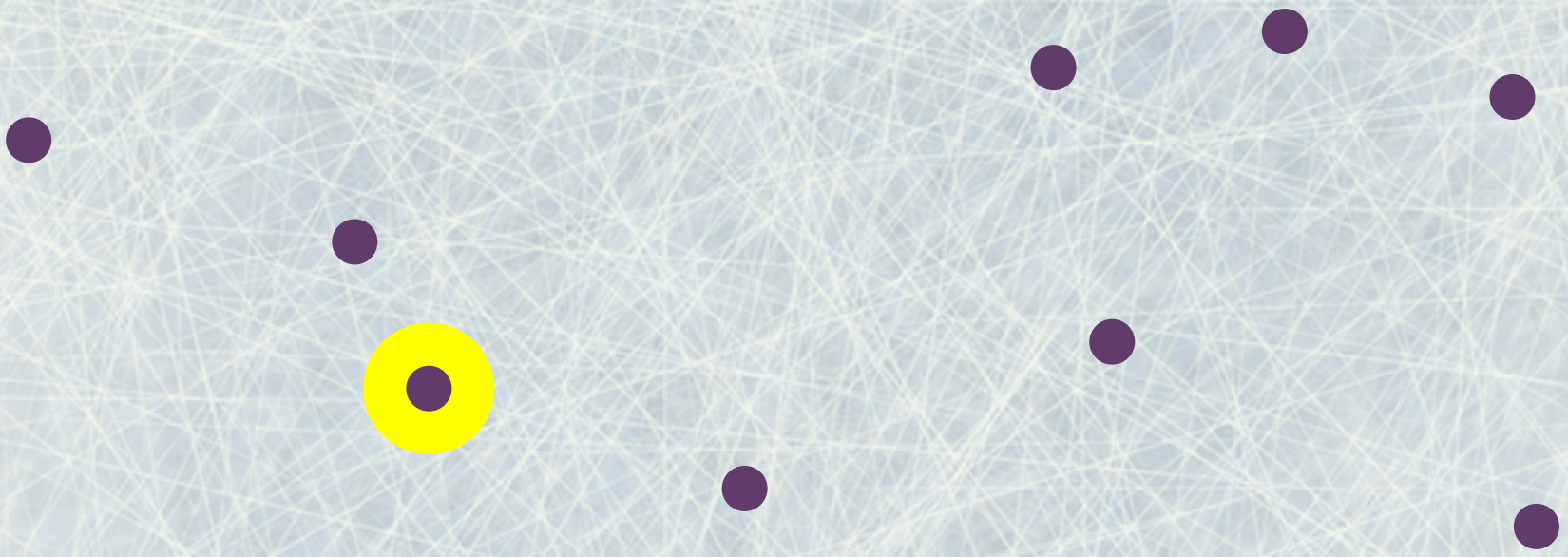

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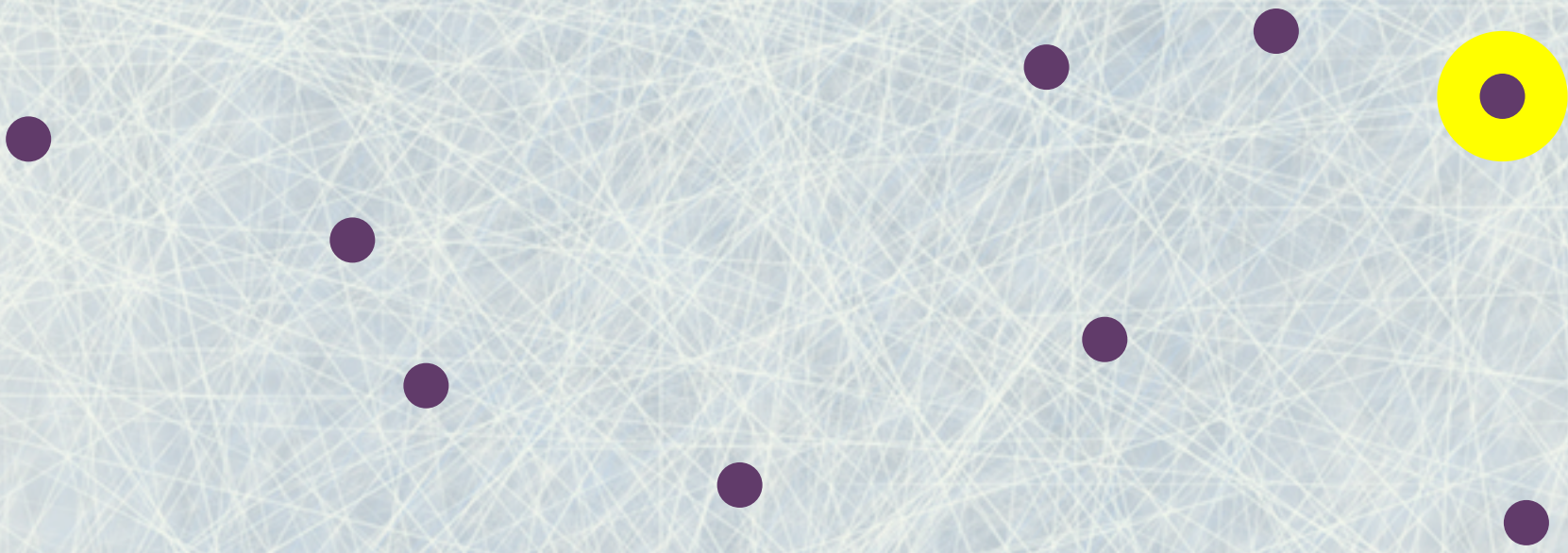

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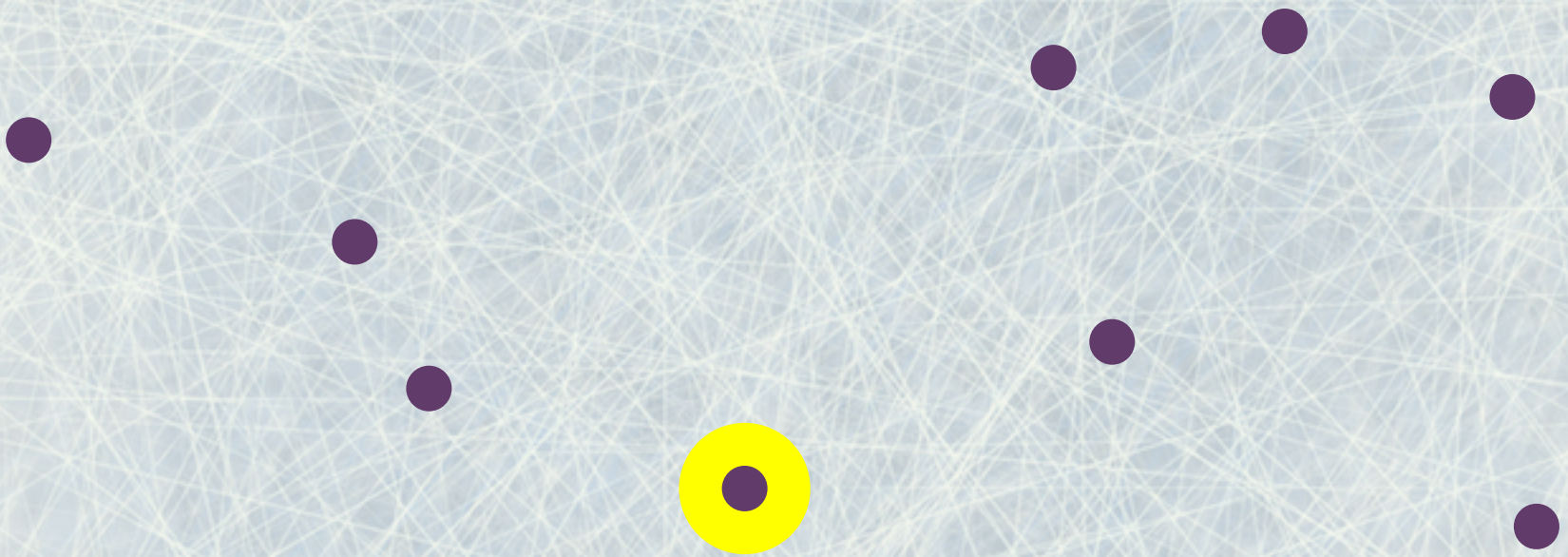

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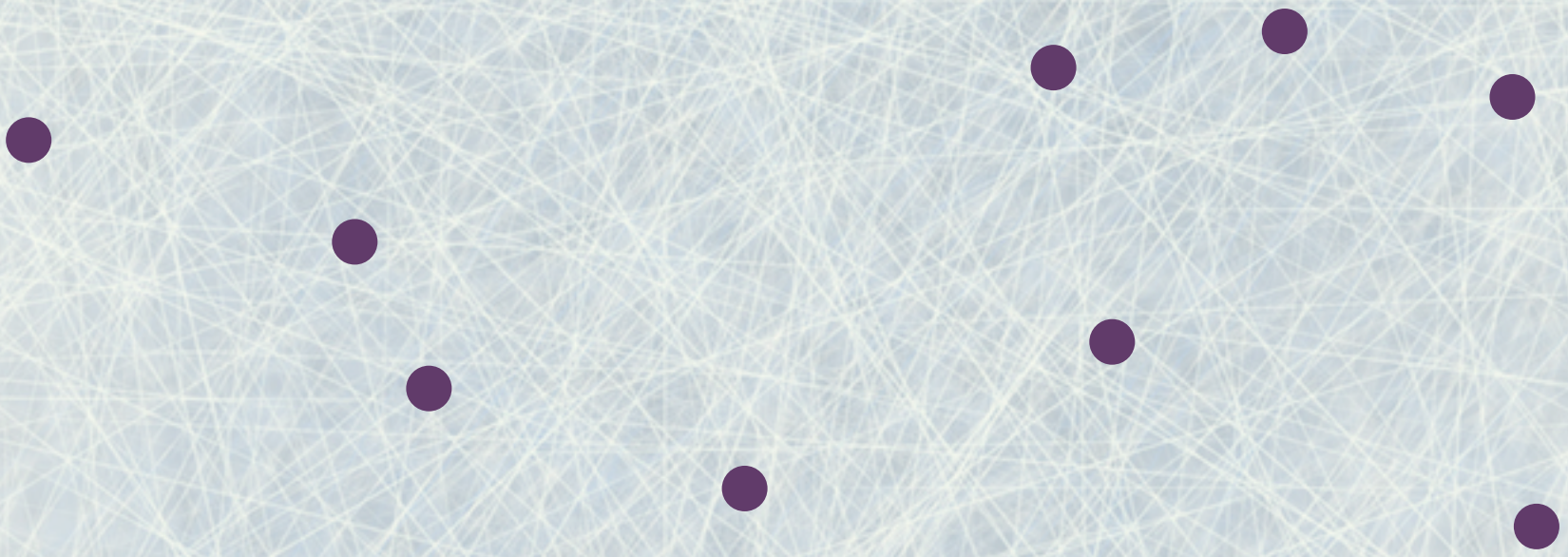

This assumption abstracts from different underlying collision handling techniques

Center-Distance vs Center-Distance-P

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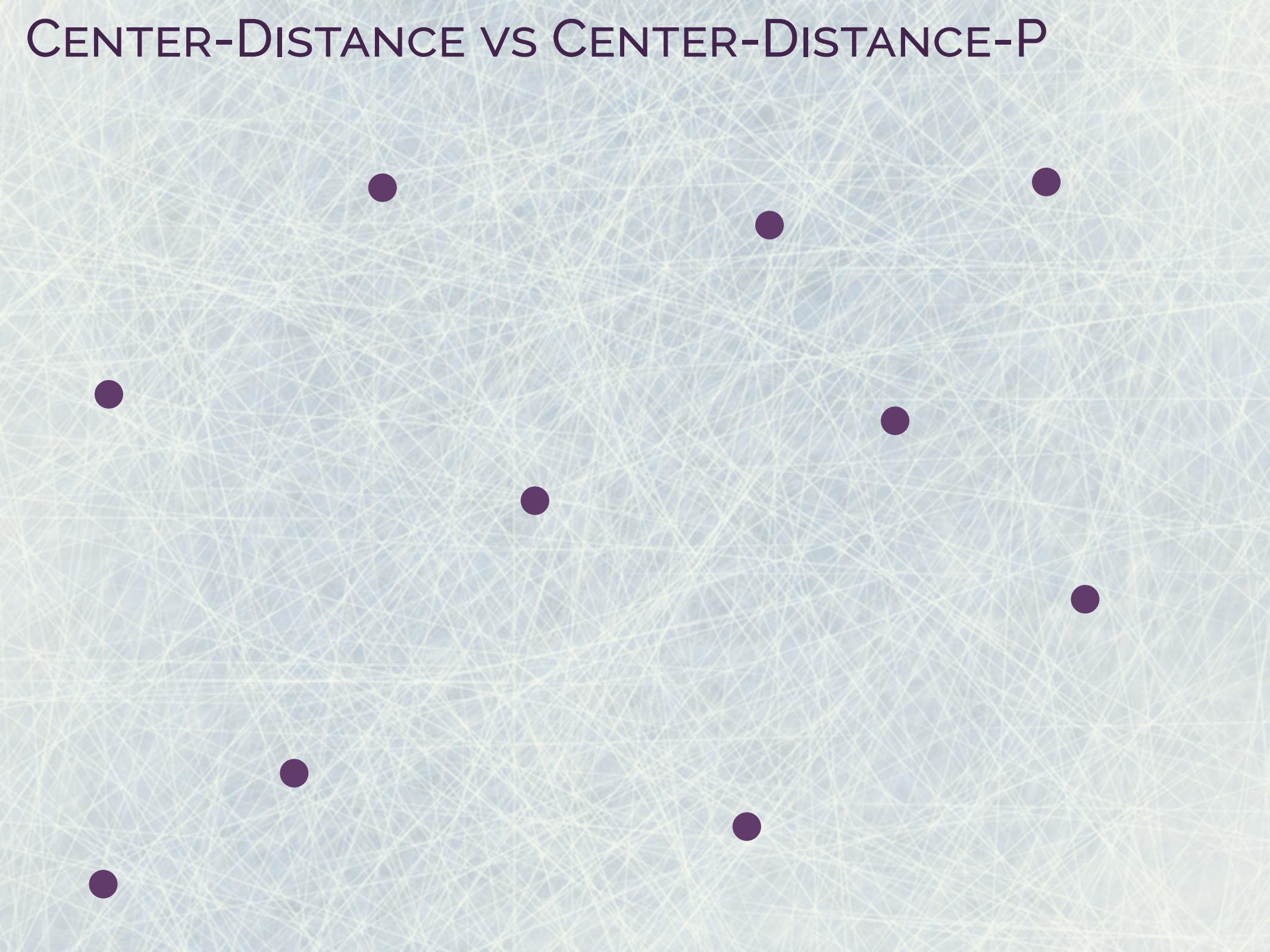


Center-Distance vs Center-Distance-P

I

Center-Distance vs Center-Distance-P

I

J

Center-Distance vs Center-Distance-P

V

I

J

Center-Distance vs Center-Distance-P

M

I

V

J

Center-Distance vs Center-Distance-P

M

V

I

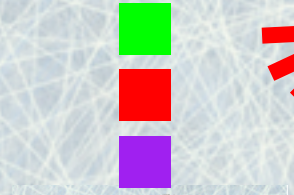
R

J

Center-Distance vs Center-Distance-P

CD&CD-P:

M



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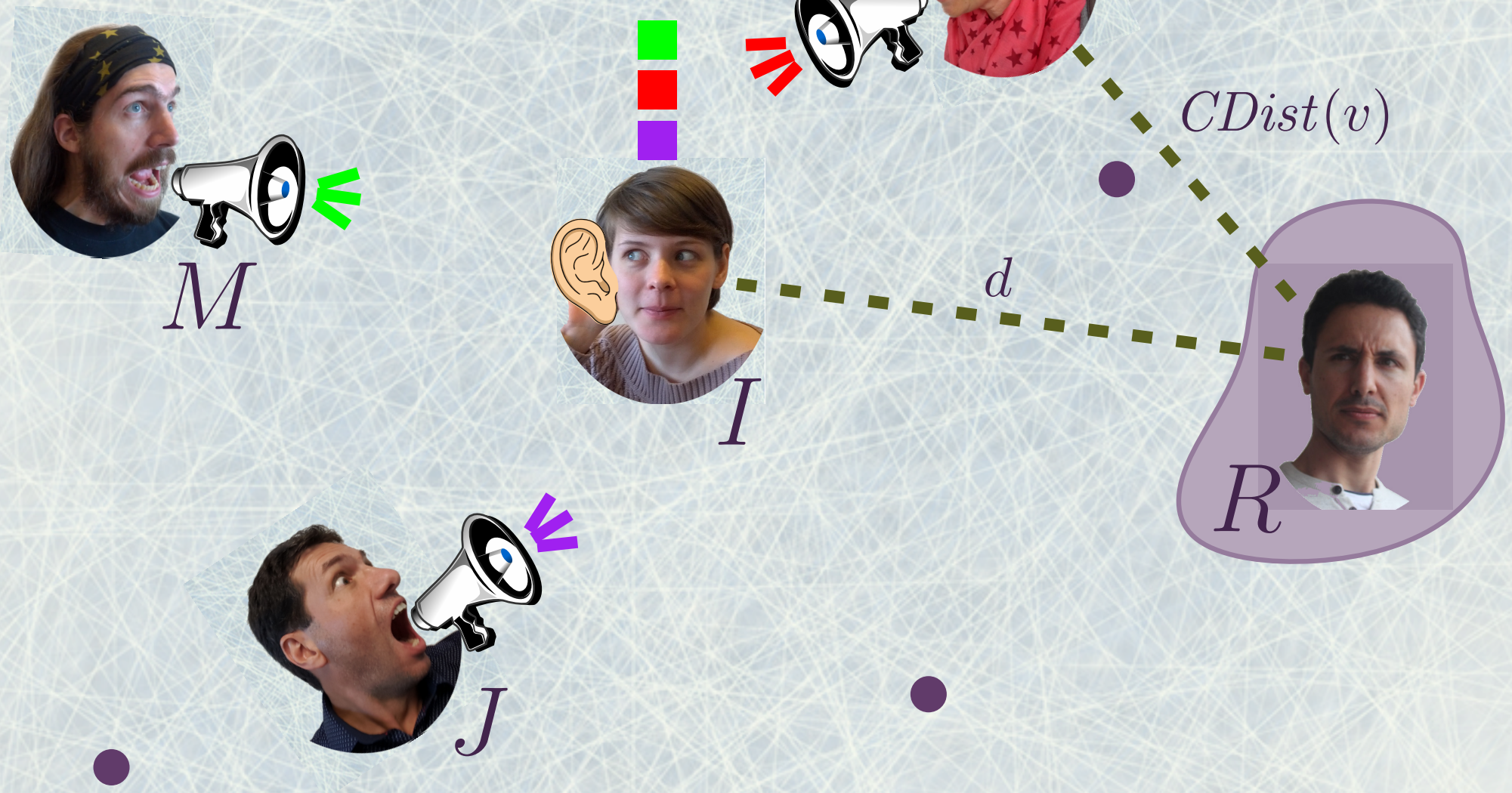

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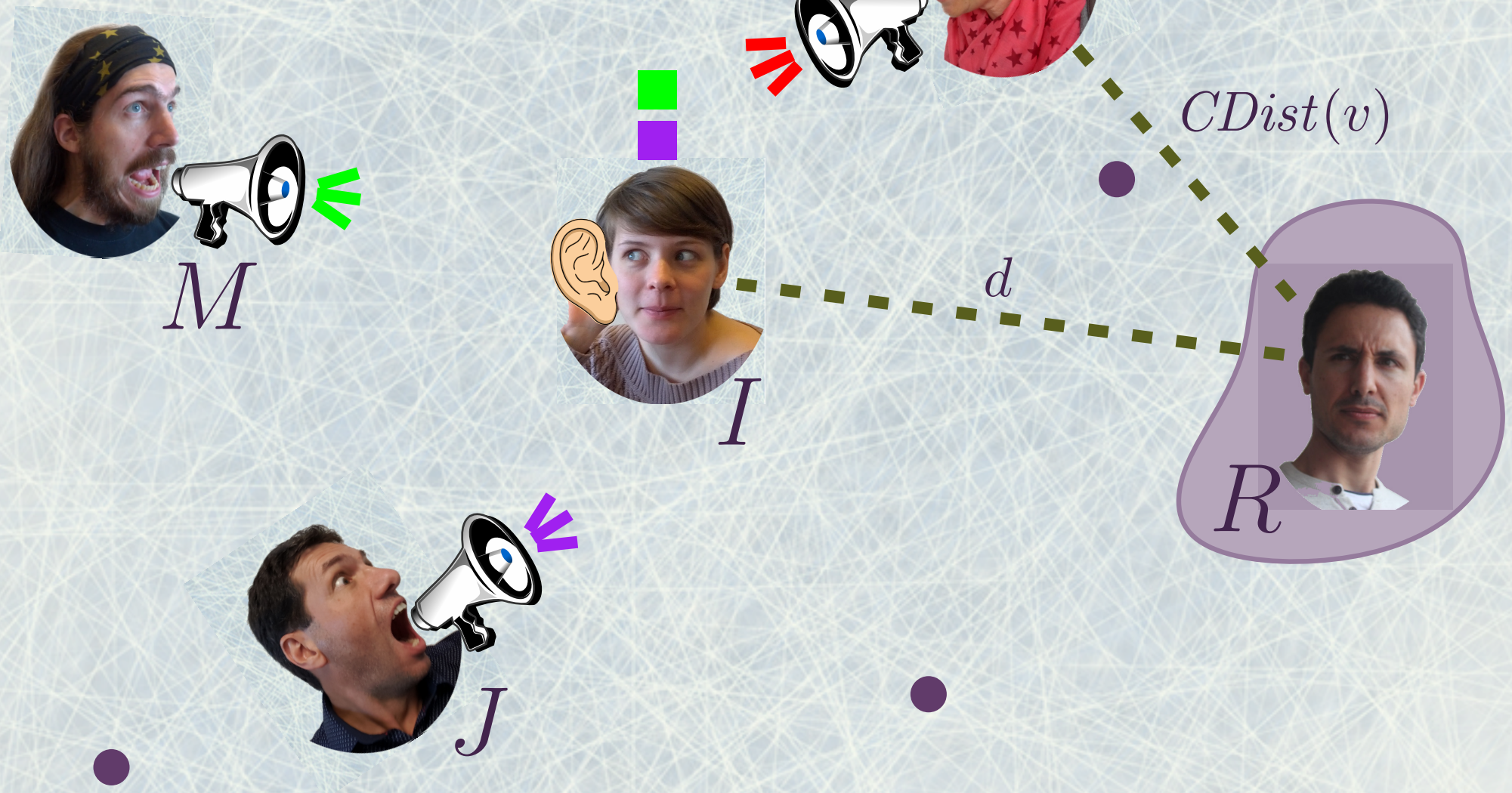

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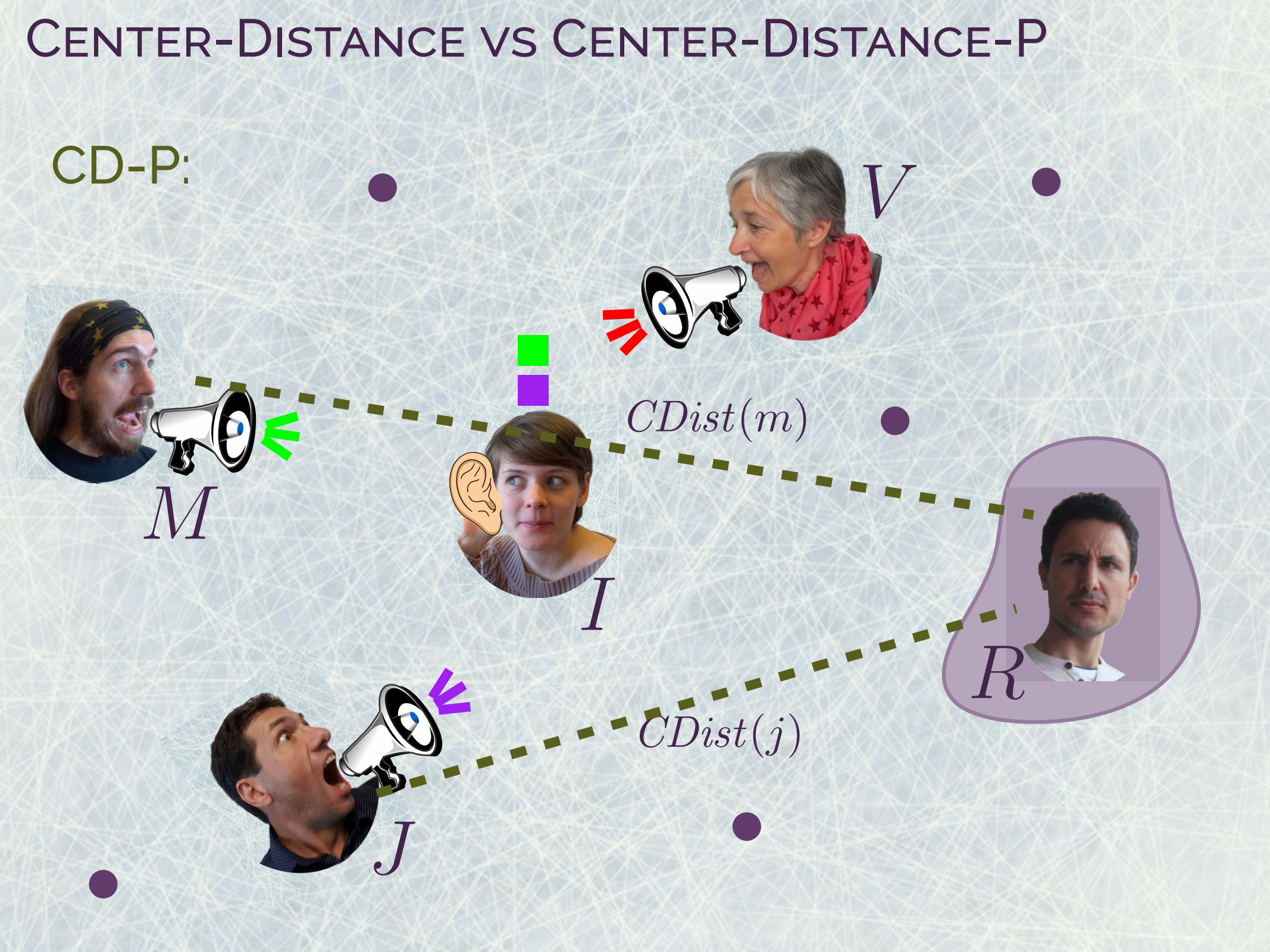

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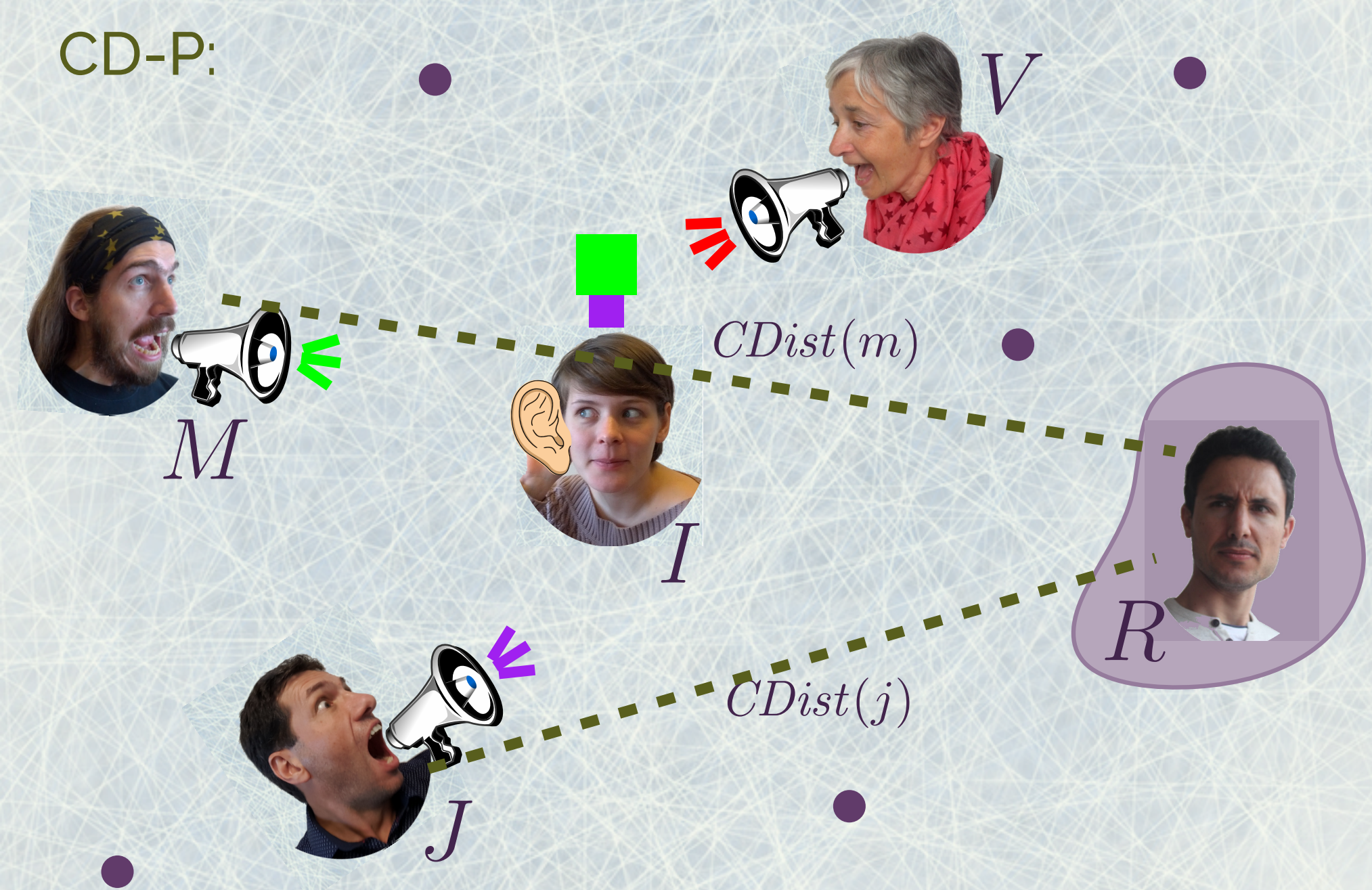

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Problem. Validate beaconless geocast heuristics within our model, and analyze success rate and **RecMess** under various scenarios.

Today

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2 scenarios in 1D:

- Unbounded reach

- Bounded reach

Today

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  Messages are sent from left to right, everybody can "hear" everybody.

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  Messages are sent from left to right, everybody can "hear" everybody.

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  Messages are sent from left to right. Each node can only hear from its r predecessors.

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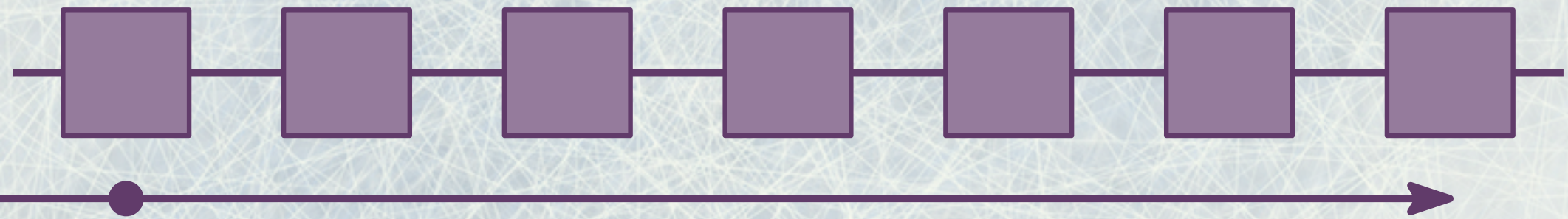

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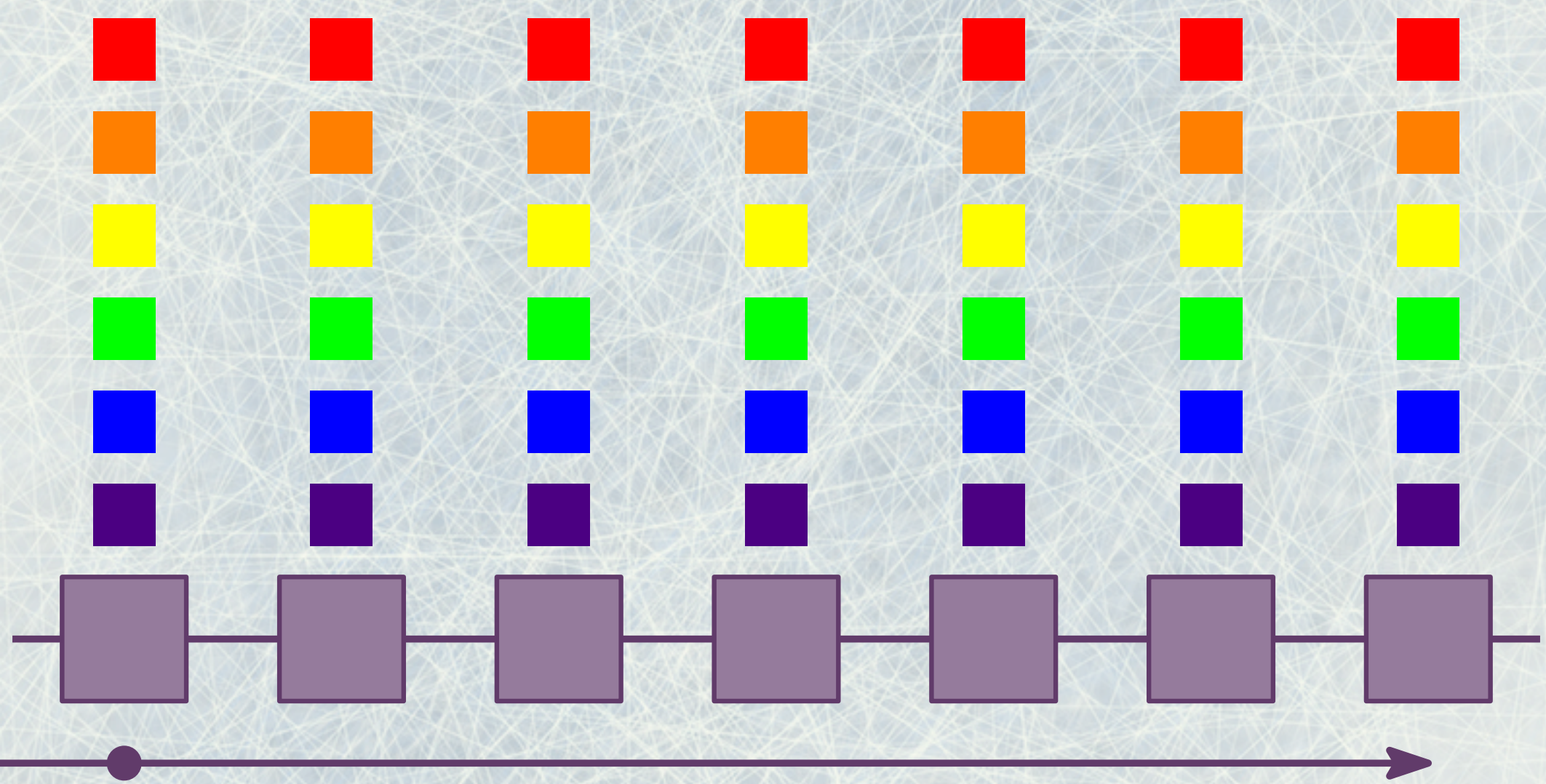

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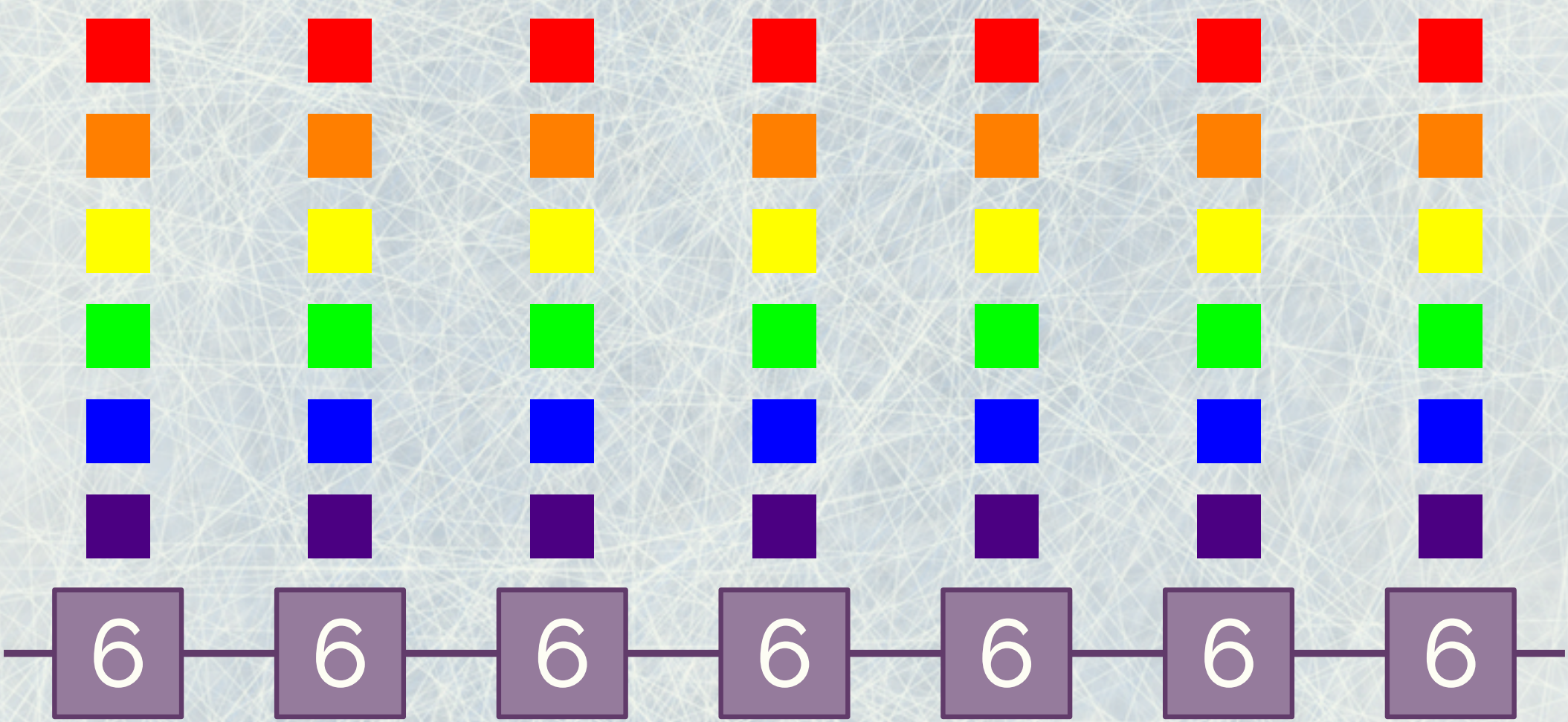

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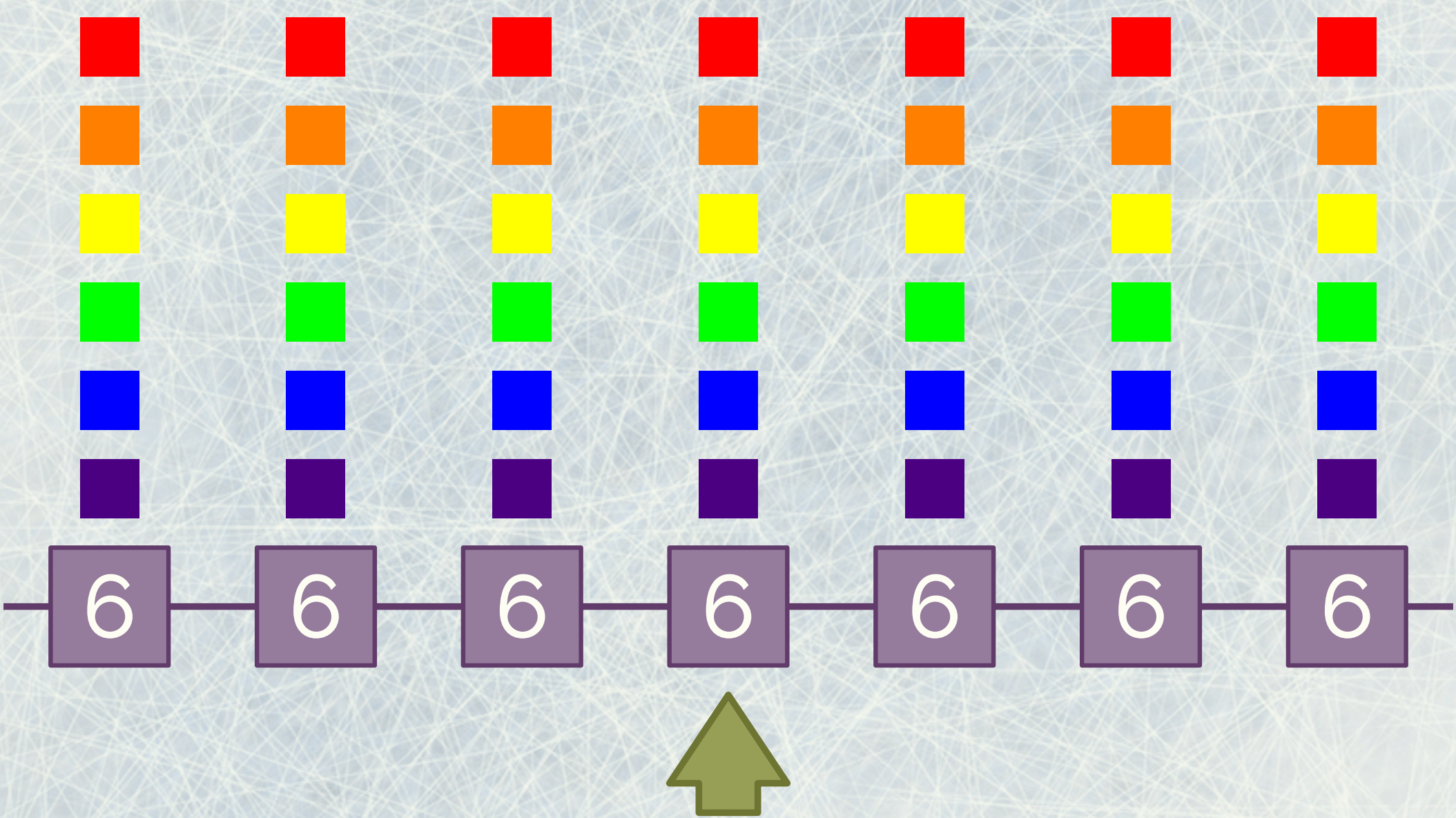

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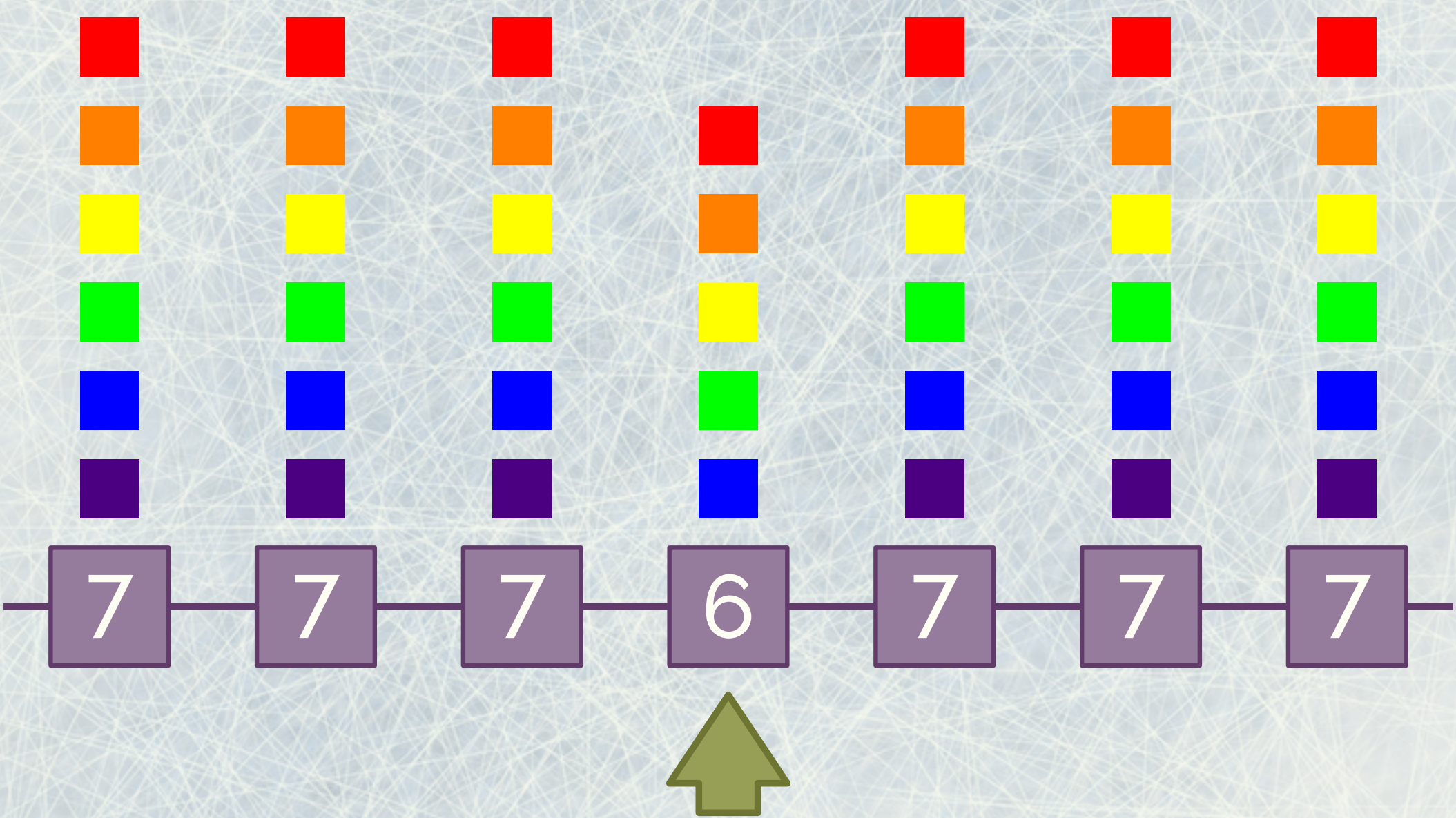

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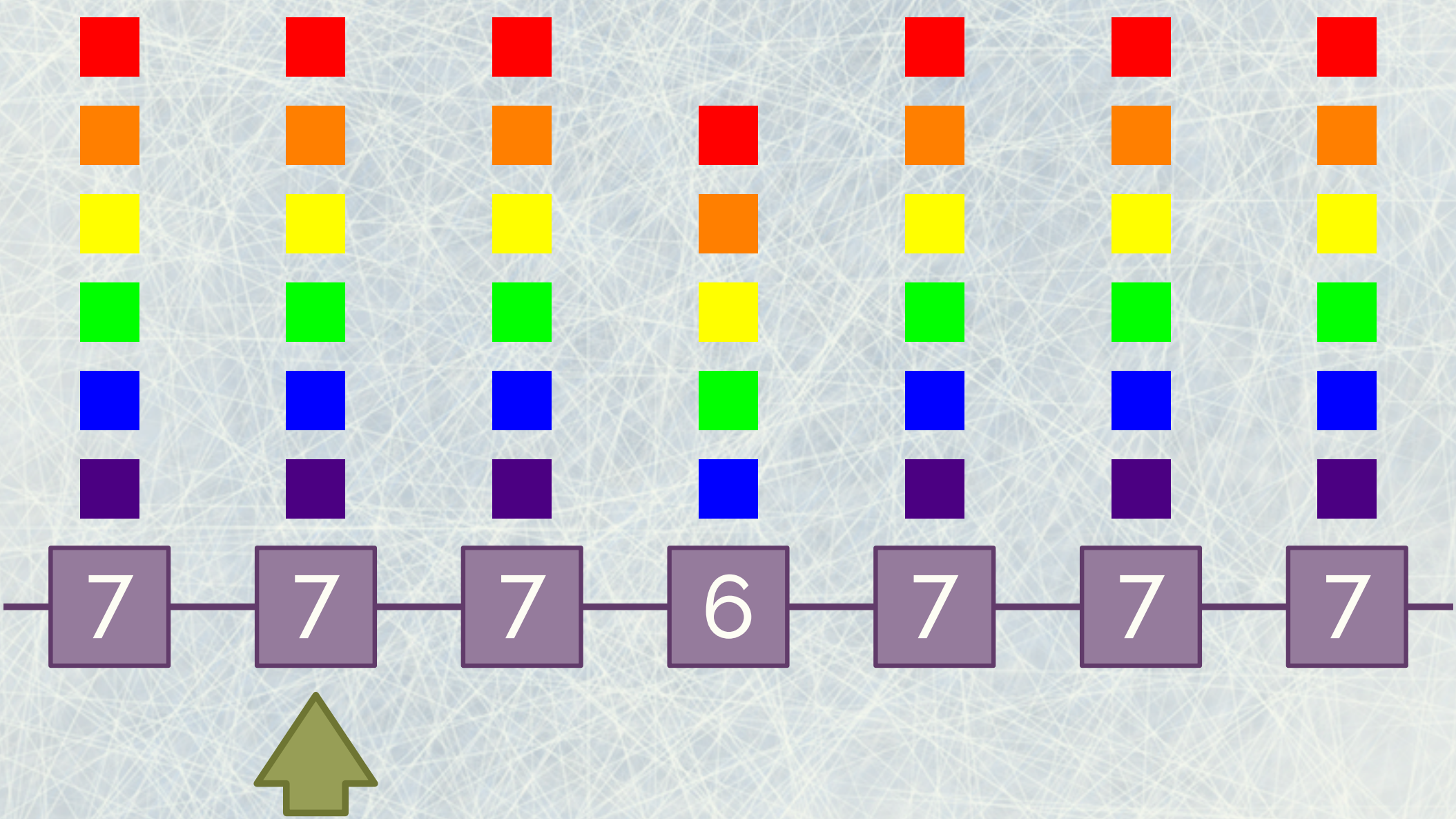

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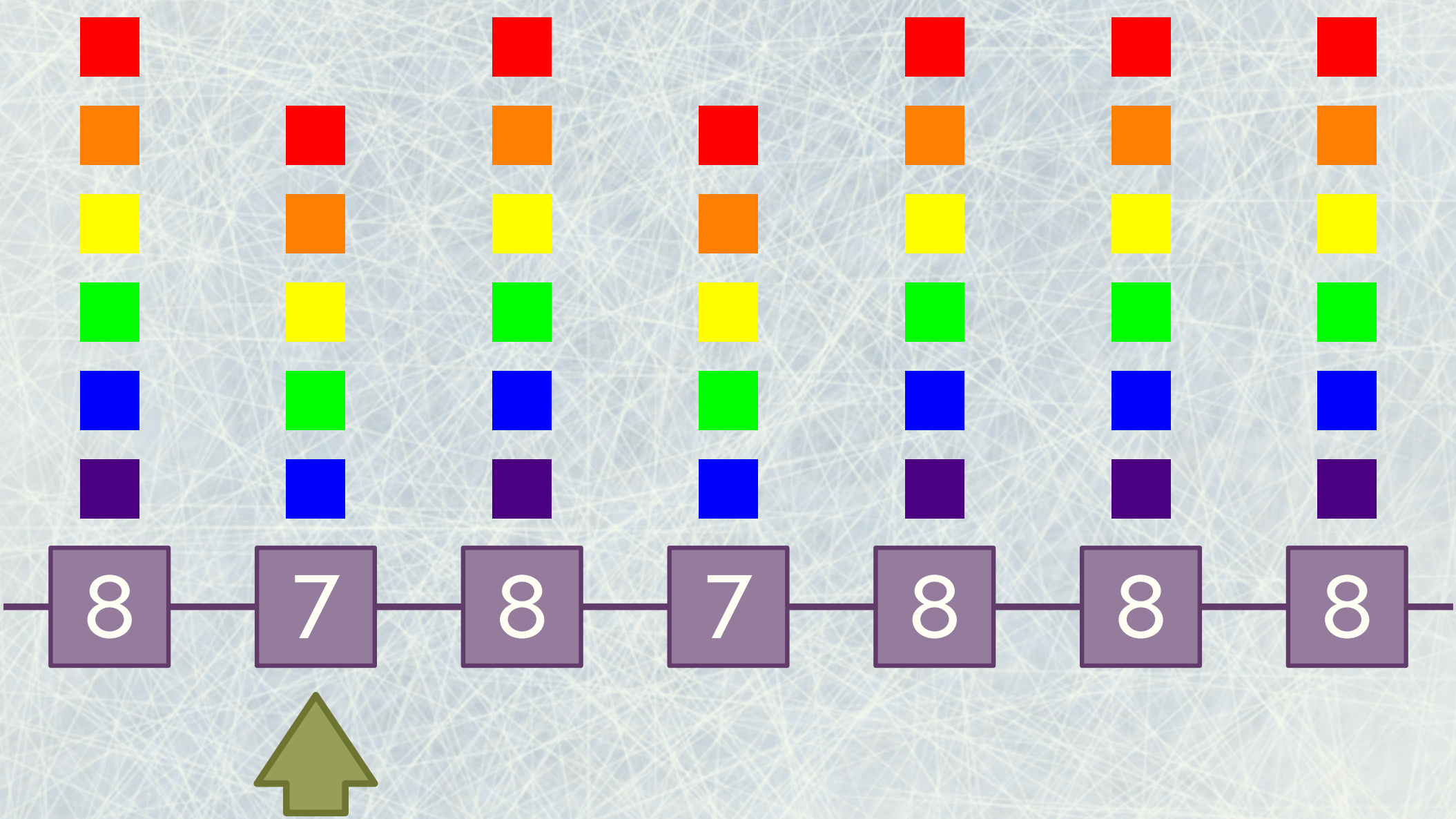

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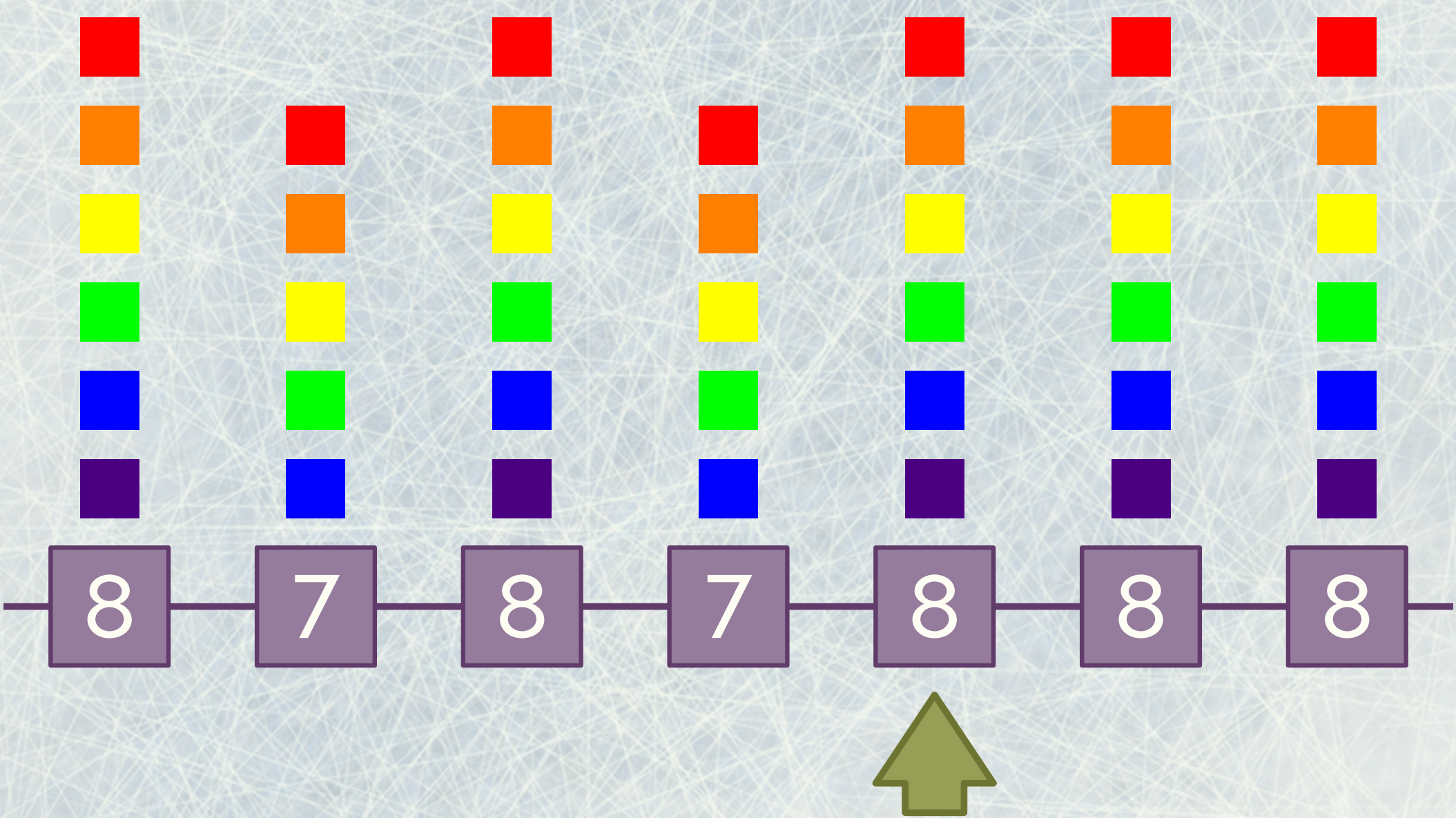

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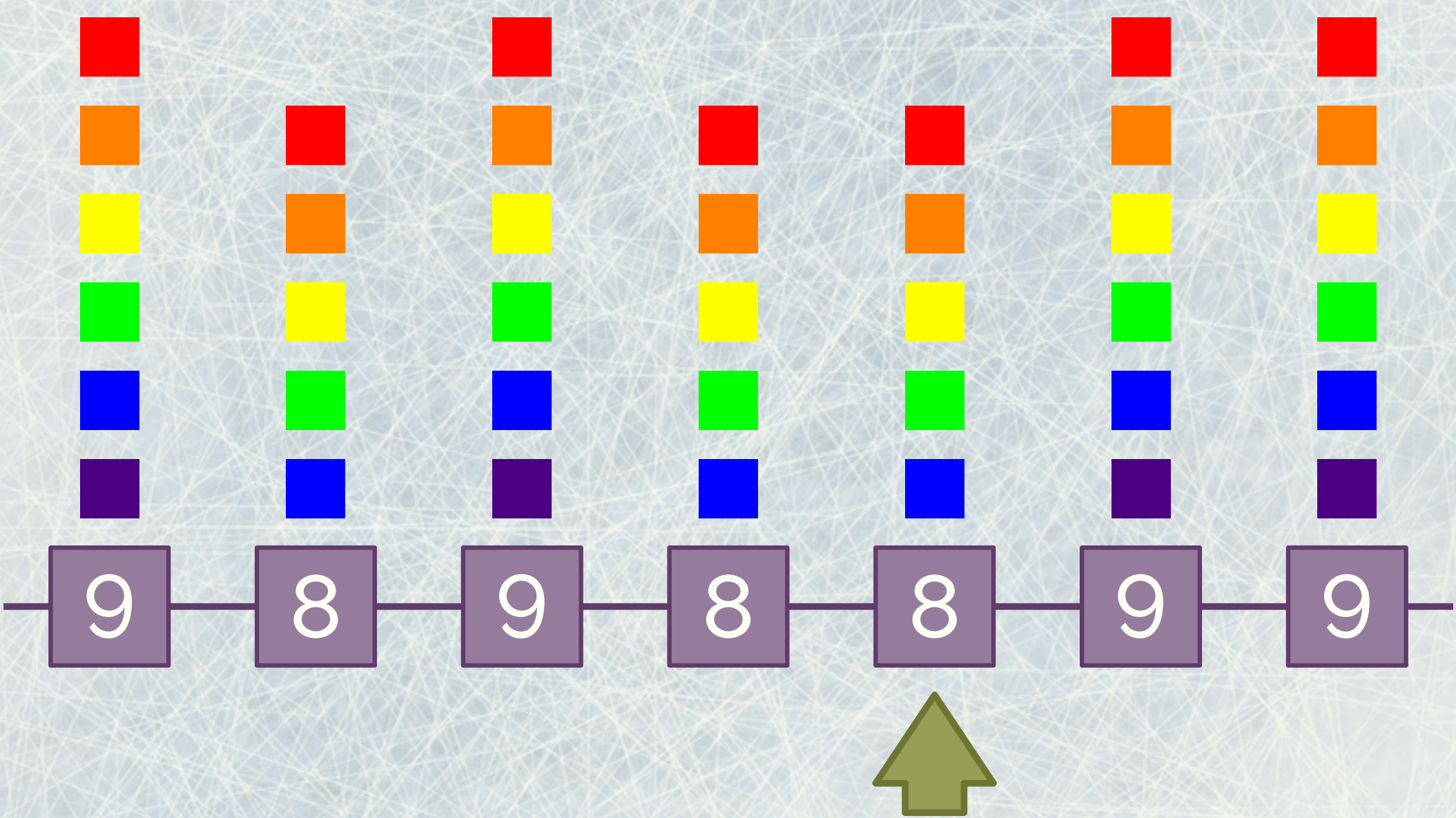

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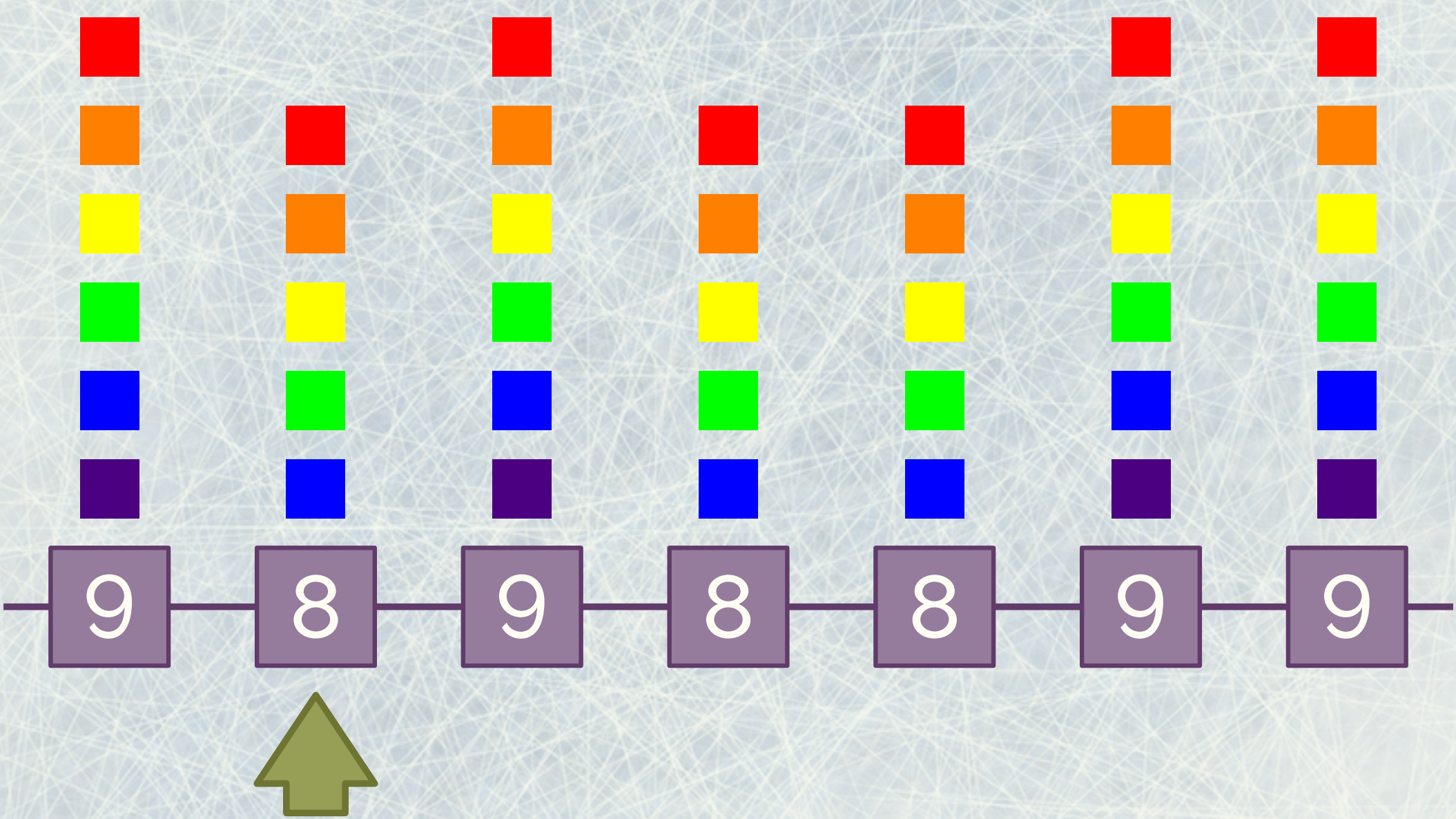

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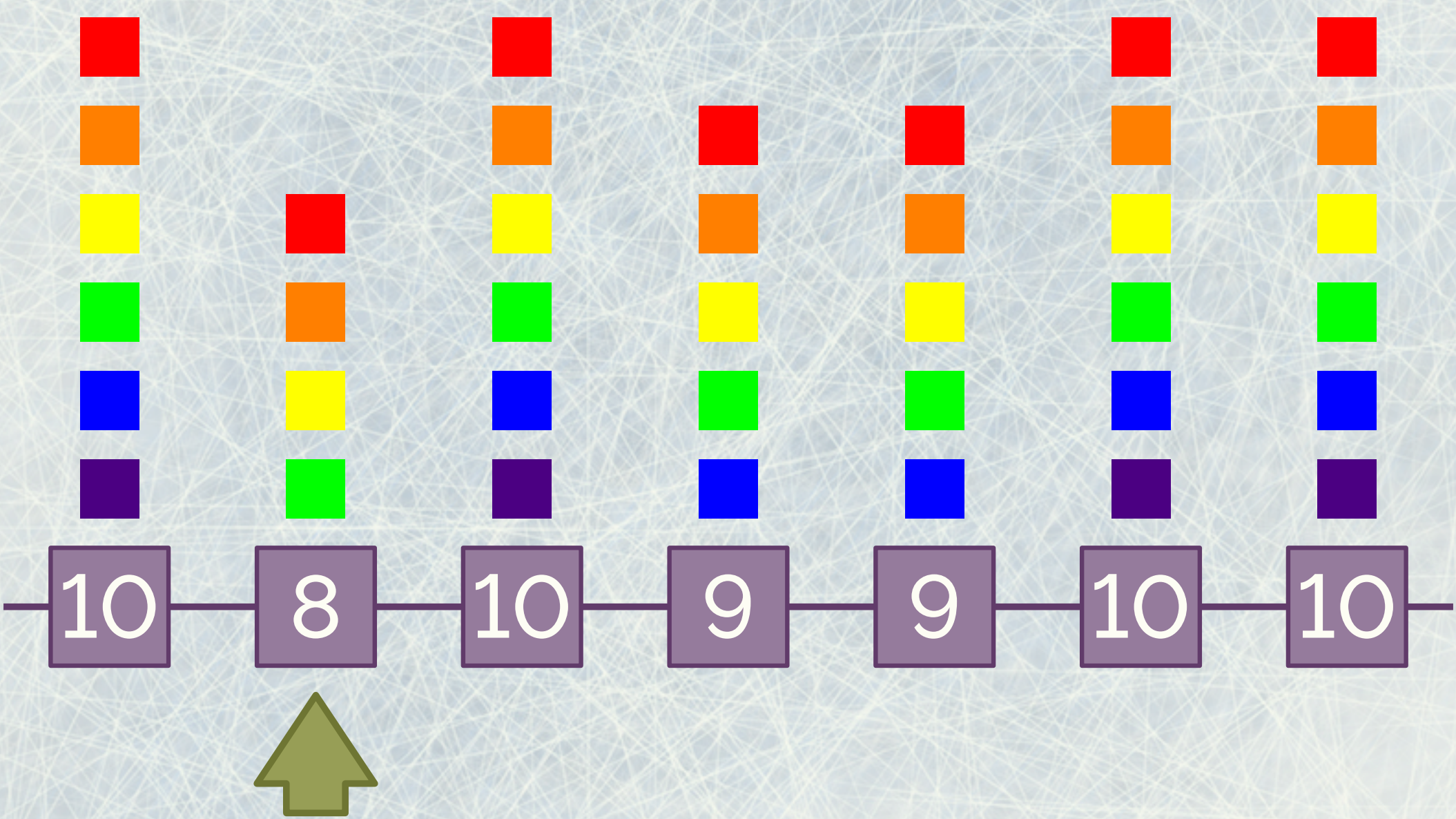
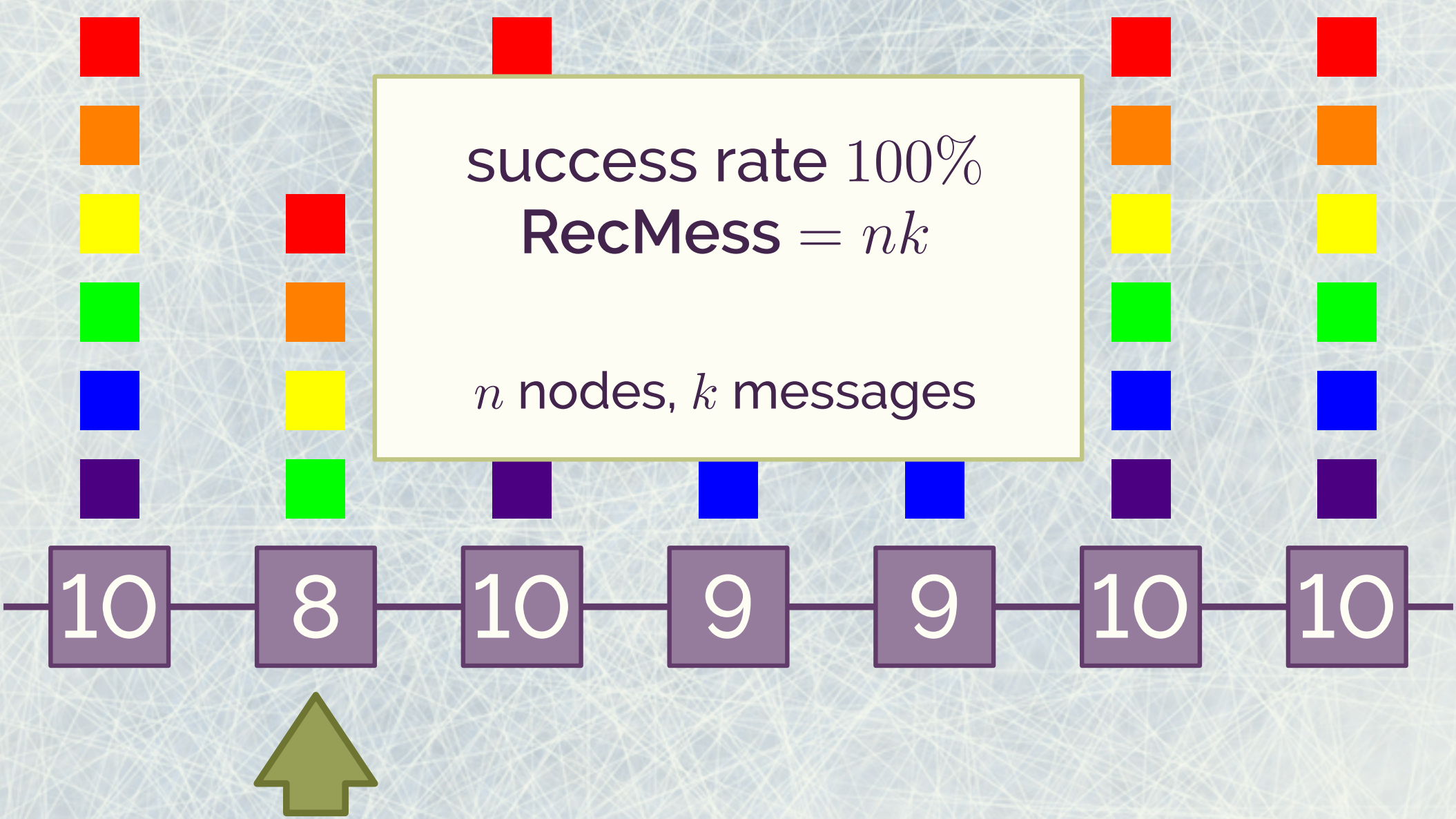
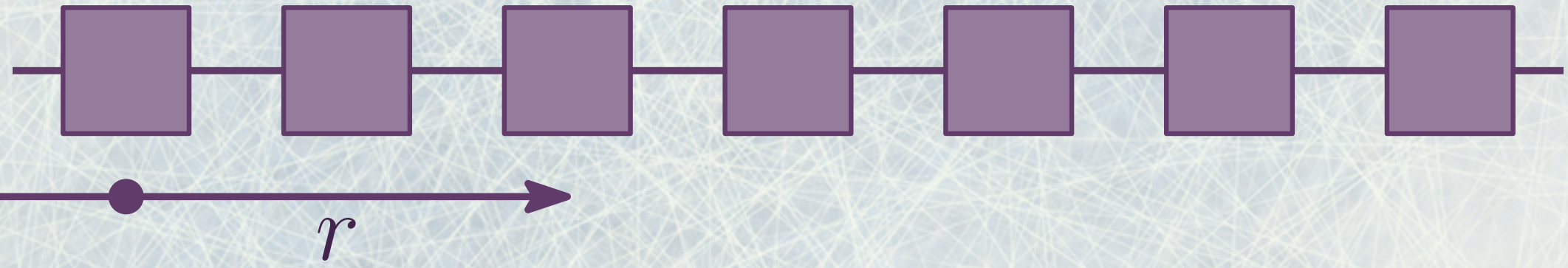


Flooding in 1D Unbounded Reach Scenario

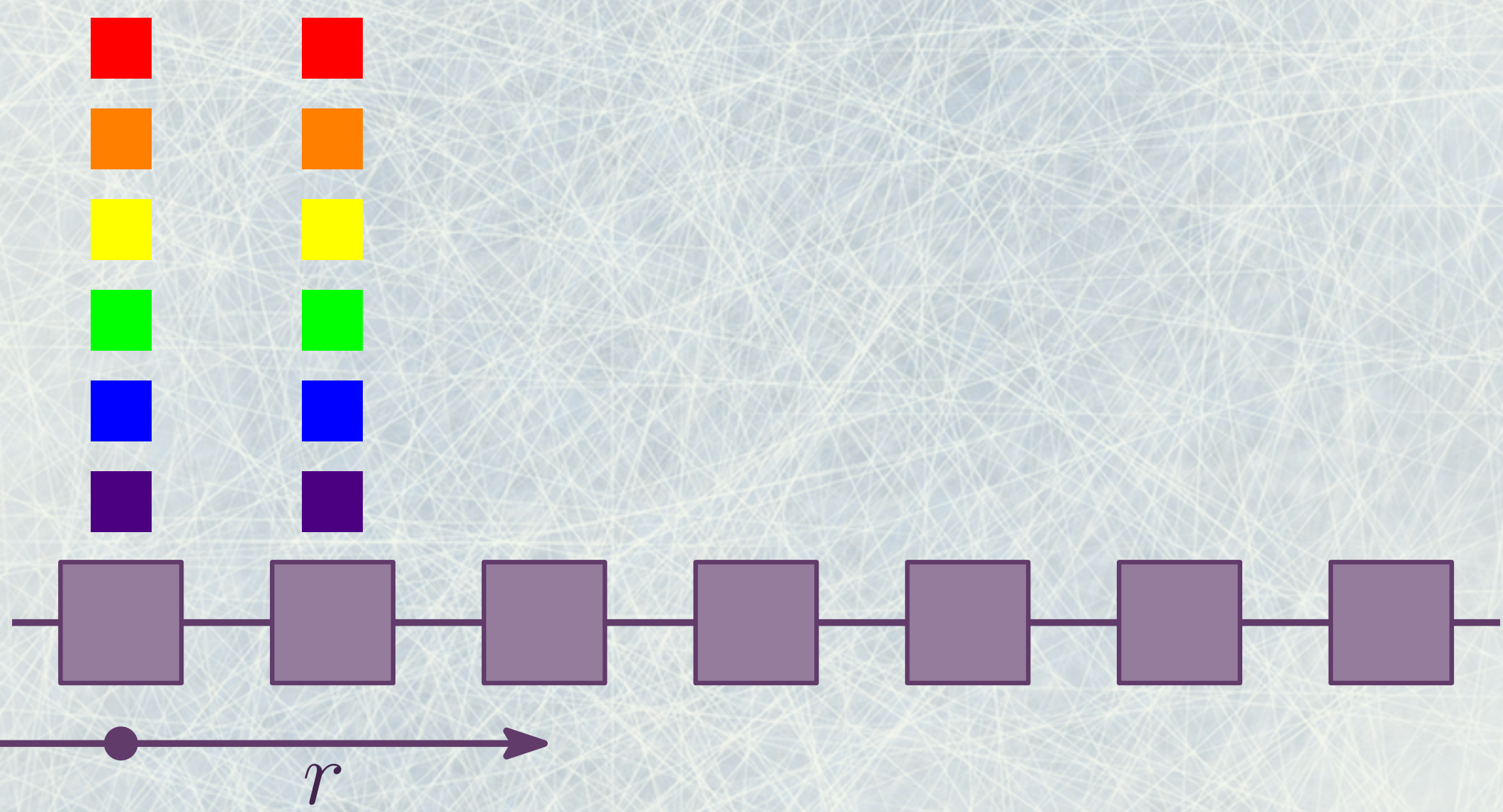


1D Bounded Reach Scenario

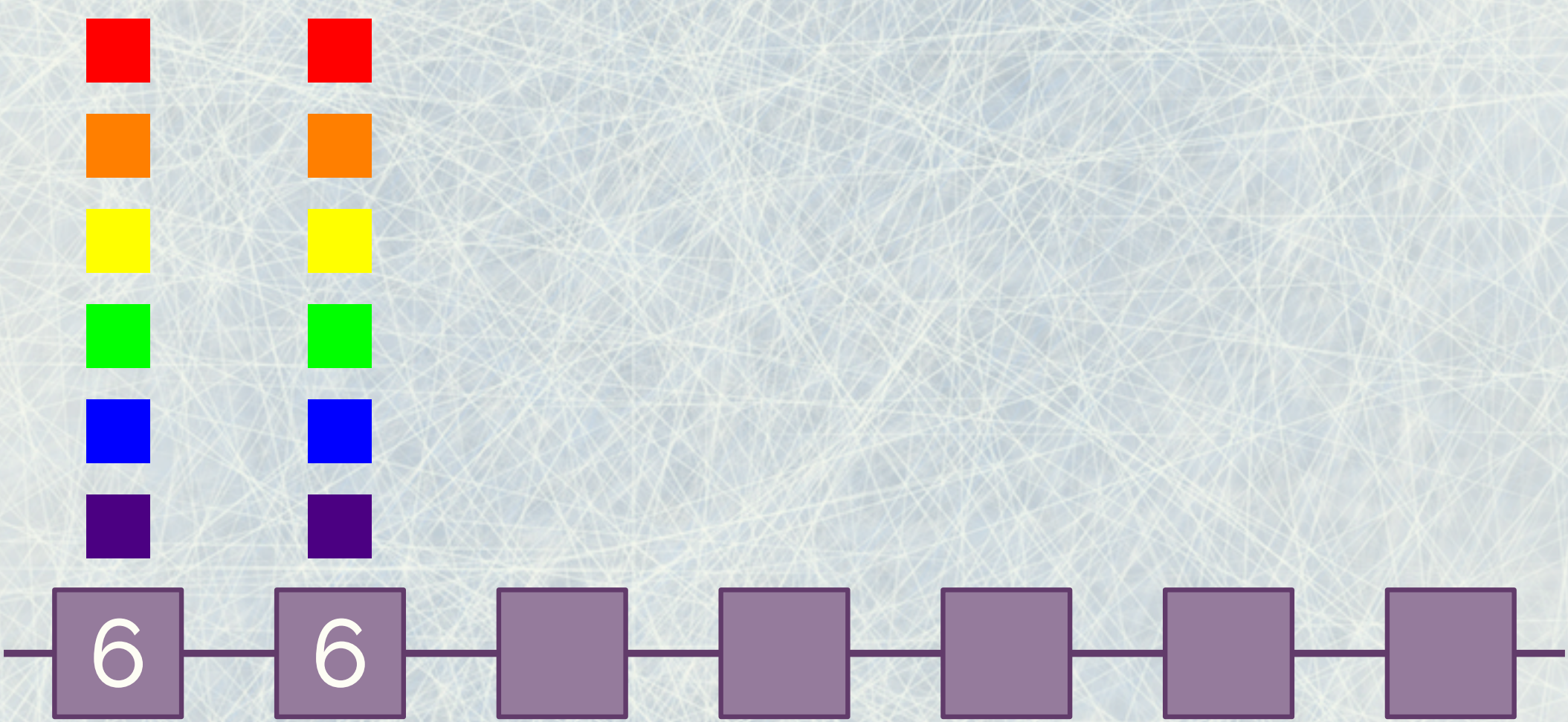
1D Bounded Reach Scenario



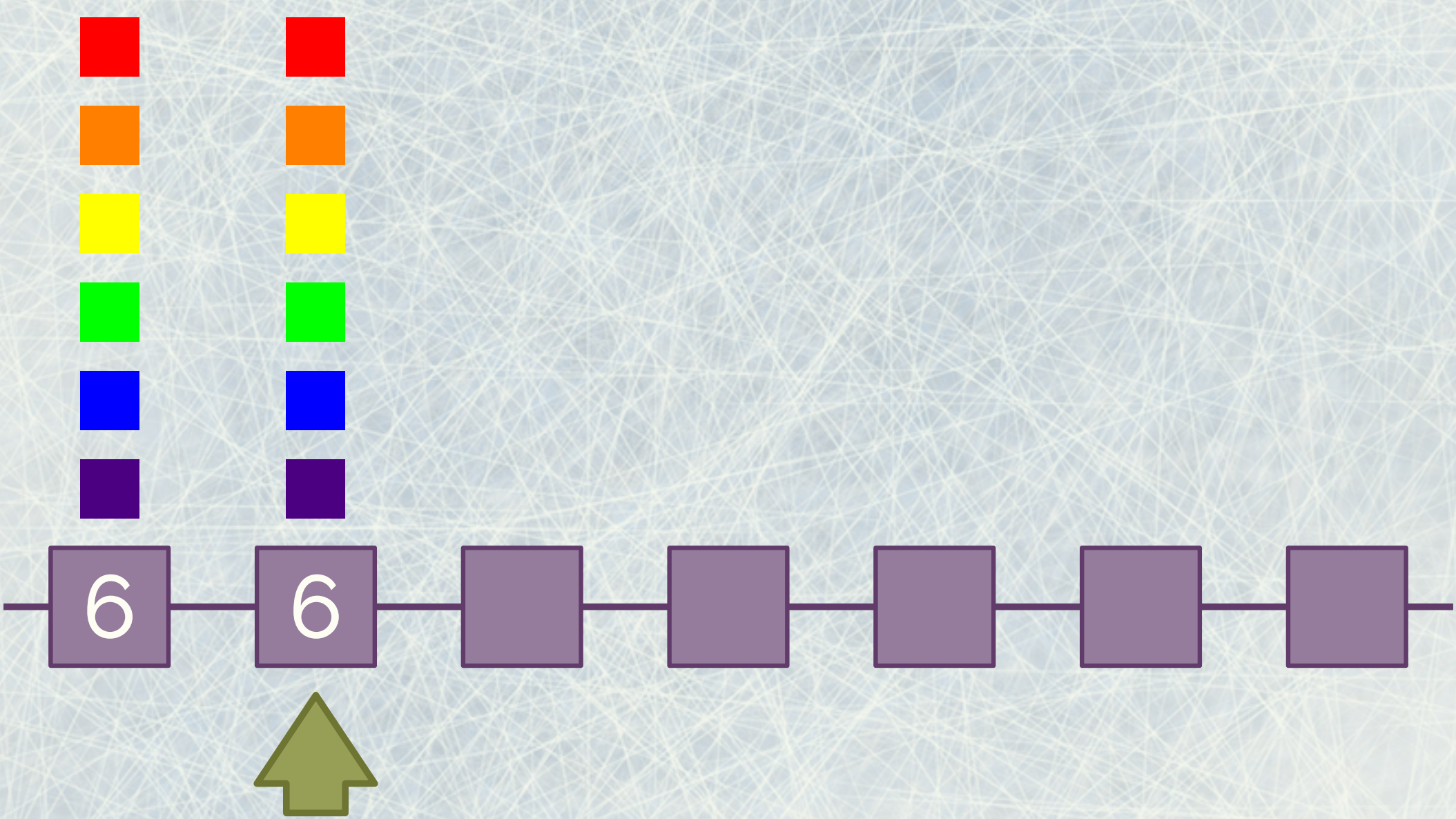
1D Bounded Reach Scenario



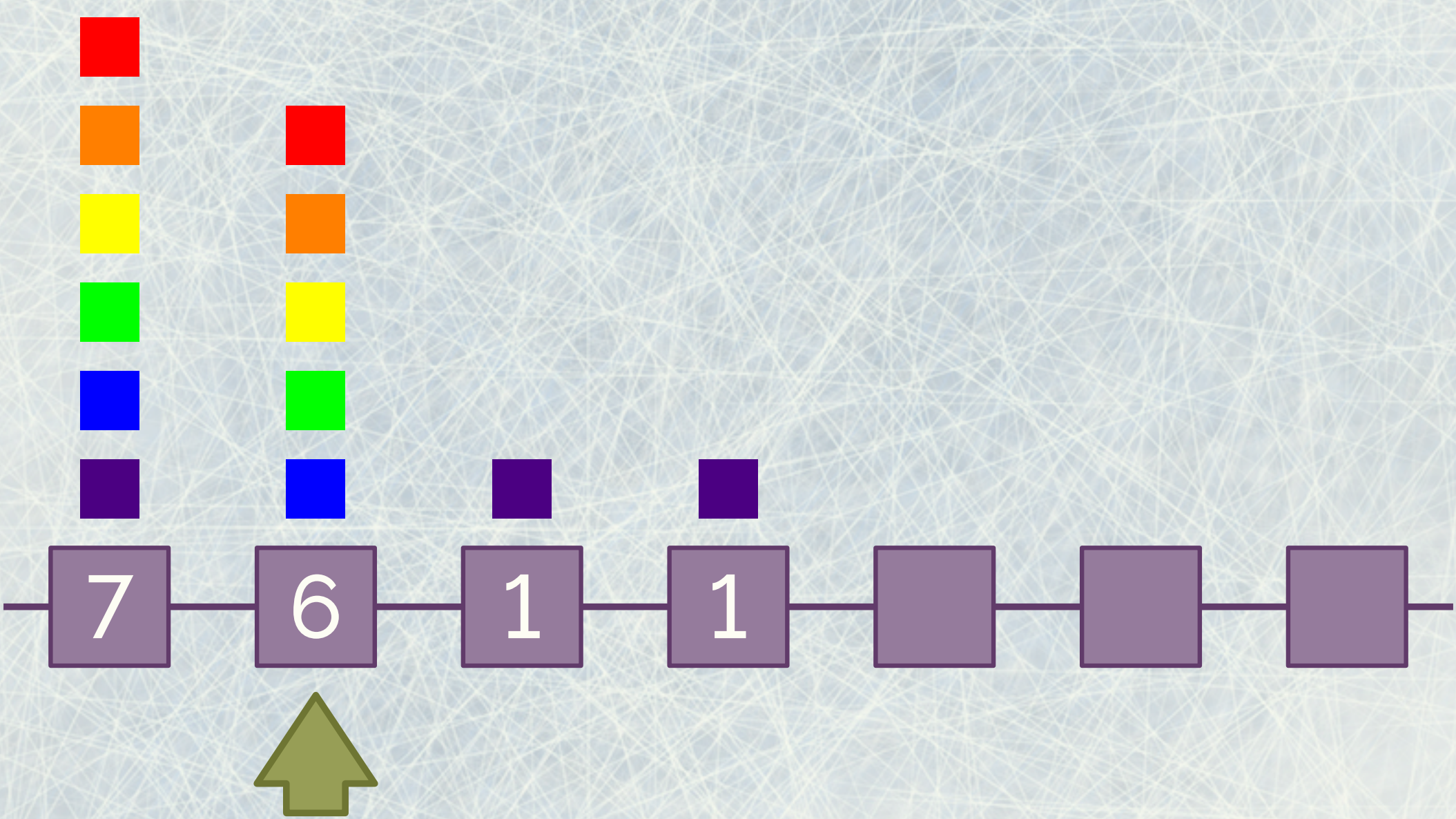
Flooding in 1D Bounded Reach Scenario



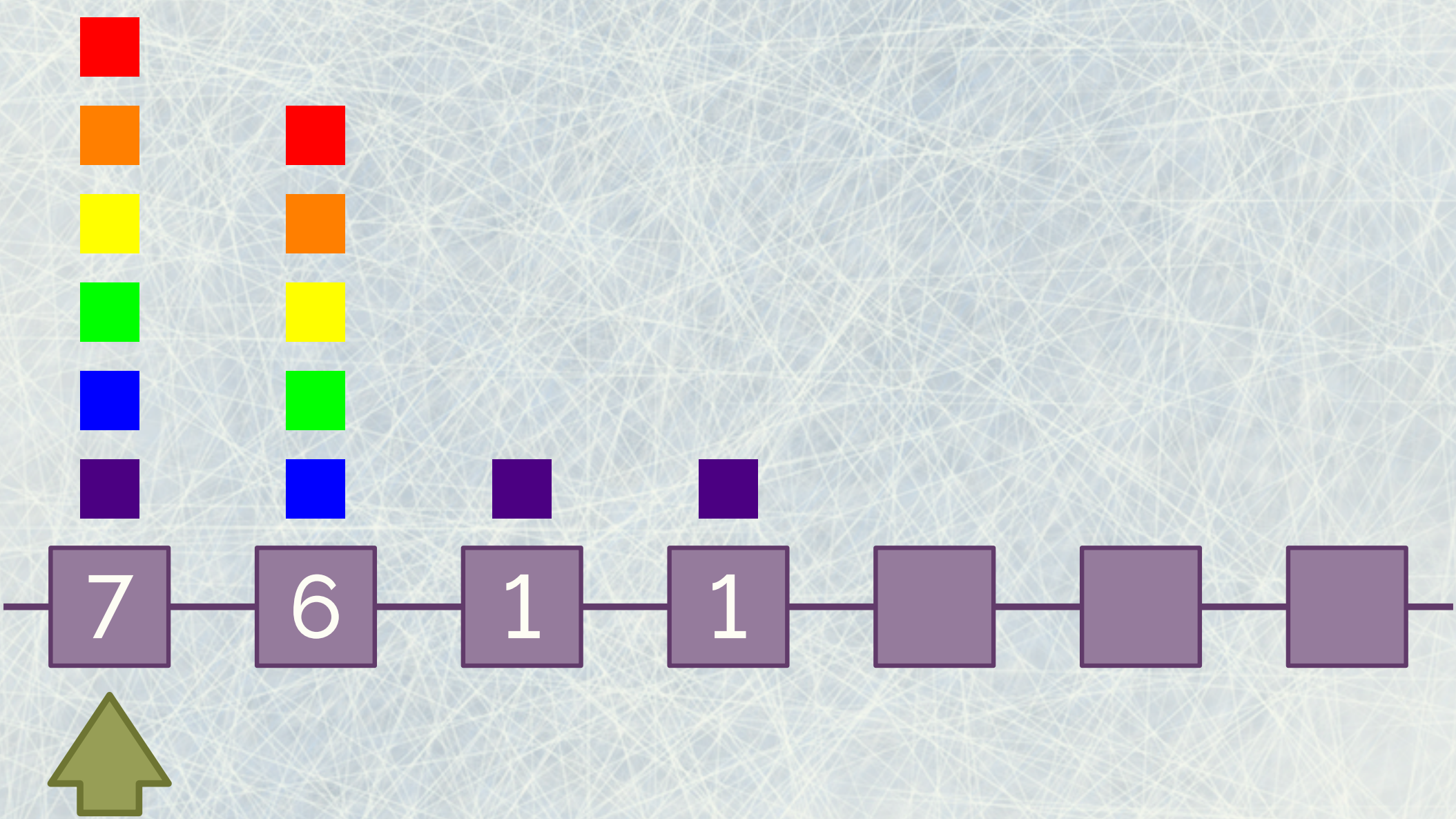
Flooding in 1D Bounded Reach Scenario



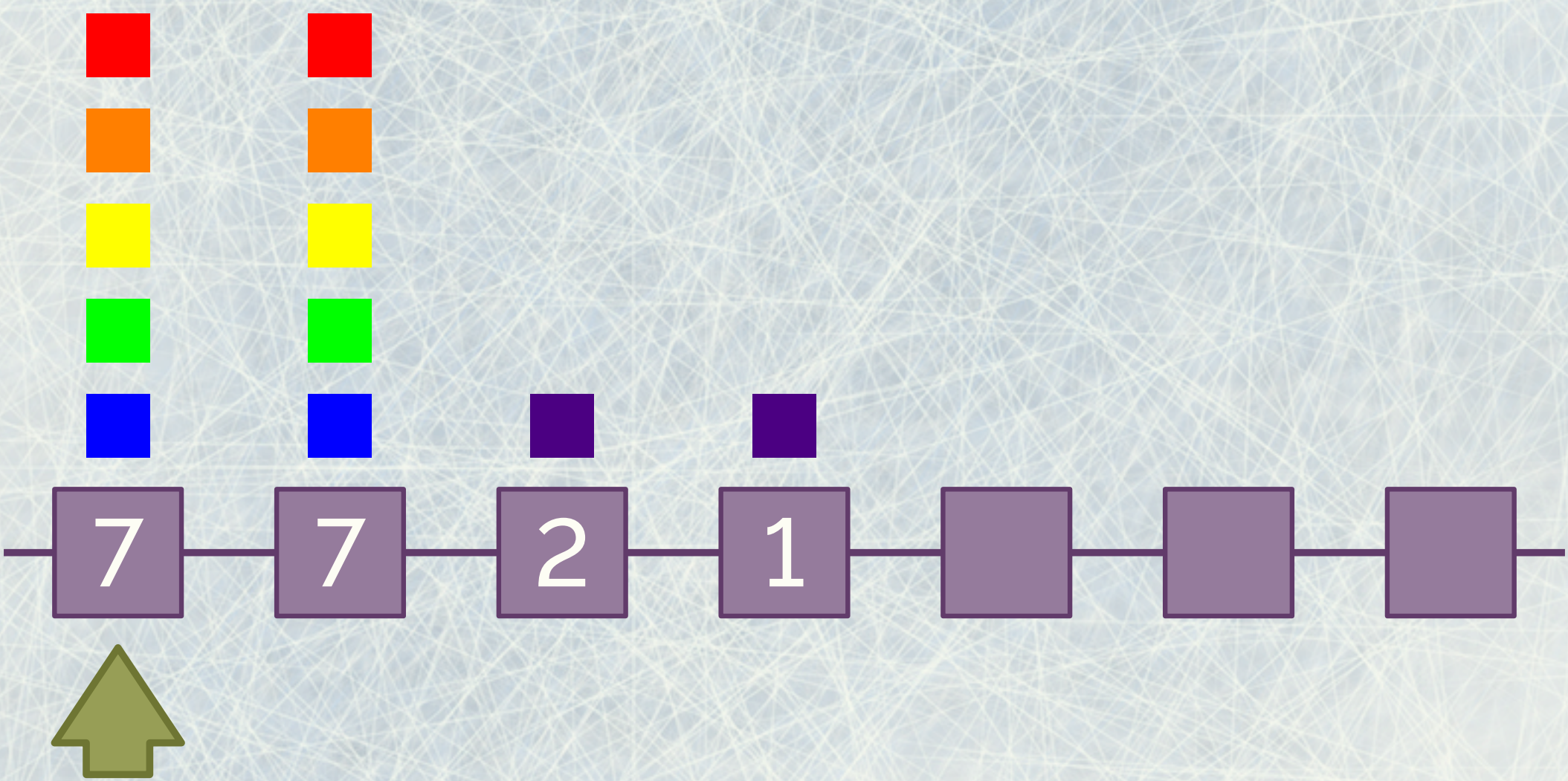
Flooding in 1D Bounded Reach Scenario



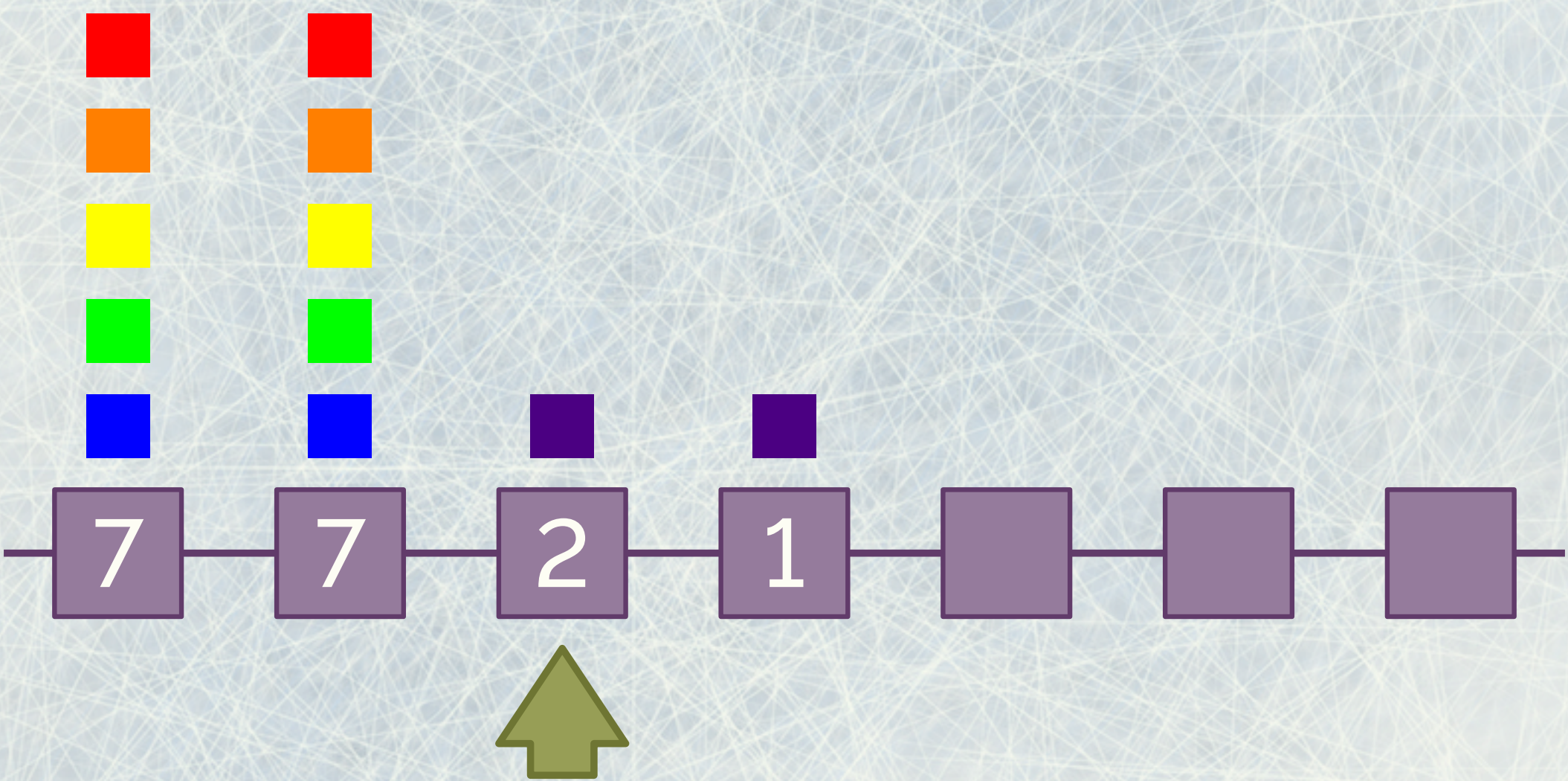
Flooding in 1D Bounded Reach Scenario



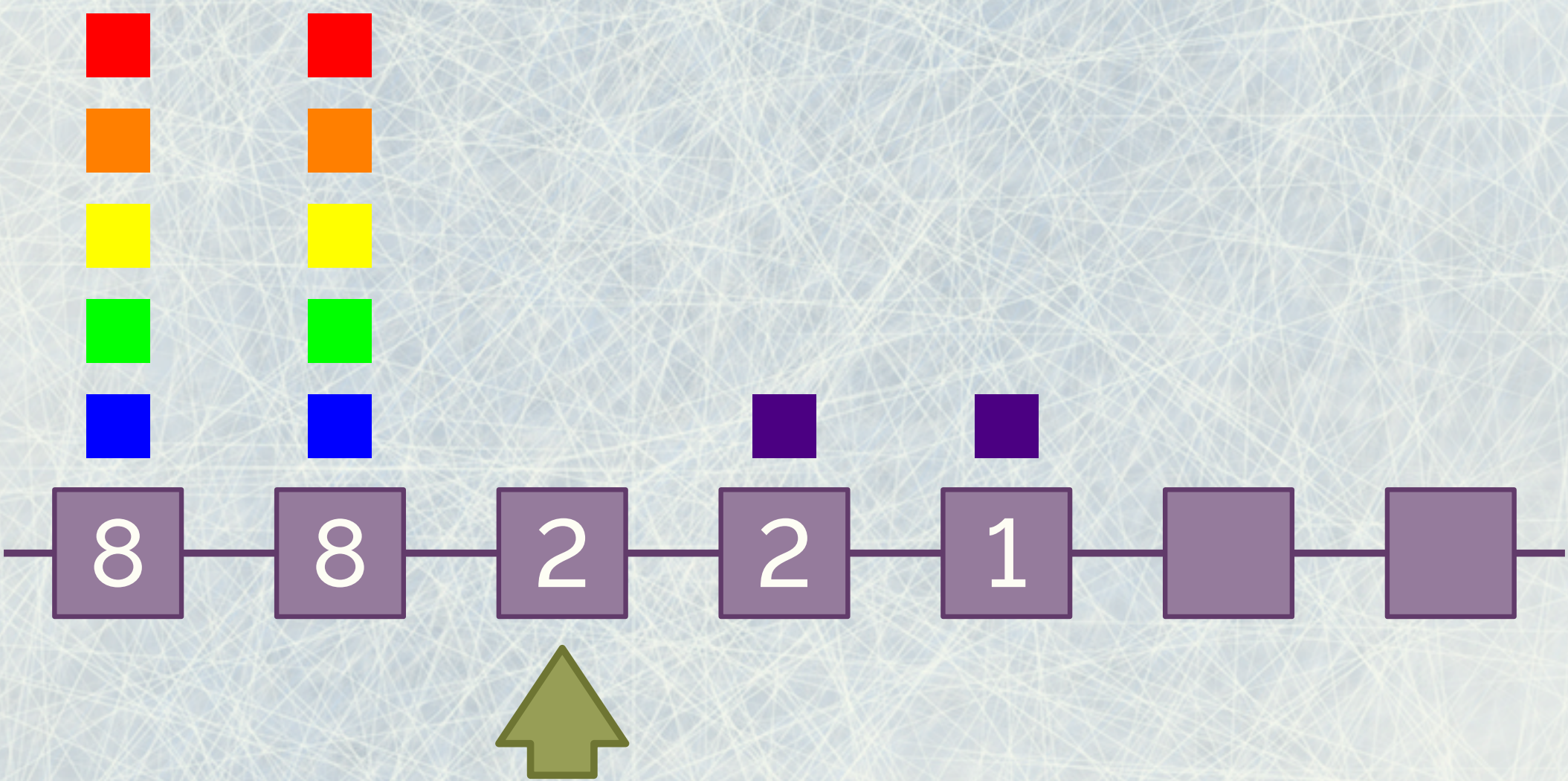
Flooding in 1D Bounded Reach Scenario



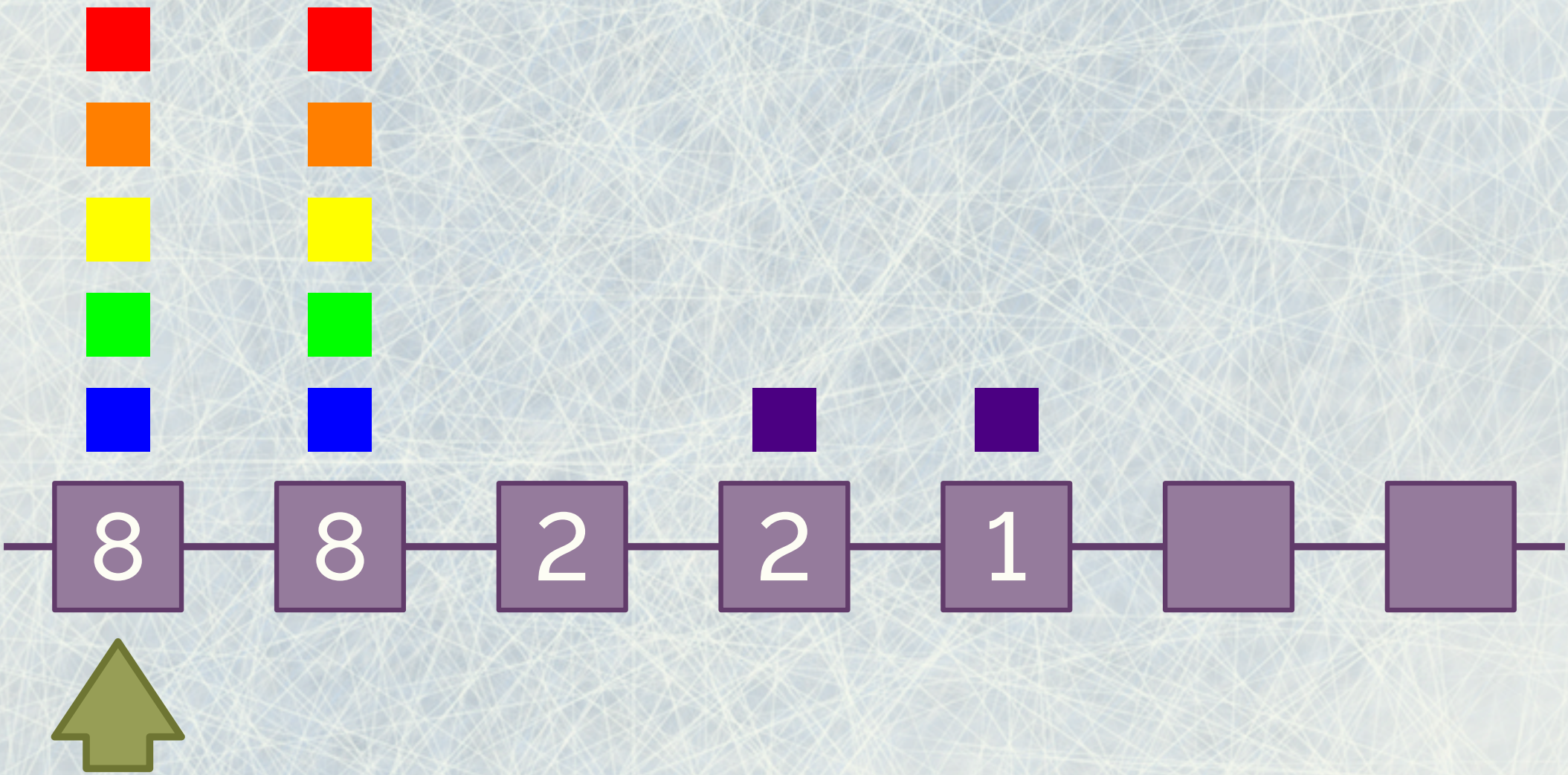
Flooding in 1D Bounded Reach Scenario



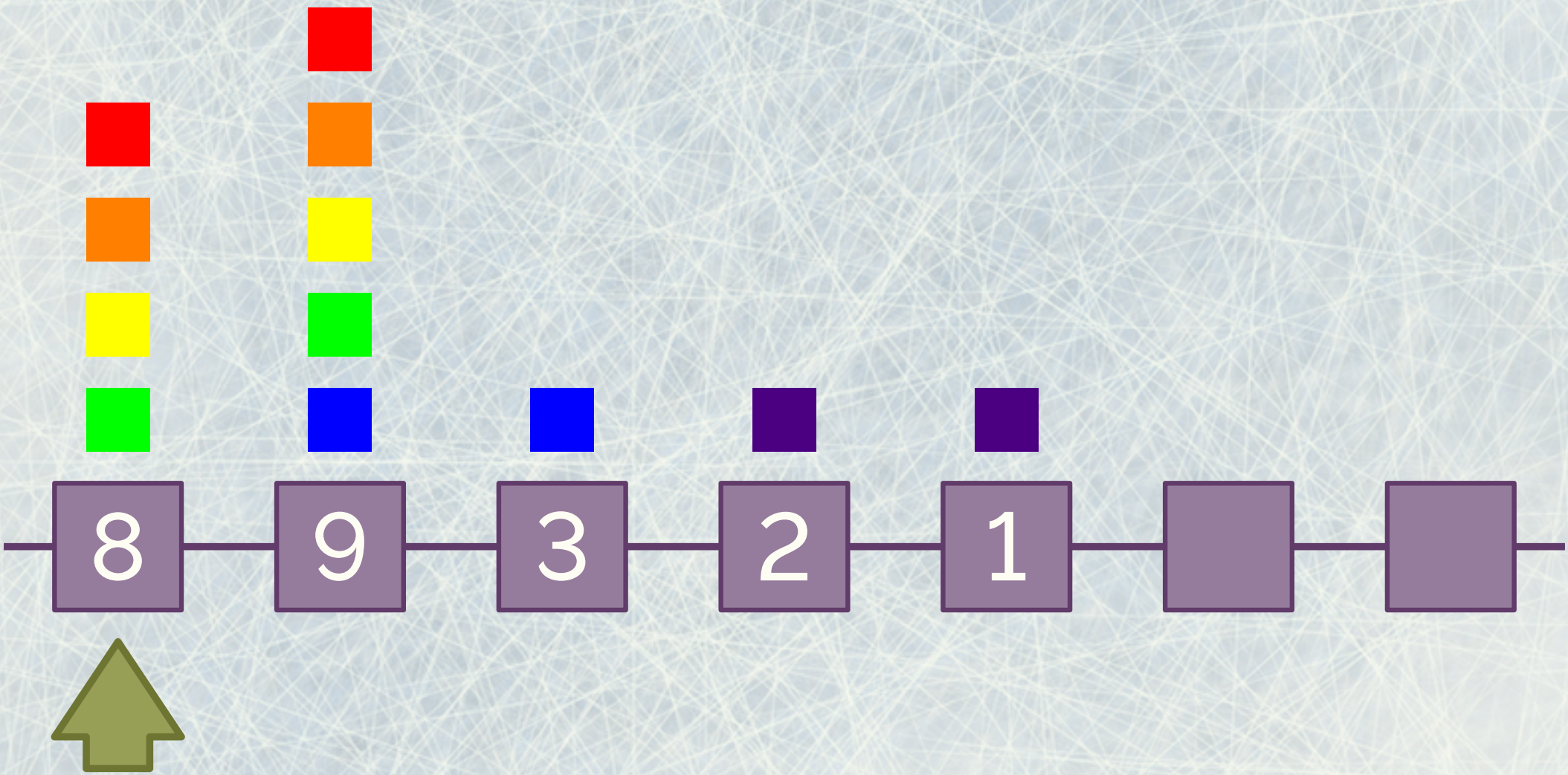
Flooding in 1D Bounded Reach Scenario



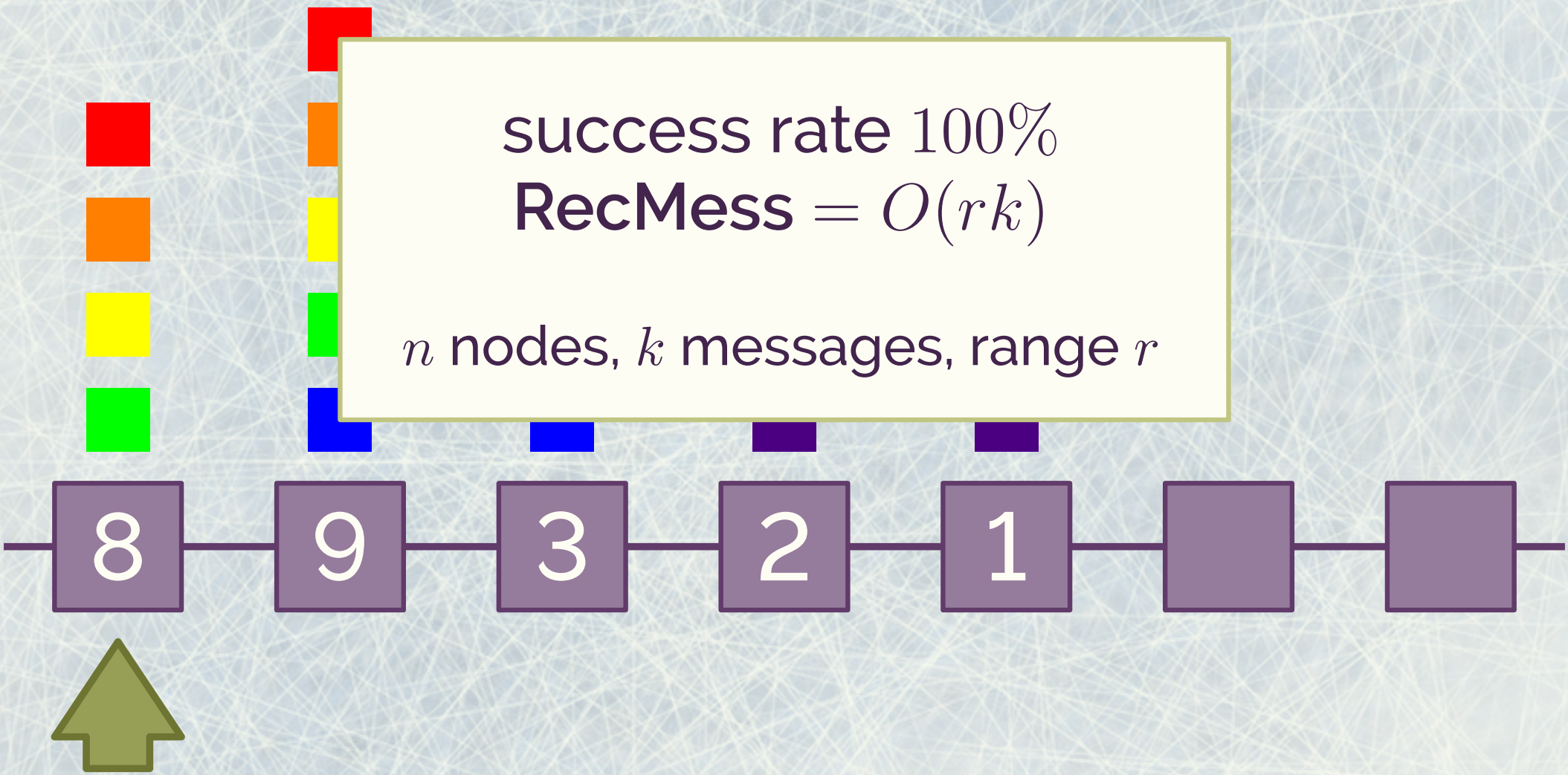
Flooding in 1D Bounded Reach Scenario



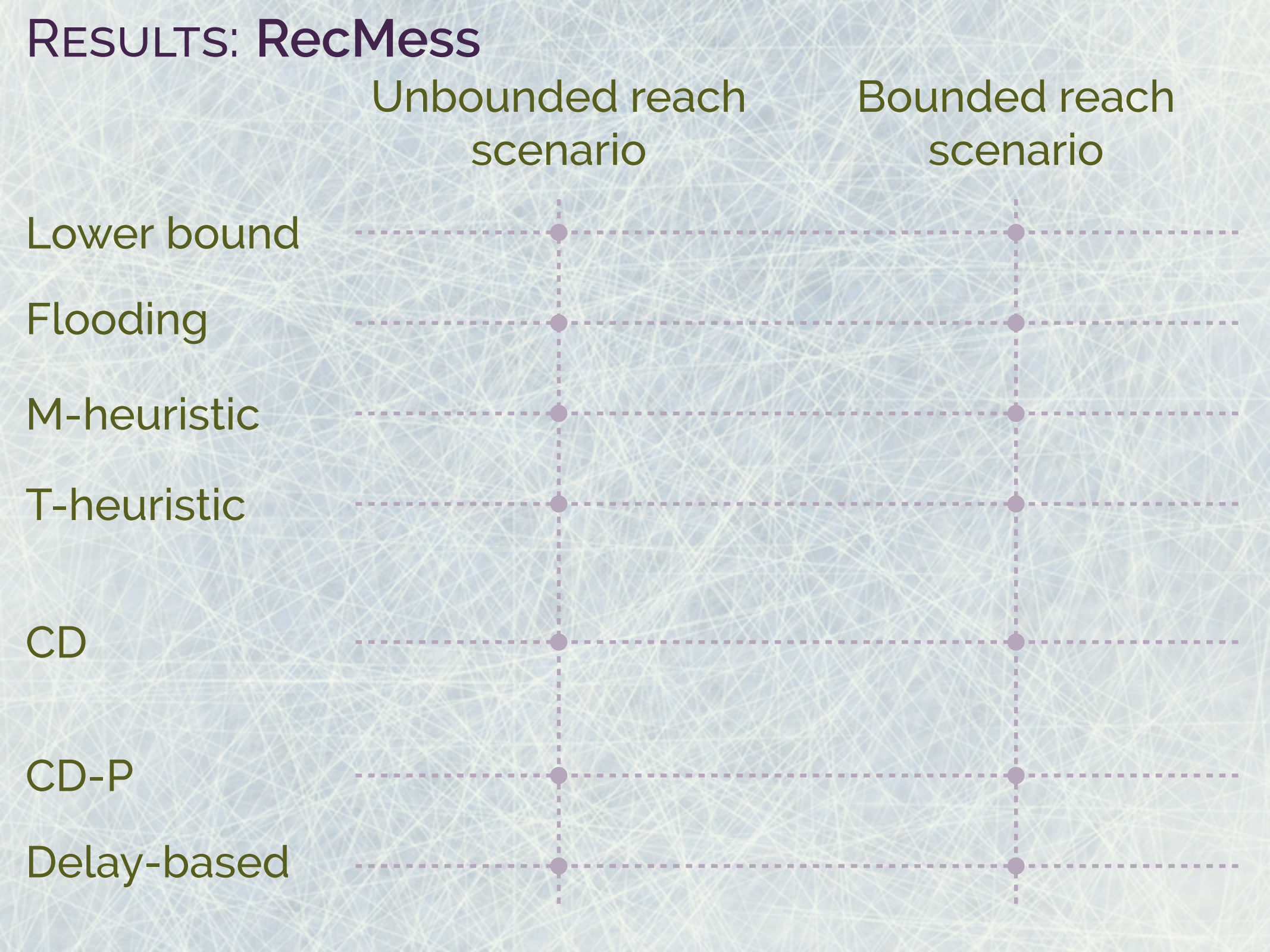
Flooding in 1D Bounded Reach Scenario



Flooding in 1D Bounded Reach Scenario



Results: RecMess



Results: RecMess

	Unbounded reach scenario	Bounded reach scenario
Lower bound	$\Omega(k)$	$\Omega(k)$
Flooding		
M-heuristic		
T-heuristic		
CD		
CD-P		
Delay-based		

Results: RecMess

	Unbounded reach scenario	Bounded reach scenario
Lower bound	$\Omega(k)$	$\Omega(k)$
Flooding	nk	$O(rk)$
M-heuristic		
T-heuristic		
CD		
CD-P		
Delay-based		

Results: RecMess

	Unbounded reach scenario	Bounded reach scenario
Lower bound	$\Omega(k)$	$\Omega(k)$
Flooding	nk	$O(rk)$
M-heuristic	Mk	$\min\{Mk, 2rk\}$
T-heuristic		
CD		
CD-P		
Delay-based		

Results: RecMess

	Unbounded reach scenario	Bounded reach scenario
Lower bound	$\Omega(k)$	$\Omega(k)$
Flooding	nk	$O(rk)$
M-heuristic	Mk	$\min\{Mk, 2rk\}$
T-heuristic	$\left[\lceil \frac{n}{2T} \rceil k, \lceil \frac{n}{T} \rceil k\right]$	$O(\frac{rk}{T})$
CD		
CD-P		
Delay-based		

Results: RecMess

	Unbounded reach scenario	Bounded reach scenario
Lower bound	$\Omega(k)$	$\Omega(k)$
Flooding	nk	$O(rk)$
M-heuristic	Mk	$\min\{Mk, 2rk\}$
T-heuristic	$\left[\lceil \frac{n}{2T} \rceil k, \lceil \frac{n}{T} \rceil k\right]$	$O(\frac{rk}{T})$
CD	$\Theta(nk)$ if $k > n$, else $\Theta(k^2 \log(\lceil n/k \rceil + 1))$	$O(k^{3/2})$
CD-P		
Delay-based		

Results: RecMess

	Unbounded reach scenario	Bounded reach scenario
Lower bound	$\Omega(k)$	$\Omega(k)$
Flooding	nk	$O(rk)$
M-heuristic	Mk	$\min\{Mk, 2rk\}$
T-heuristic	$\left[\lceil \frac{n}{2T} \rceil k, \lceil \frac{n}{T} \rceil k\right]$	$O(\frac{rk}{T})$
CD	$\Theta(nk)$ if $k > n$, else $\Theta(k^2 \log(\lceil n/k \rceil + 1))$	$O(k^{3/2})$
CD-P	$O(k \log n)$	$\Theta(k)$
Delay-based		

RESULTS: RecMess

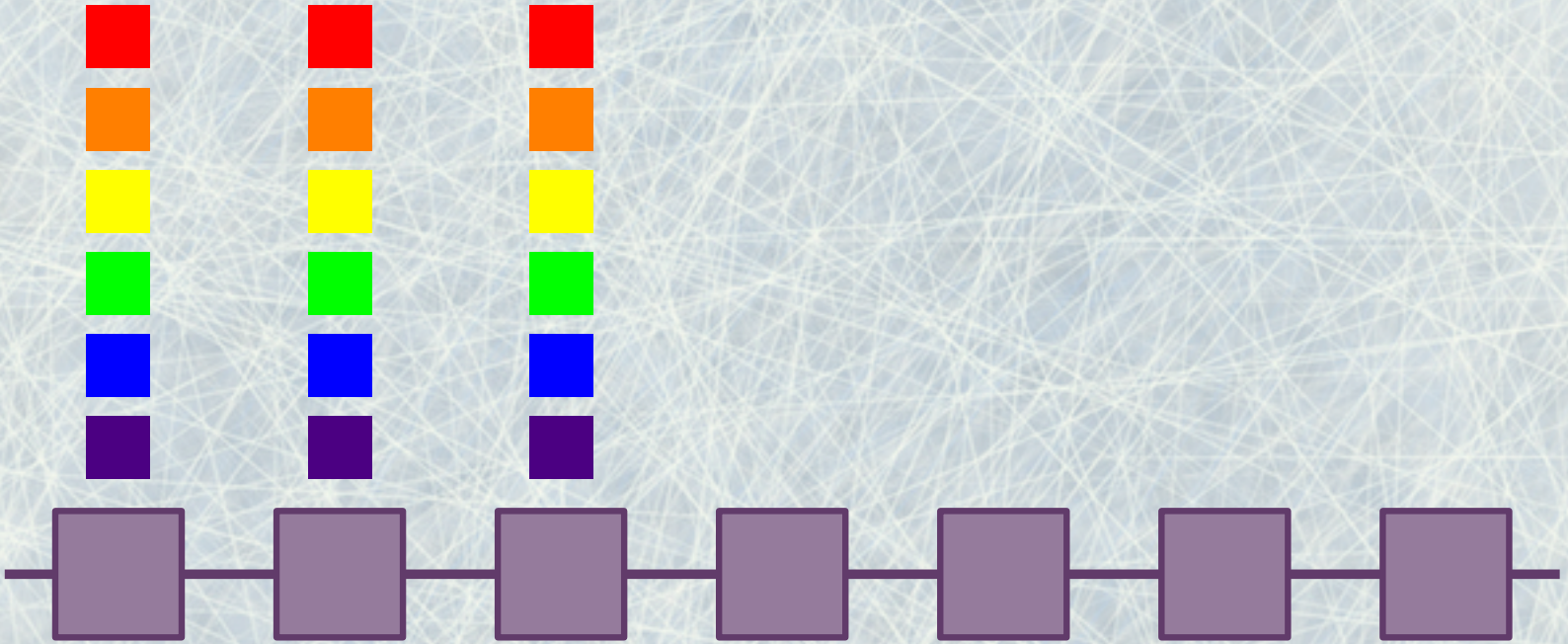
	Unbounded reach scenario	Bounded reach scenario
Lower bound	$\Omega(k)$	$\Omega(k)$
Flooding	nk	$O(rk)$
M-heuristic	Mk	$\min\{Mk, 2rk\}$
T-heuristic	$\left[\lceil \frac{n}{2T} \rceil k, \lceil \frac{n}{T} \rceil k\right]$	$O(\frac{rk}{T})$
CD	$\Theta(nk)$ if $k > n$, else $\Theta(k^2 \log(\lceil n/k \rceil + 1))$	$O(k^{3/2})$
CD-P	$O(k \log n)$	$\Theta(k)$
Delay-based	$\min\{2^k, n(1+k-\log n)\}$	$O(\frac{nk}{r})$

Results: RecMess

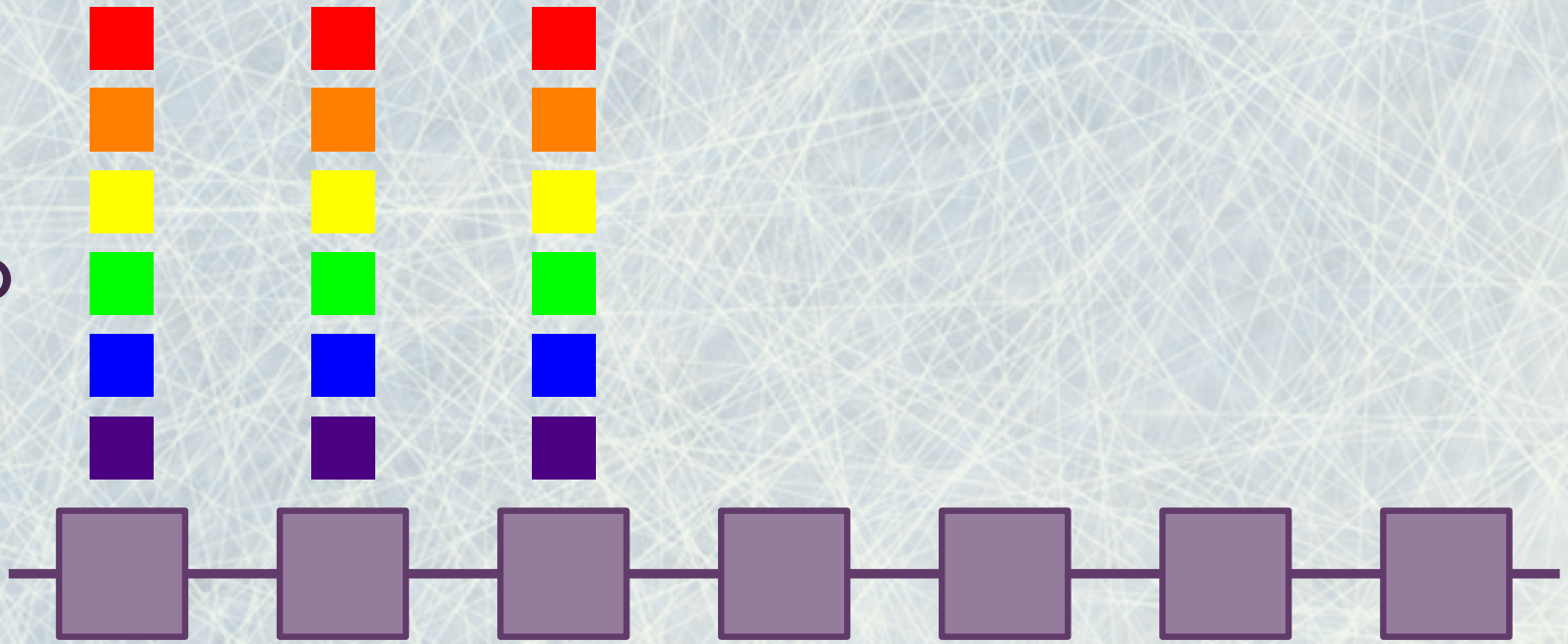
	Unbounded reach scenario	Bounded reach scenario
Lower bound	$\Omega(k)$	$\Omega(k)$
Flooding	nk	$O(rk)$
M-heuristic	Mk	$\min\{Mk, 2rk\}$
T-heuristic	$\left[\lceil \frac{n}{2T} \rceil k, \lceil \frac{n}{T} \rceil k\right]$	$O(\frac{rk}{T})$
CD	$\Theta(nk)$ if $k > n$, else $\Theta(k^2 \log(\lceil n/k \rceil + 1))$	$O(k^{3/2})$
CD-P	$O(k \log n)$	$\Theta(k)$
Delay-based	$\min\{2^k, n(1+k-\log n)\}$	$O(\frac{nk}{r})$

CD and CD-P in Bounded Reach Scenario

CD

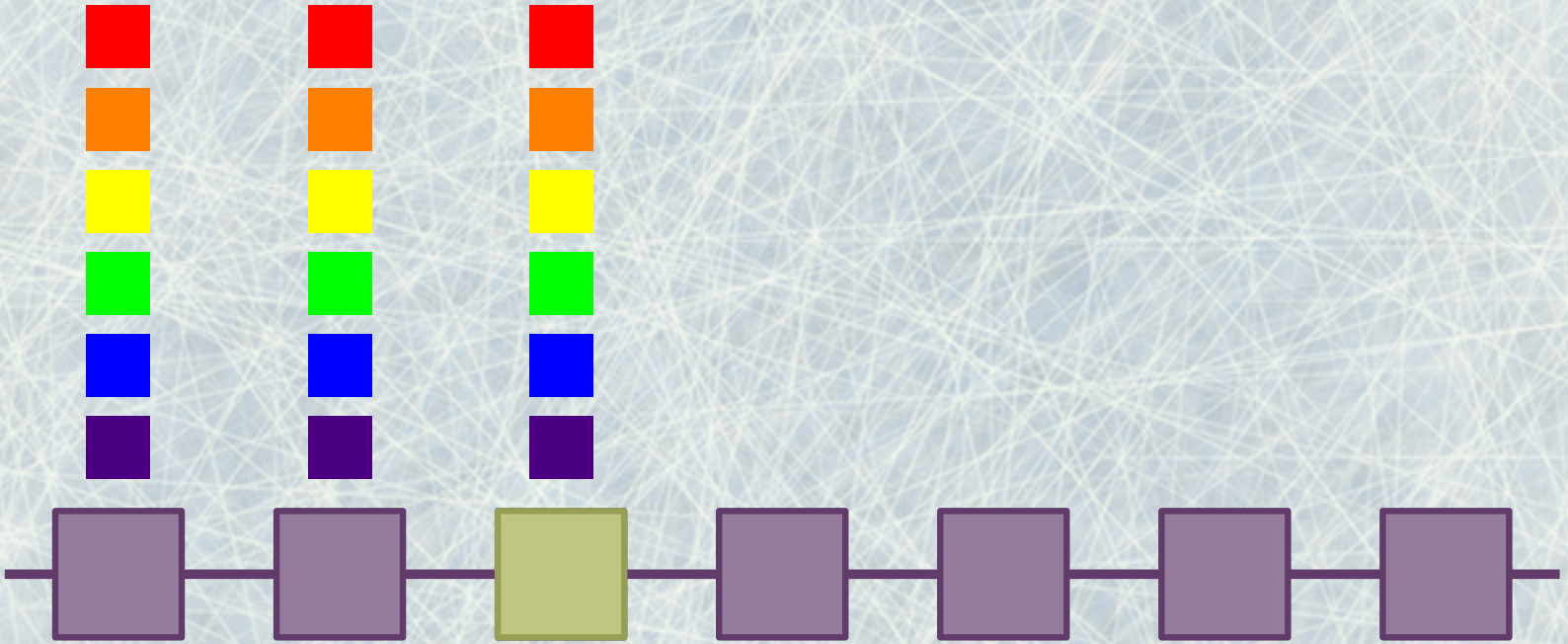


CD-P

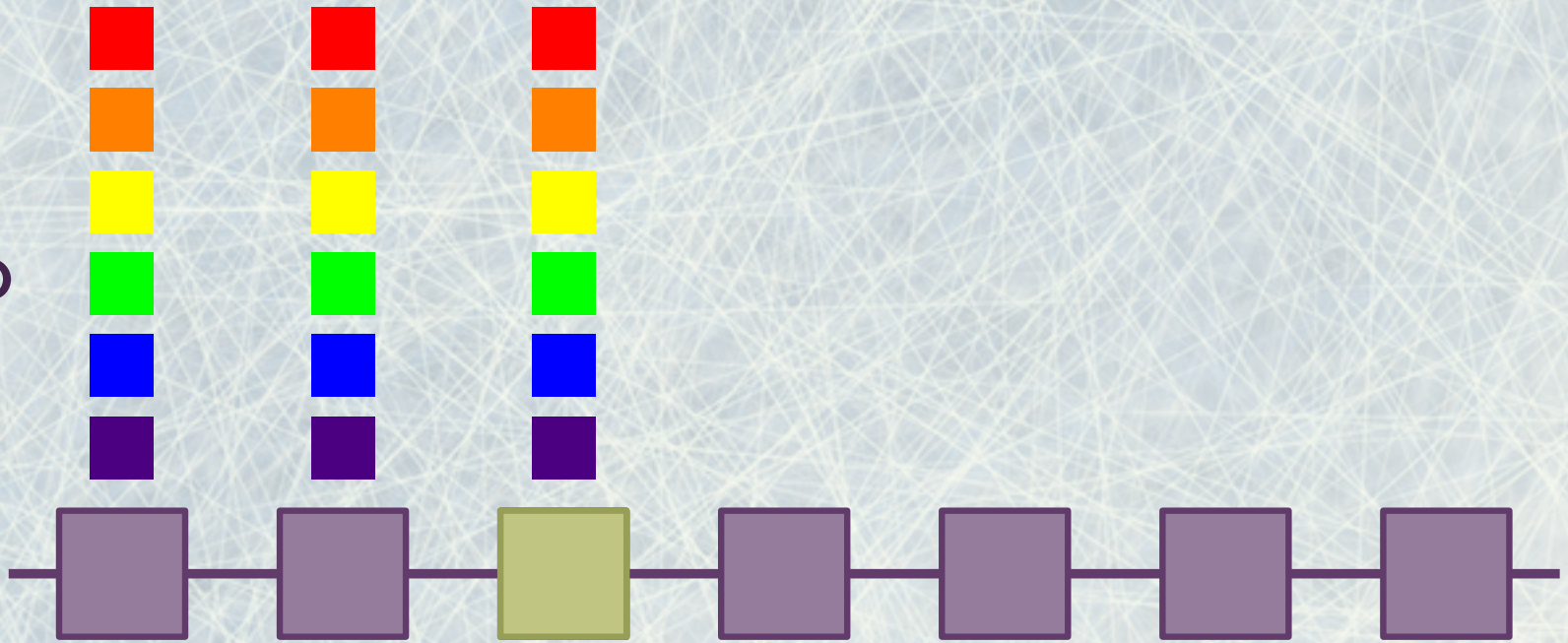


CD and CD-P in Bounded Reach Scenario

CD

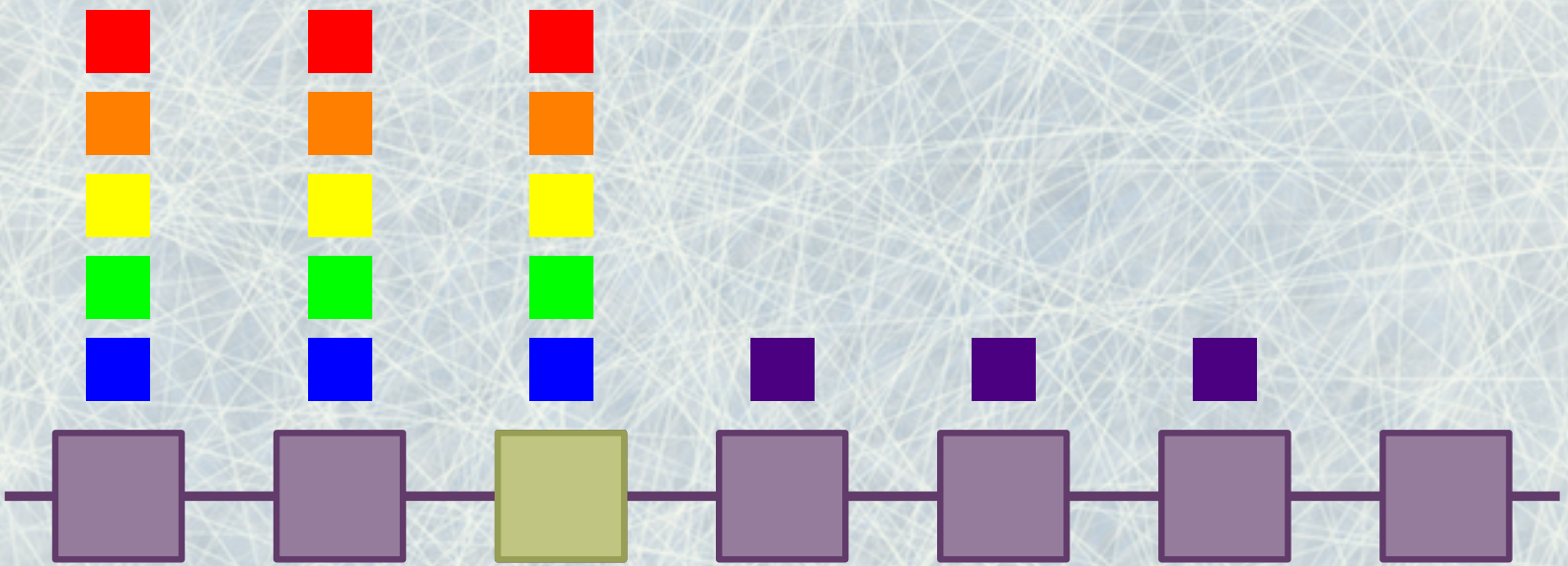


CD-P

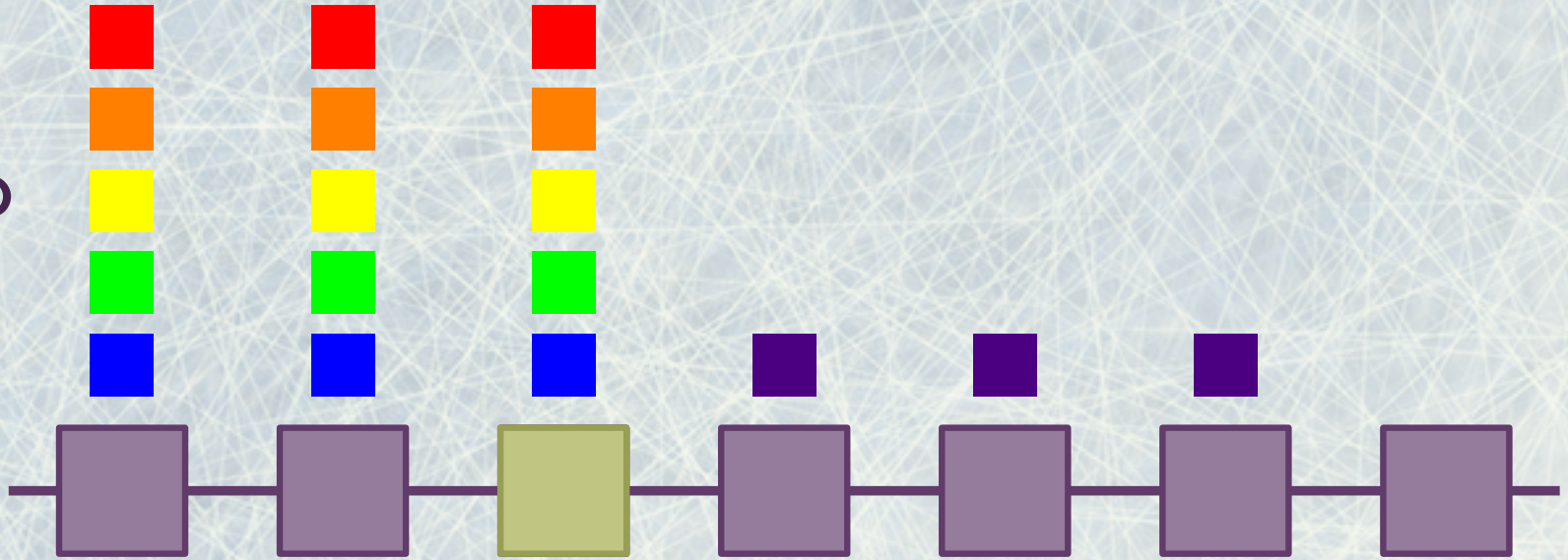


CD and CD-P in Bounded Reach Scenario

CD

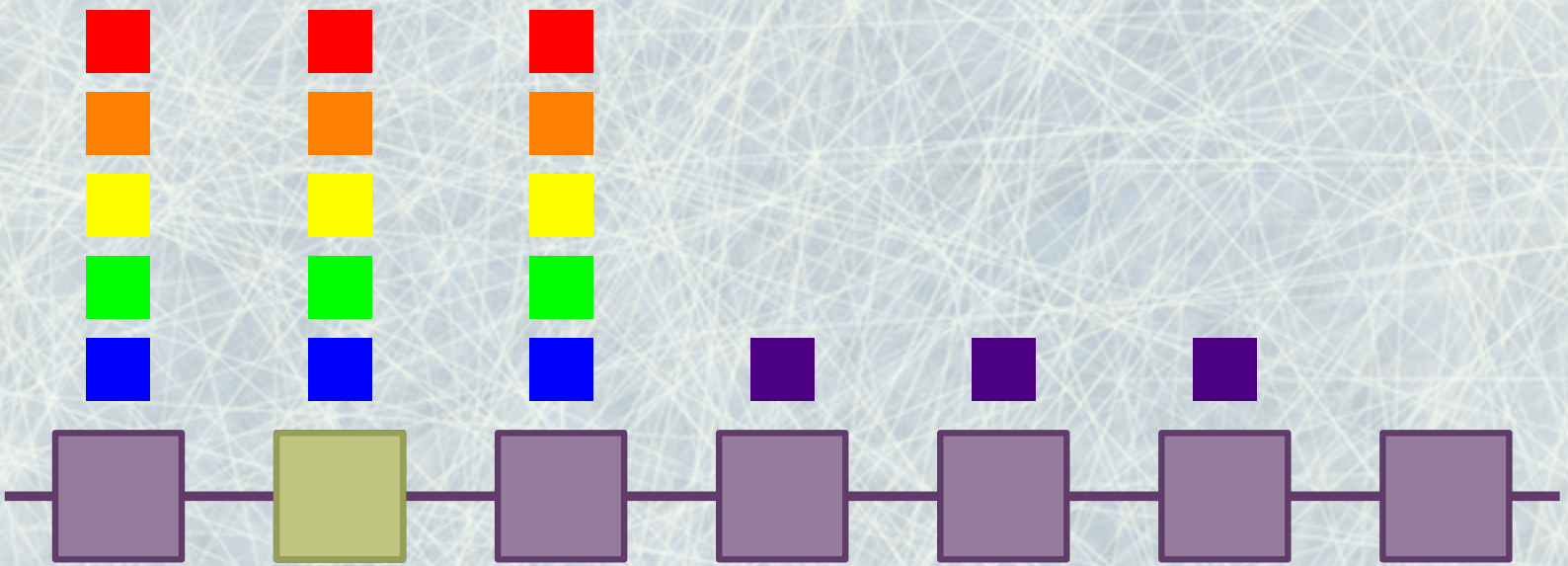


CD-P

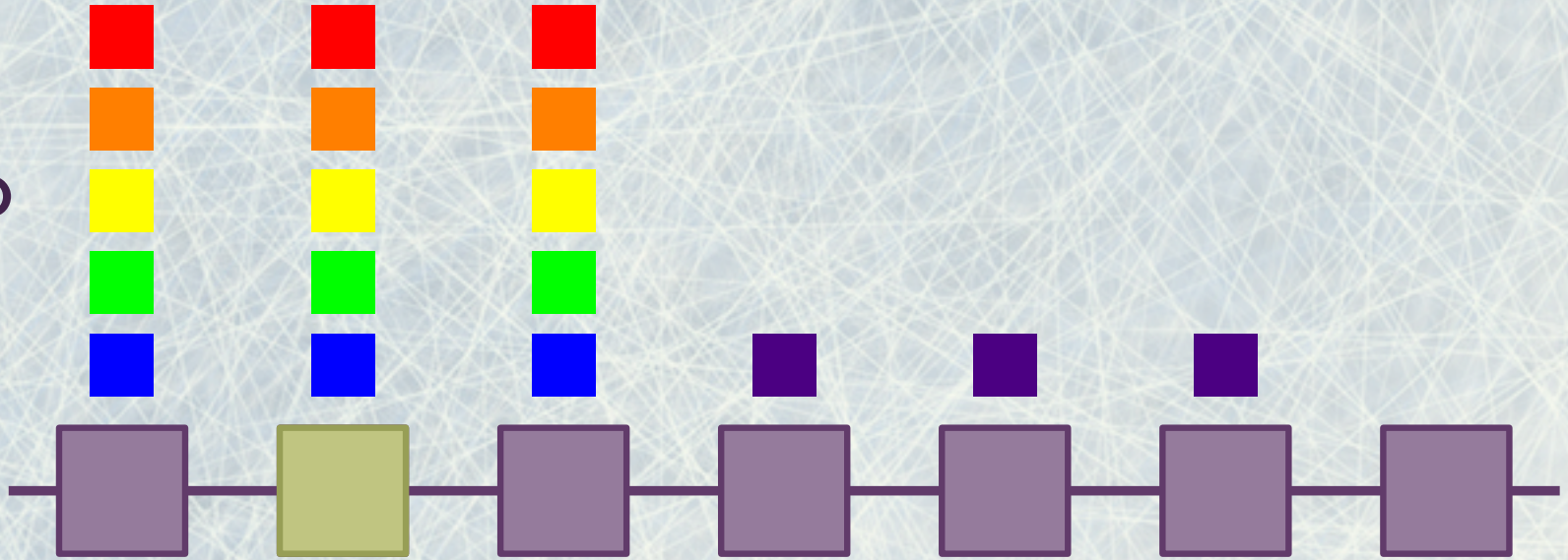


CD and CD-P in Bounded Reach Scenario

CD

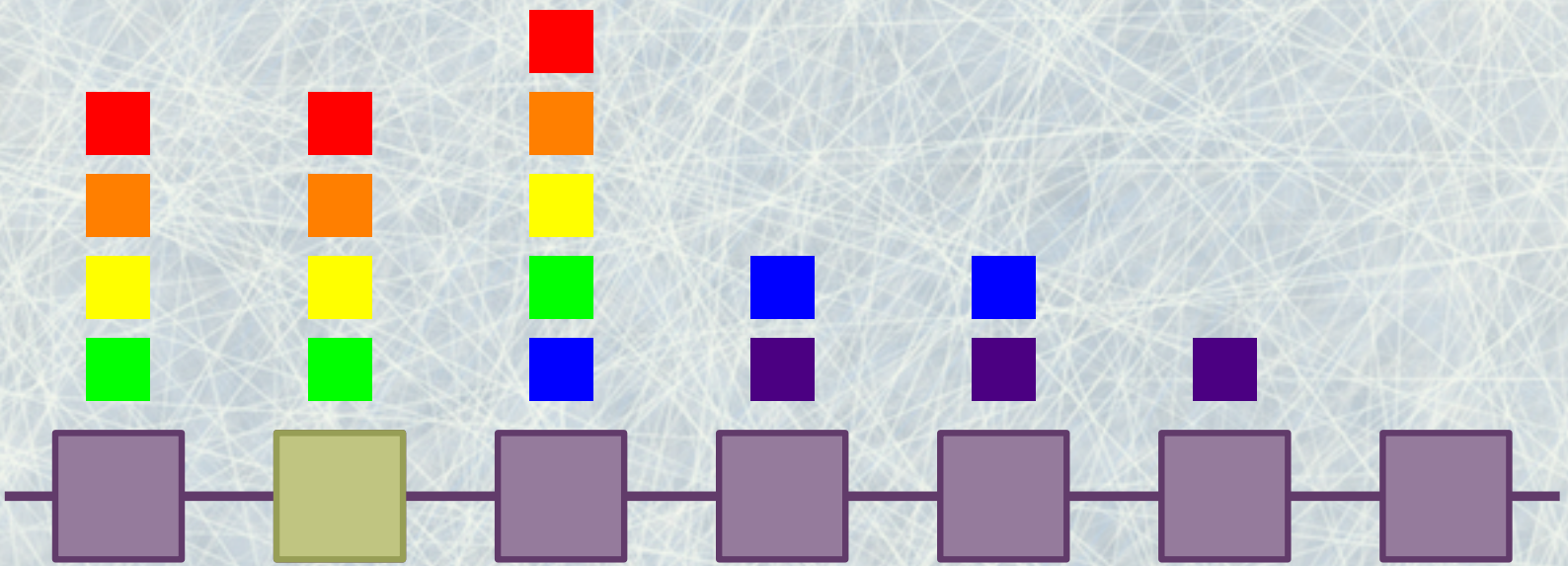


CD-P

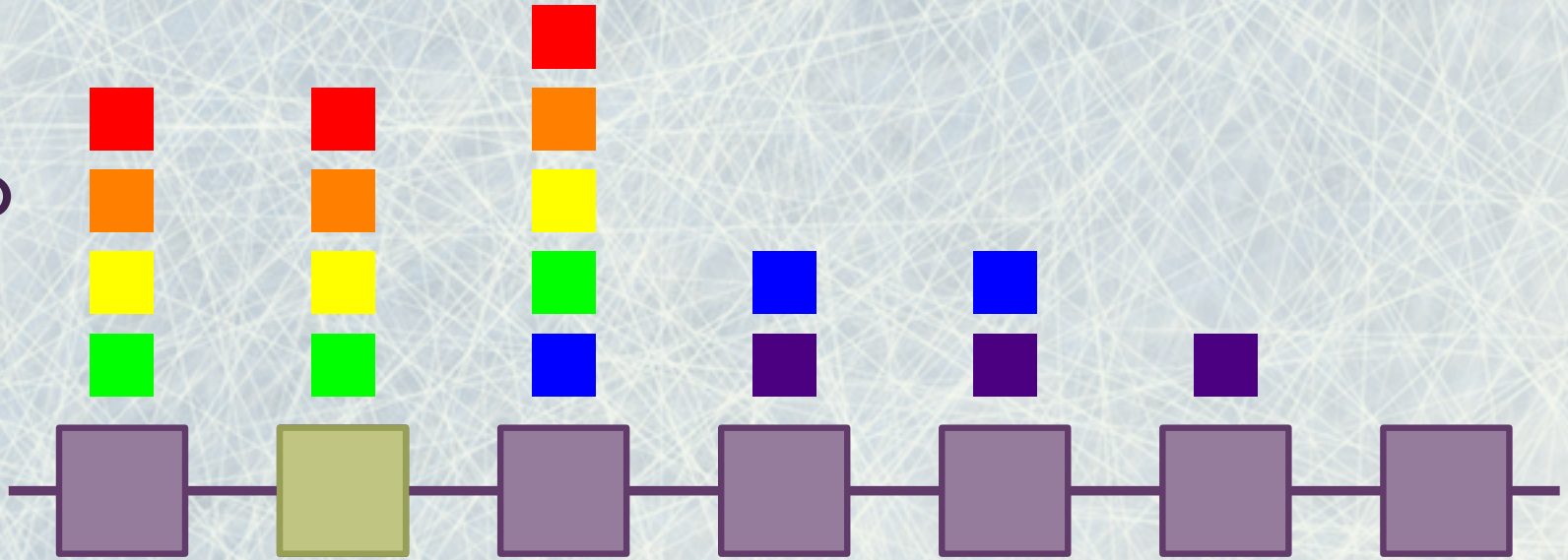


CD and CD-P in Bounded Reach Scenario

CD

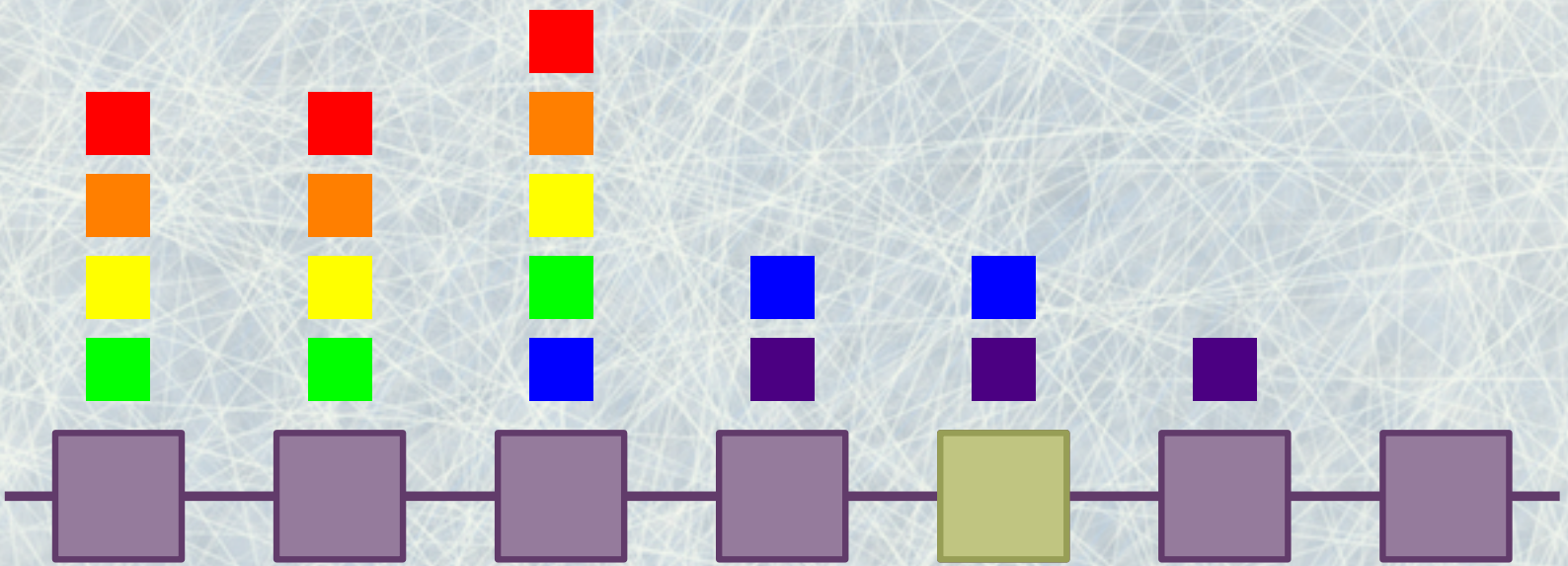


CD-P

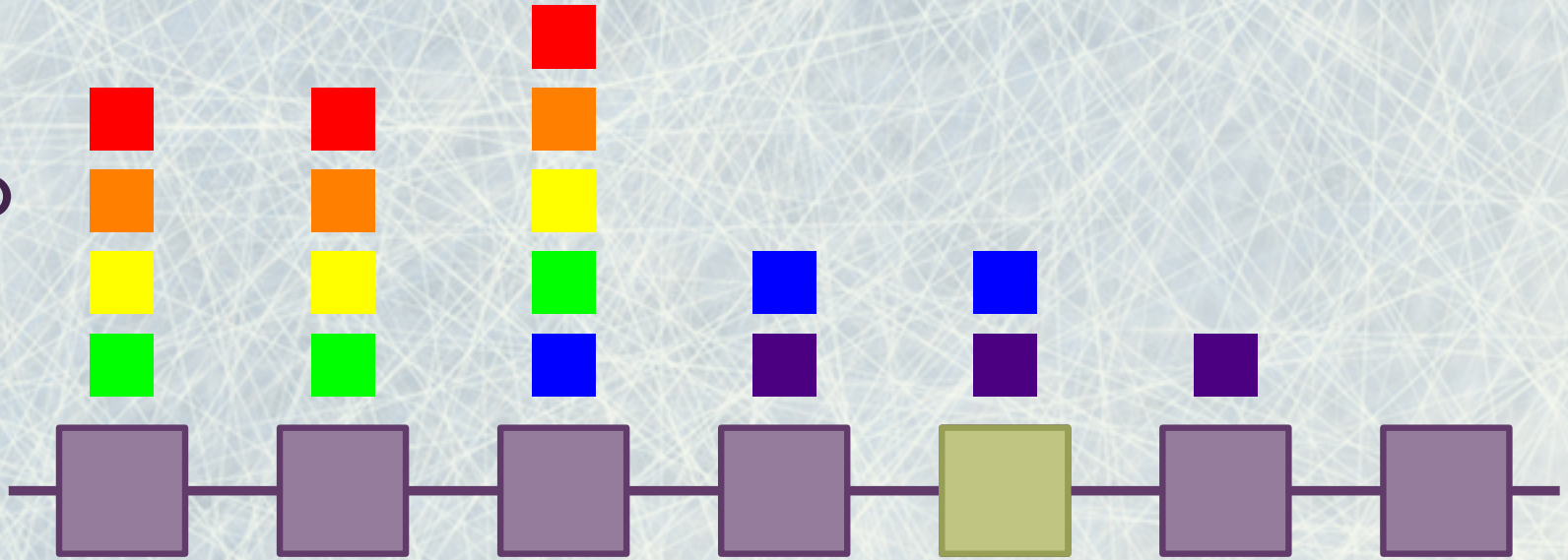


CD and CD-P in Bounded Reach Scenario

CD

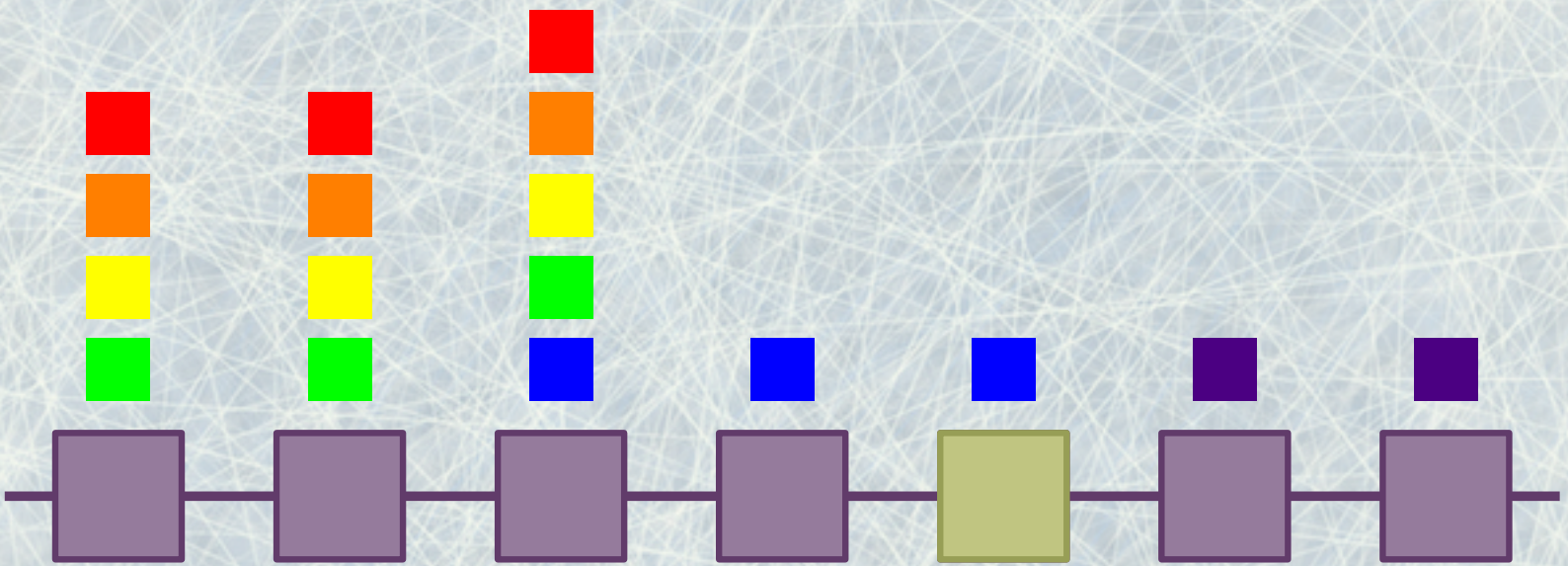


CD-P

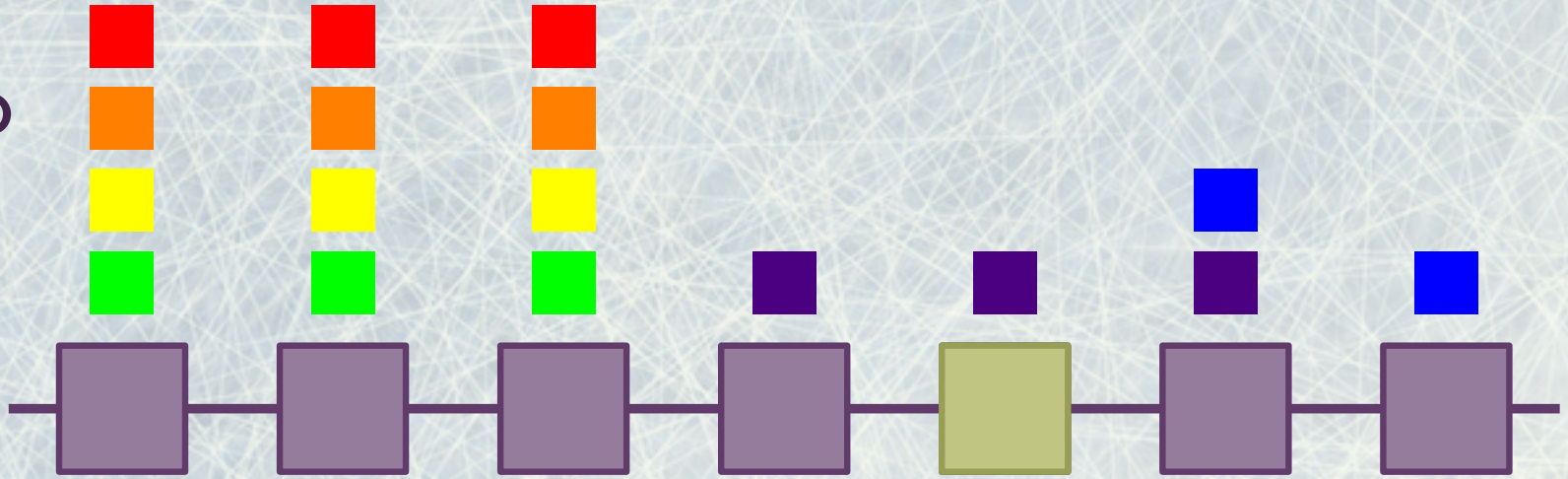


CD and CD-P in Bounded Reach Scenario

CD

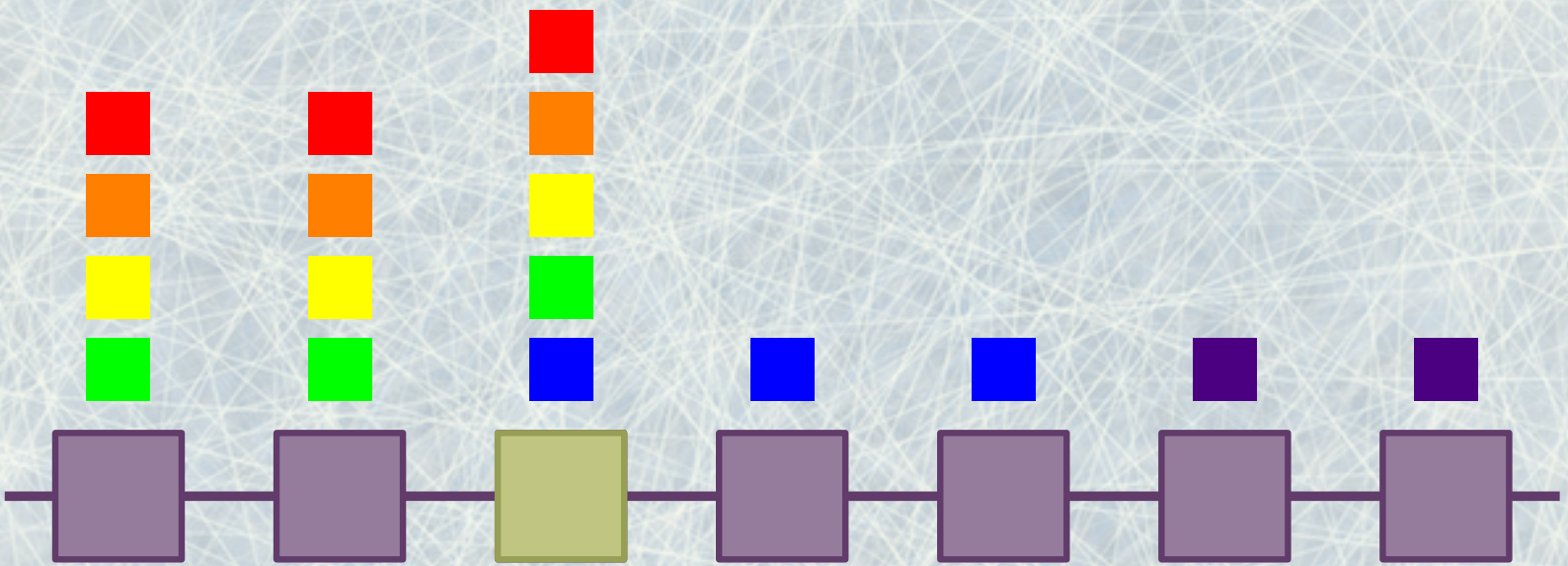


CD-P

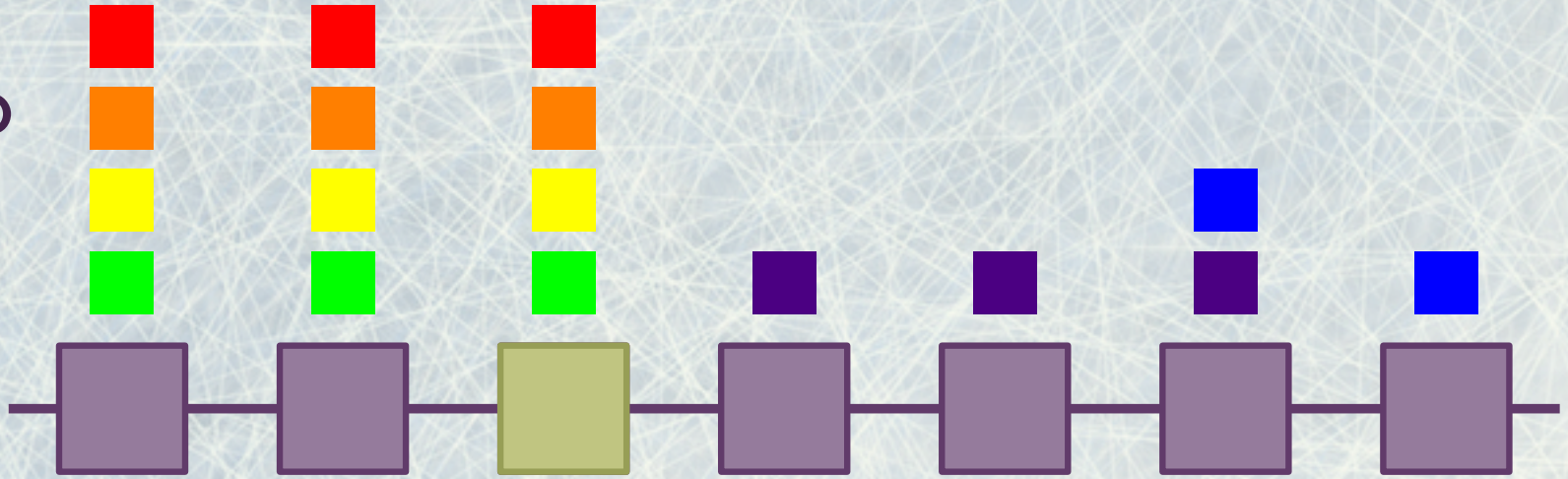


CD and CD-P in Bounded Reach Scenario

CD

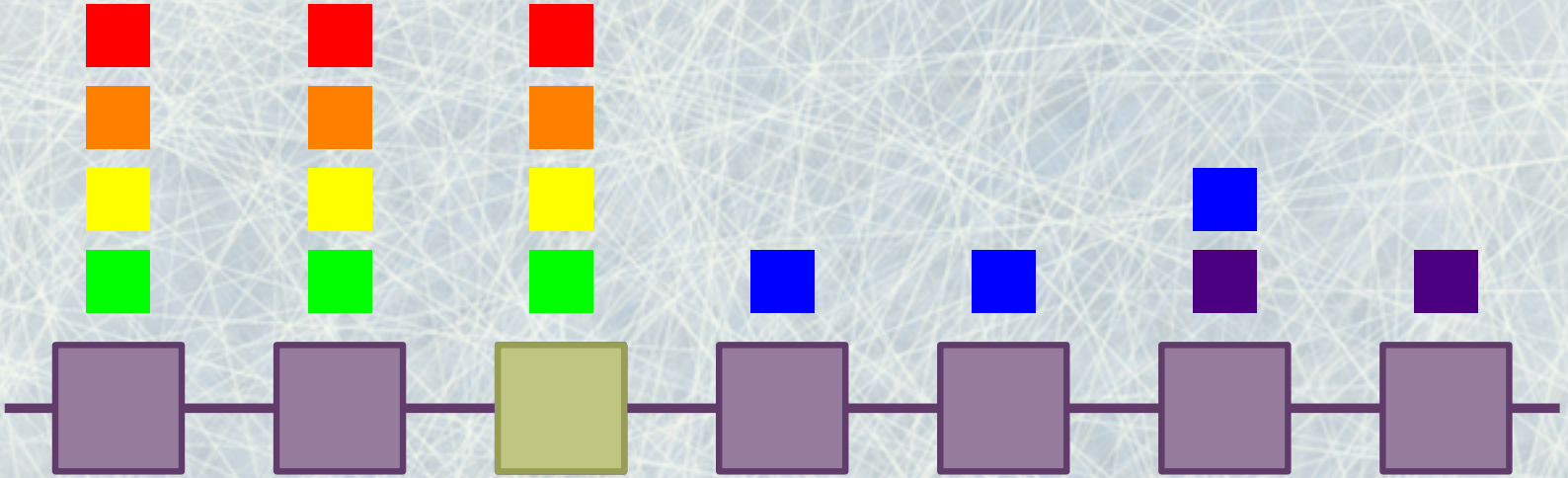


CD-P

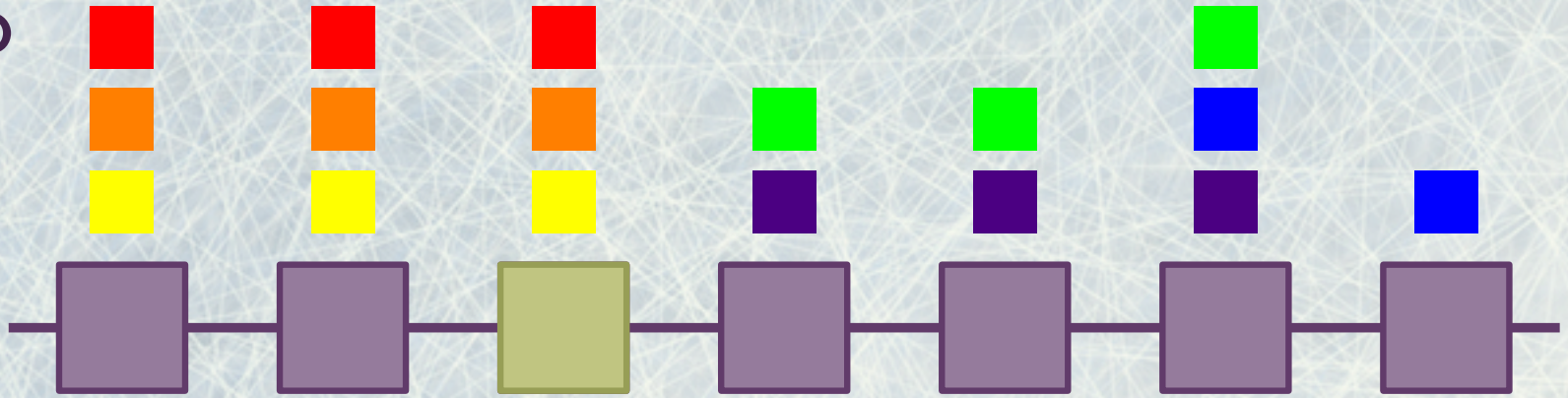


CD and CD-P in Bounded Reach Scenario

CD

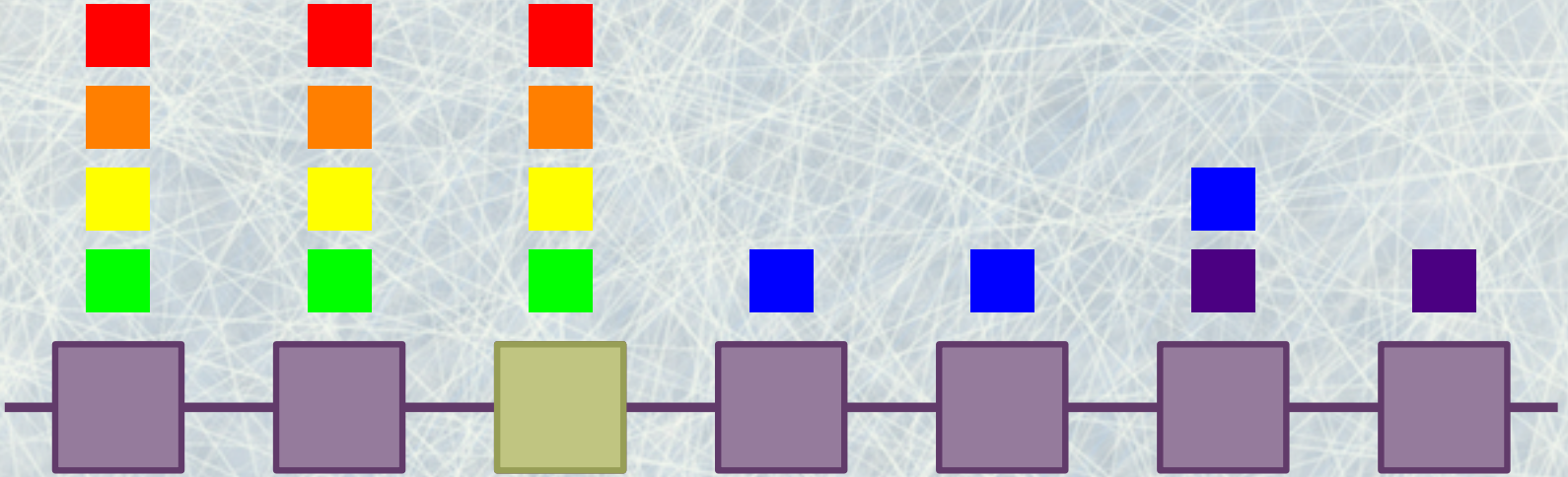


CD-P



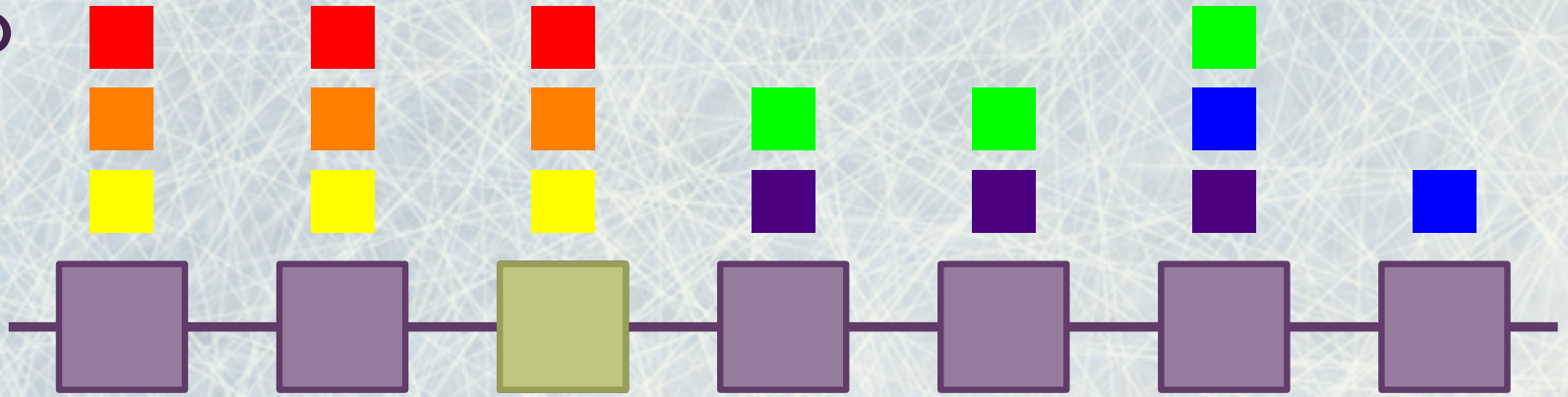
CD and CD-P in Bounded Reach Scenario

CD

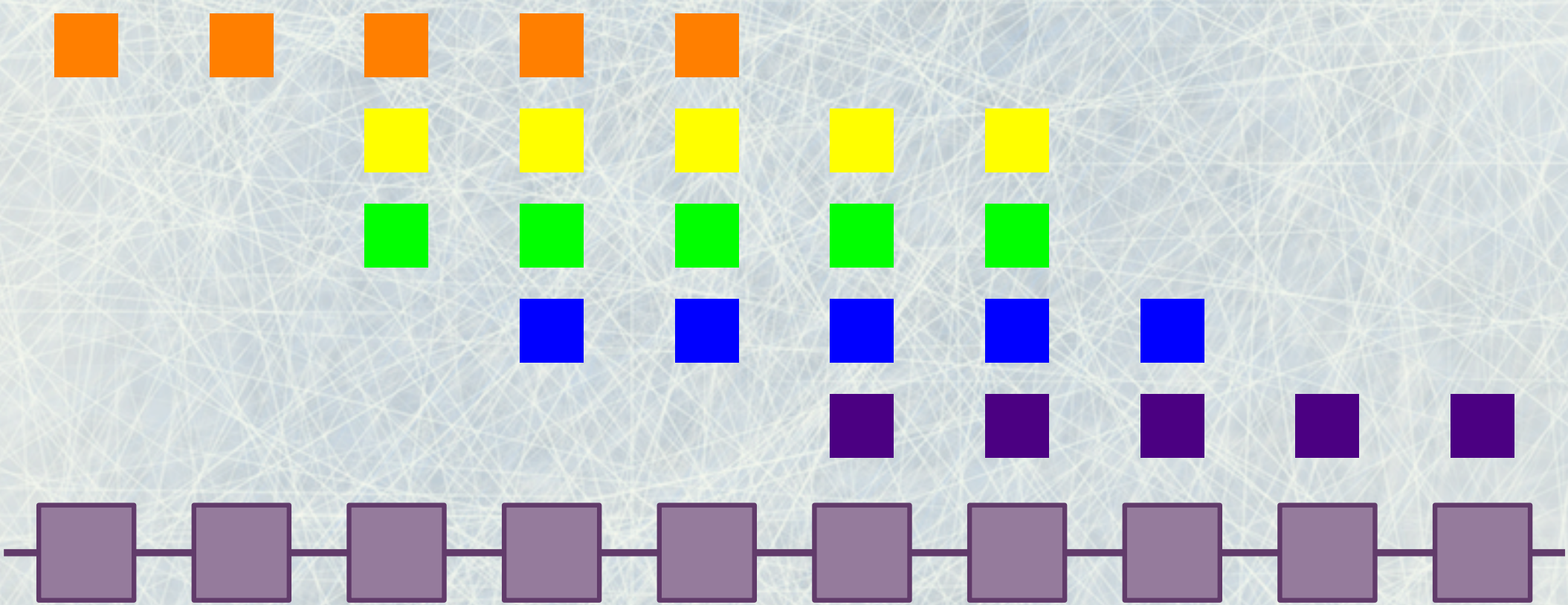


CD-P is better than CD

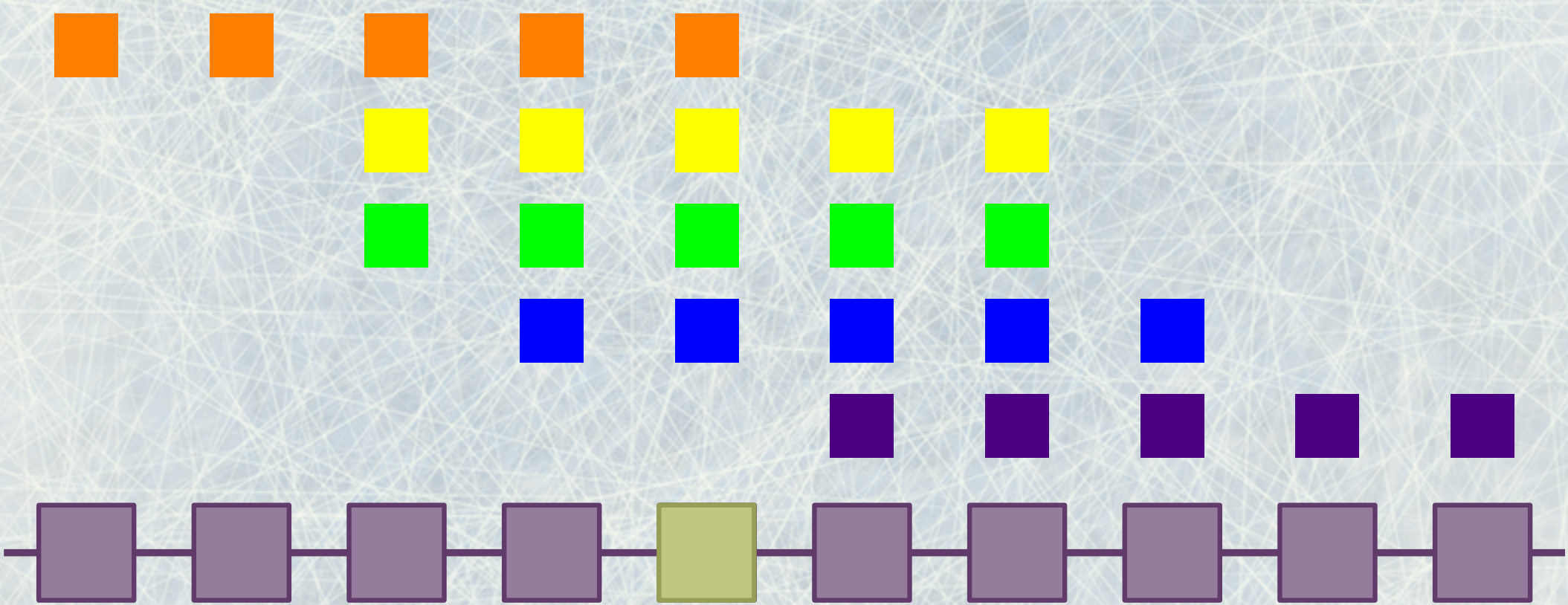
CD-P



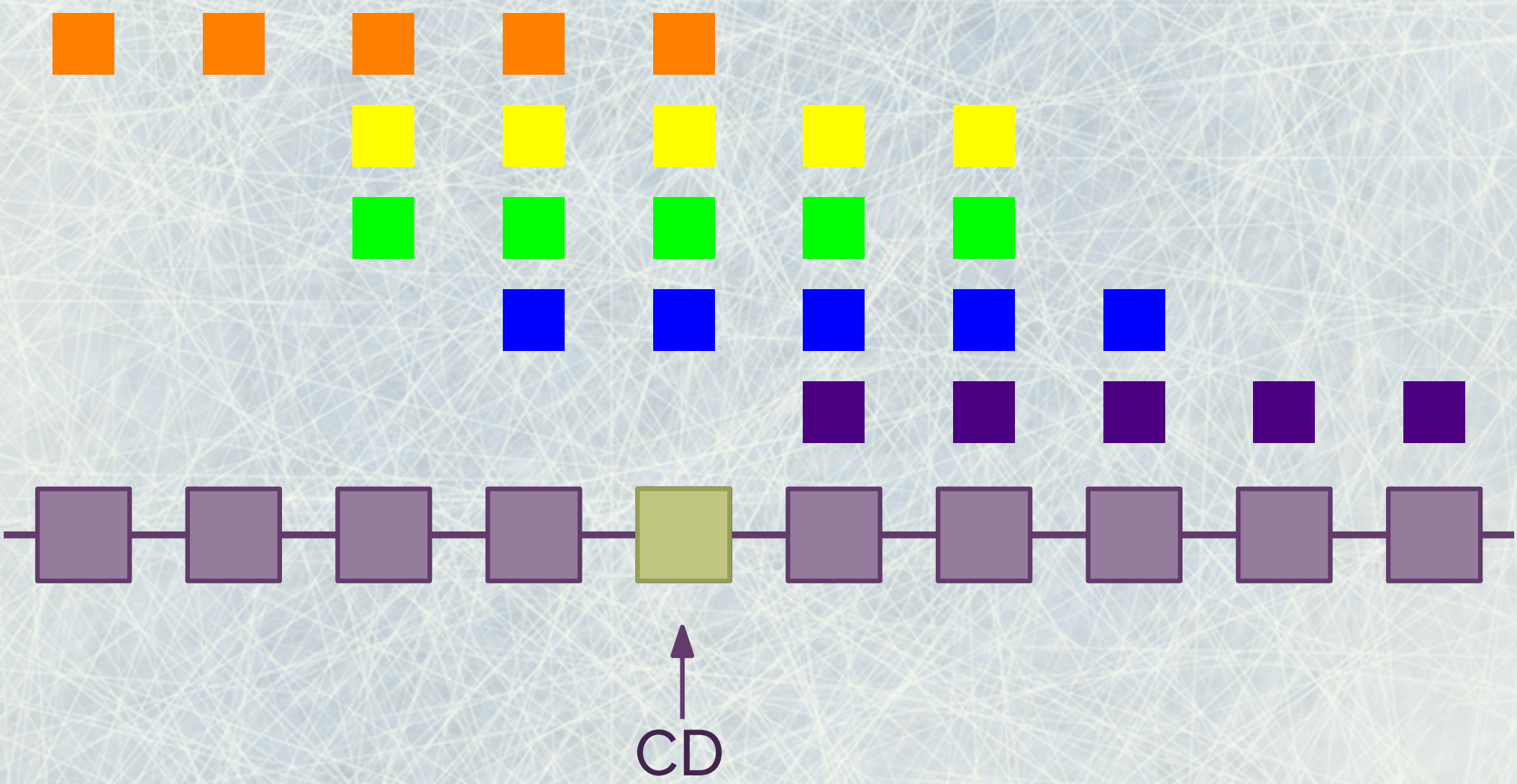
CD and CD-P in Bounded Reach Scenario



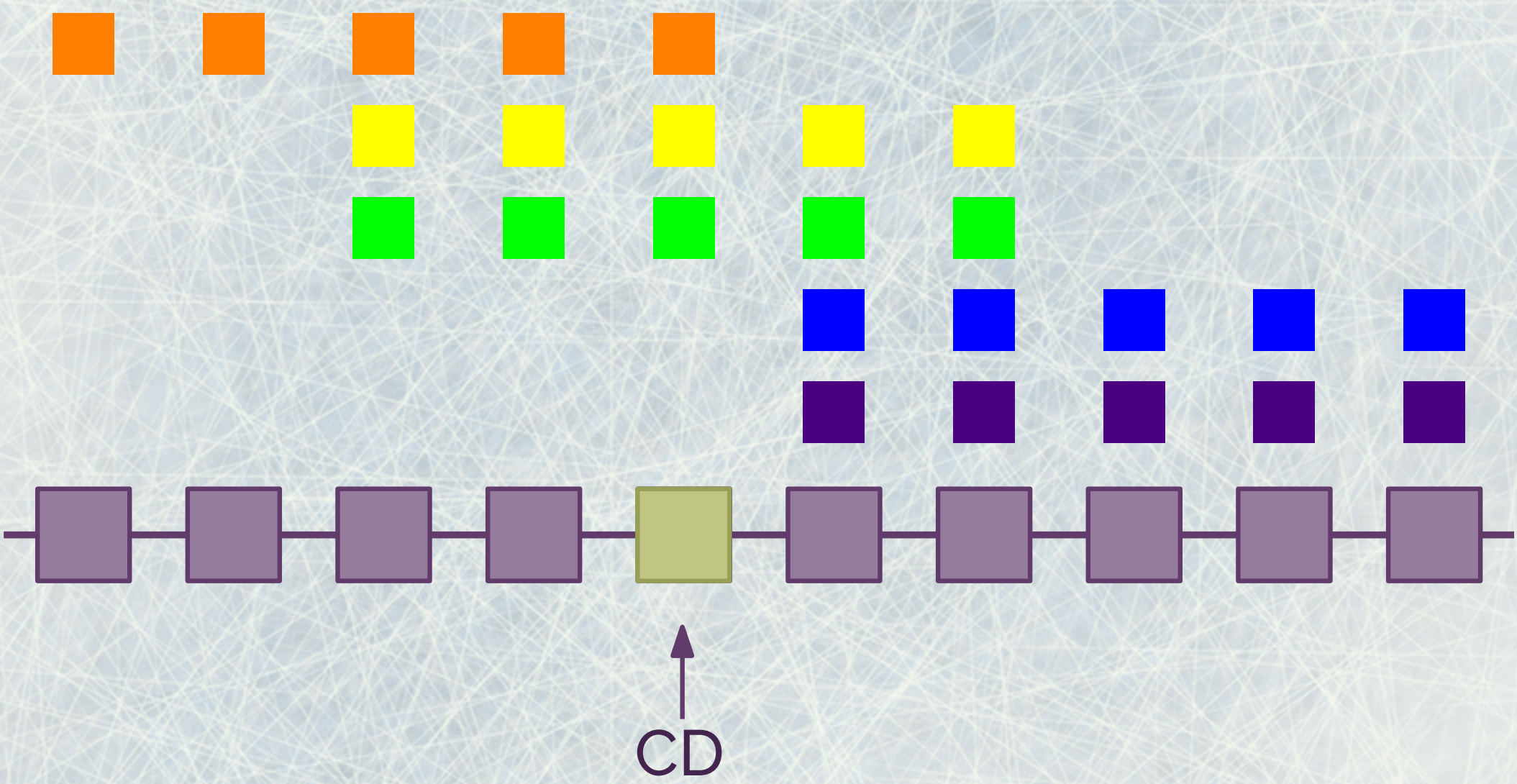
CD and CD-P in Bounded Reach Scenario



CD and CD-P in Bounded Reach Scenario



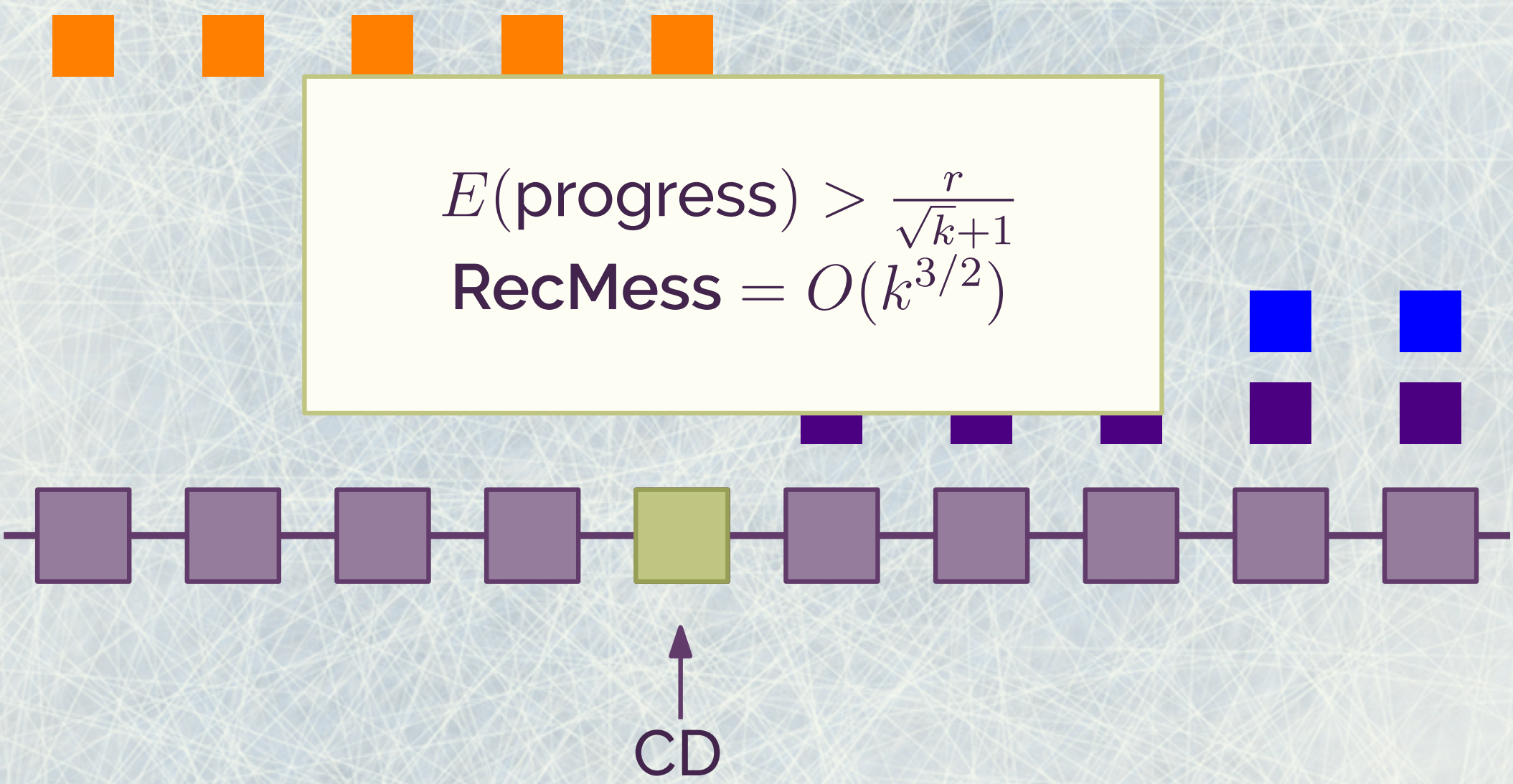
CD and CD-P in Bounded Reach Scenario



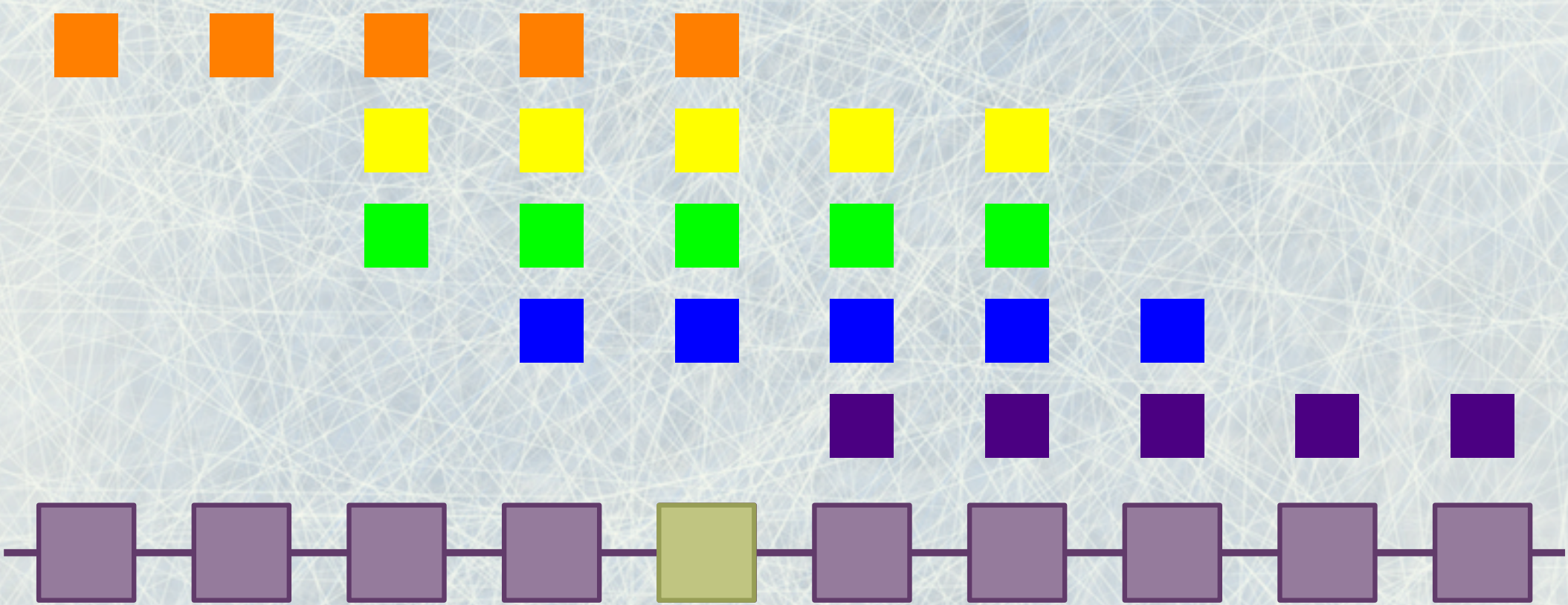
CD and CD-P in Bounded Reach Scenario

$$E(\text{progress}) > \frac{r}{\sqrt{k}+1}$$

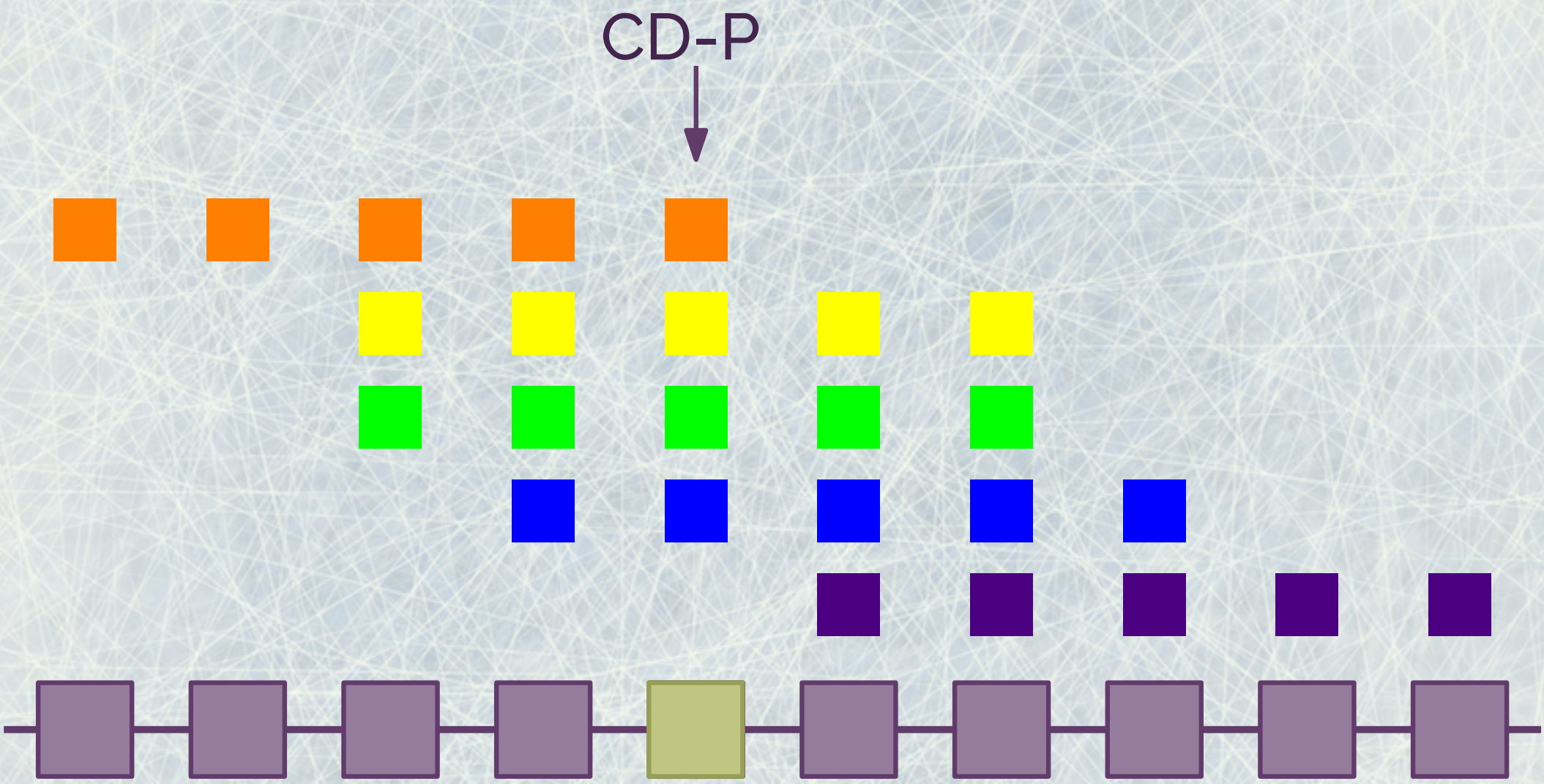
$$\textbf{RecMess} = O(k^{3/2})$$



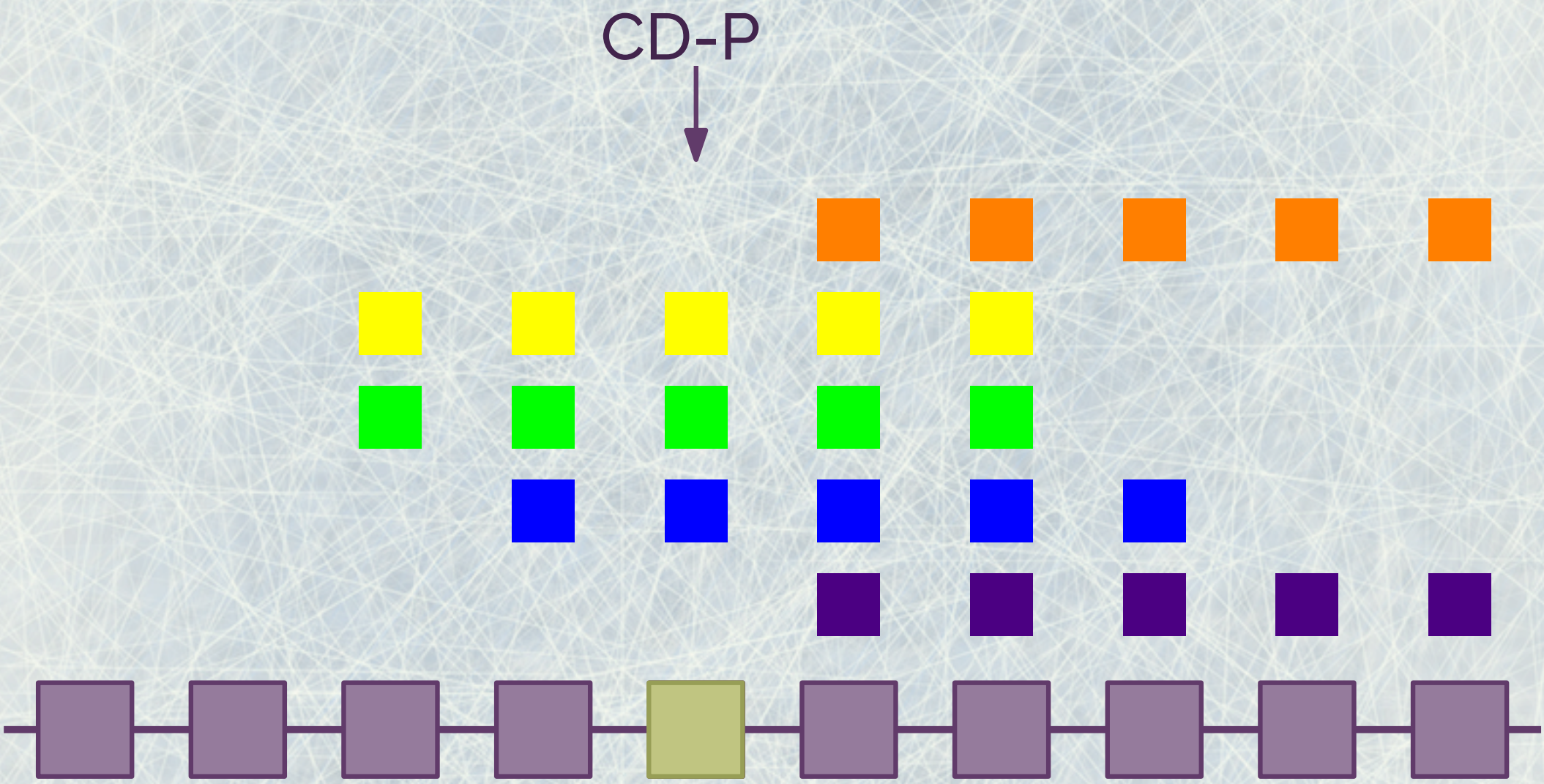
CD and CD-P in Bounded Reach Scenario



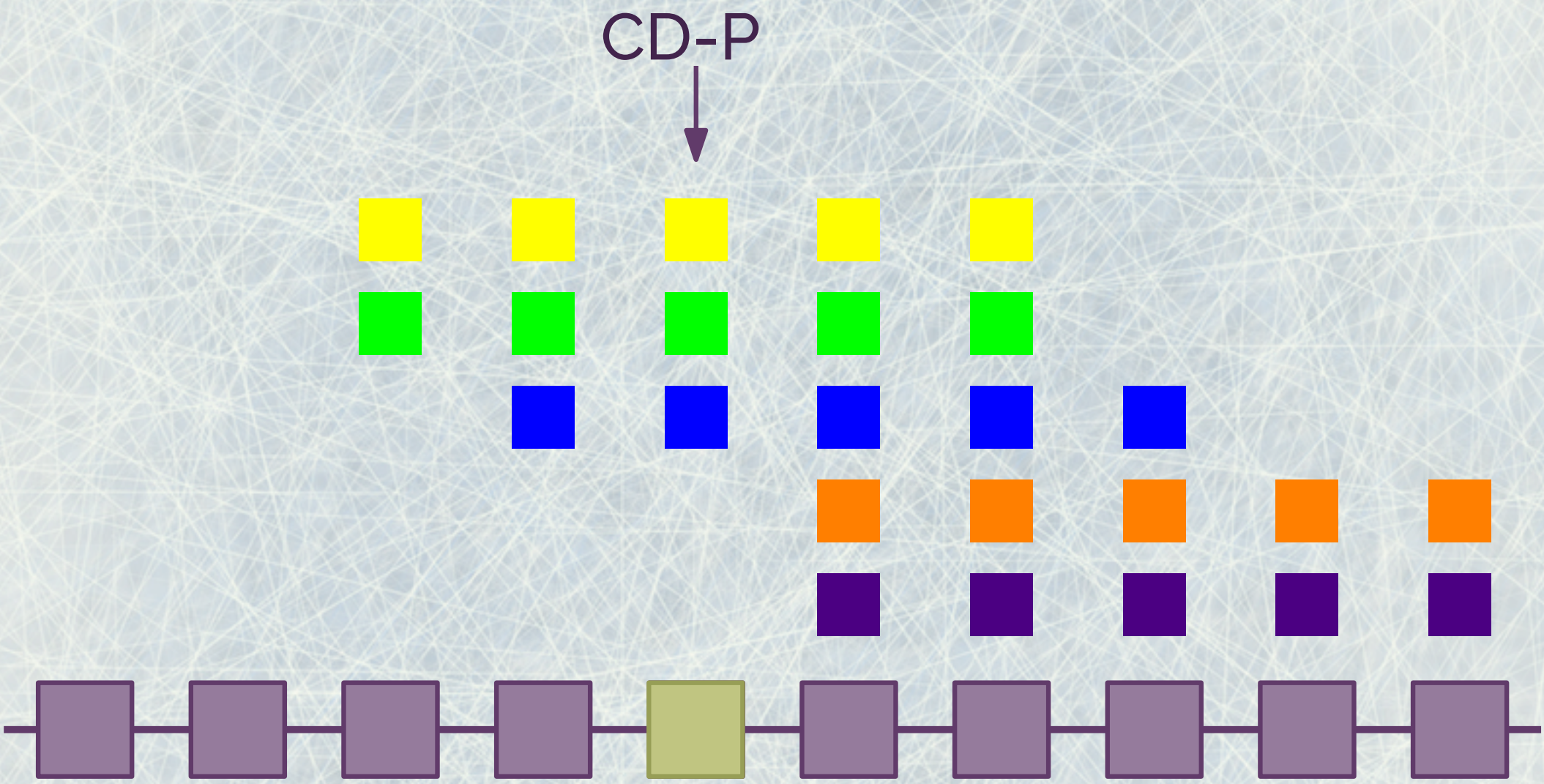
CD and CD-P in Bounded Reach Scenario



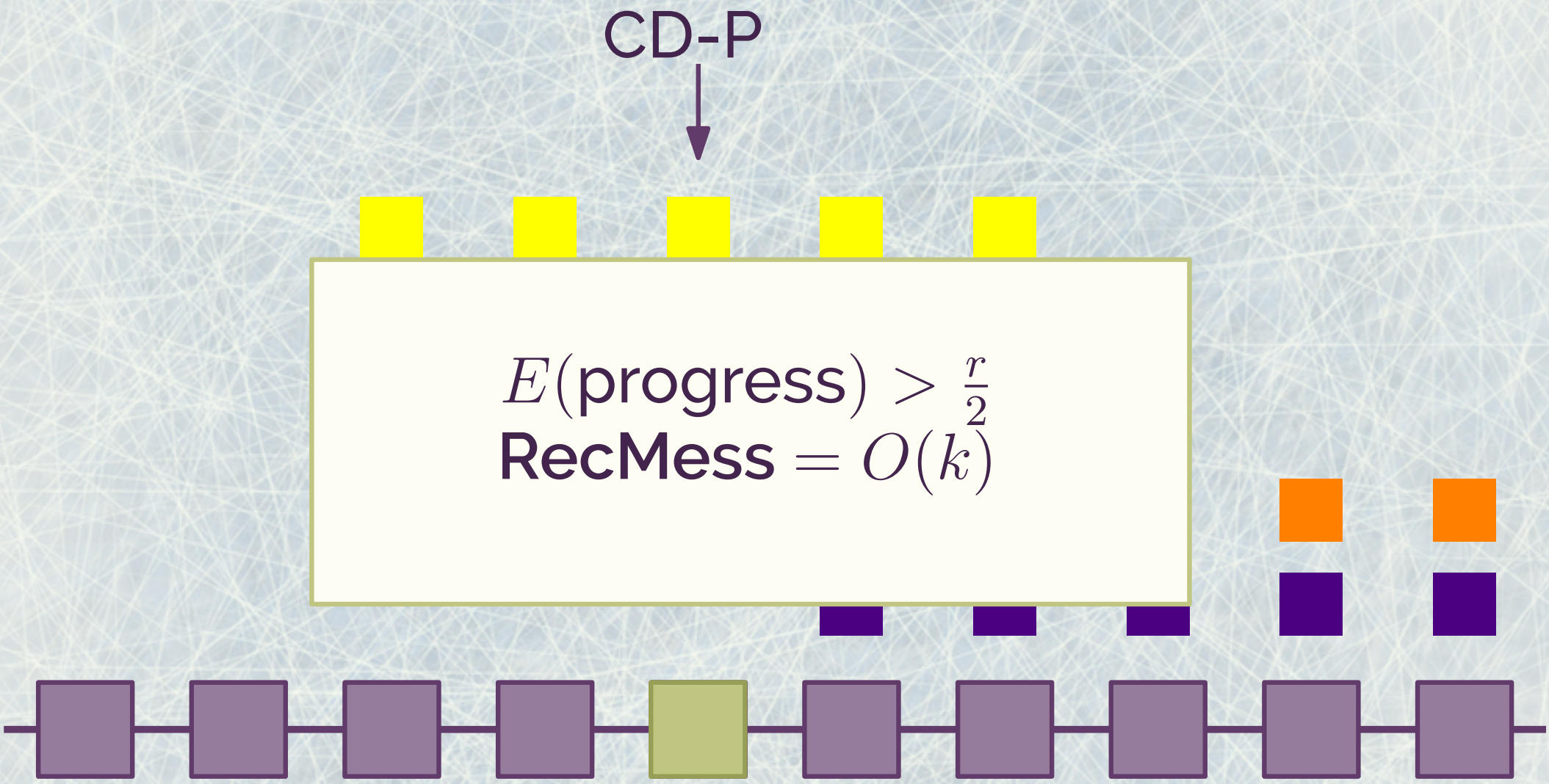
CD and CD-P in Bounded Reach Scenario



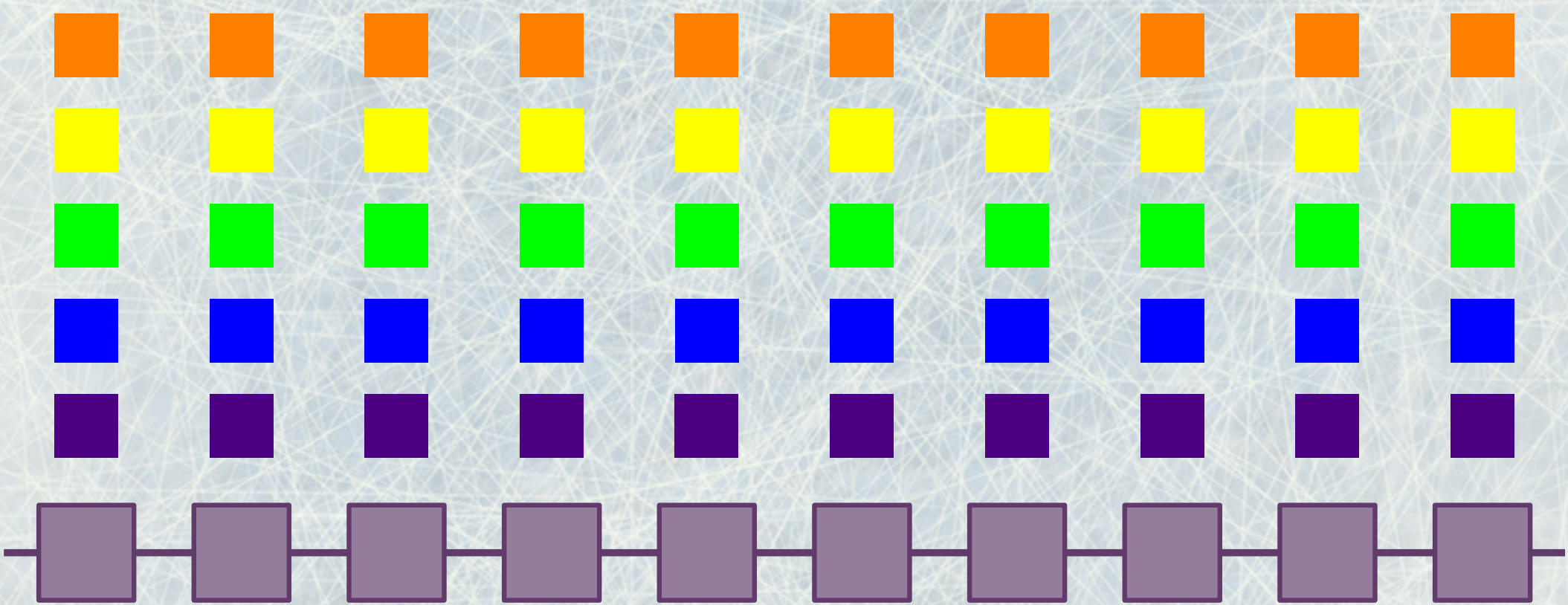
CD and CD-P in Bounded Reach Scenario



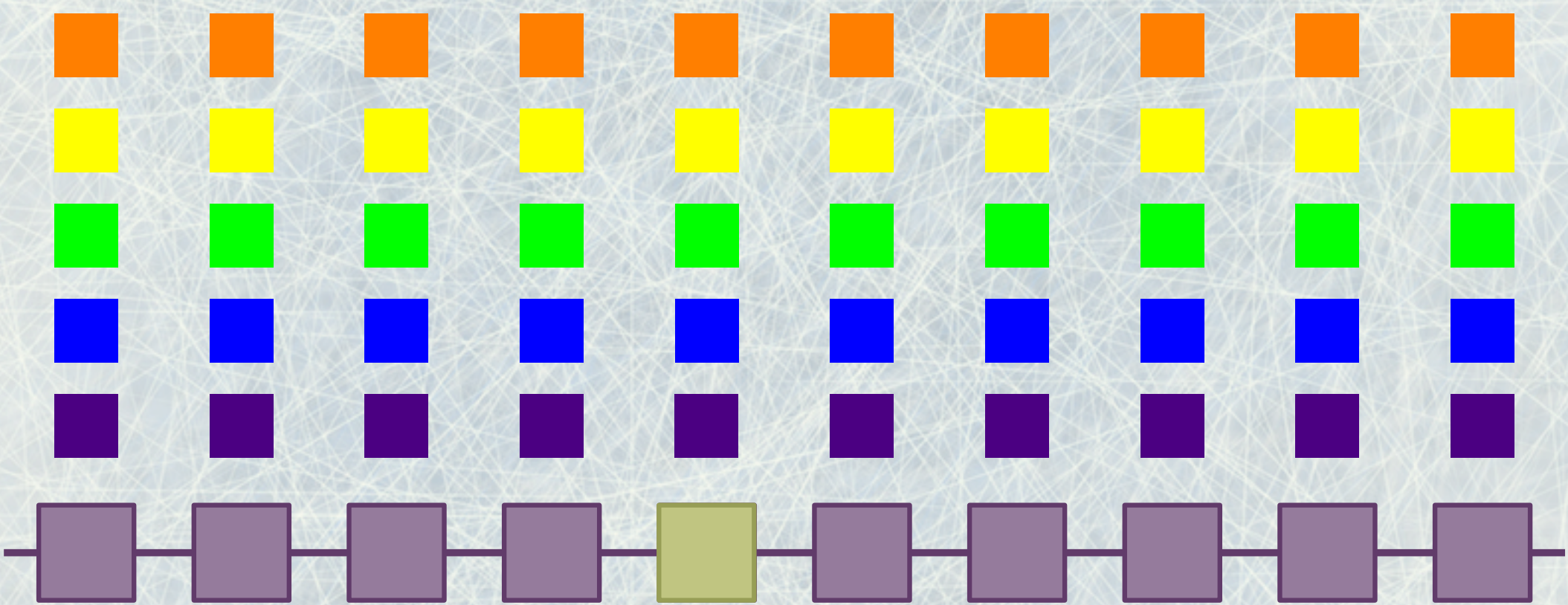
CD and CD-P in Bounded Reach Scenario



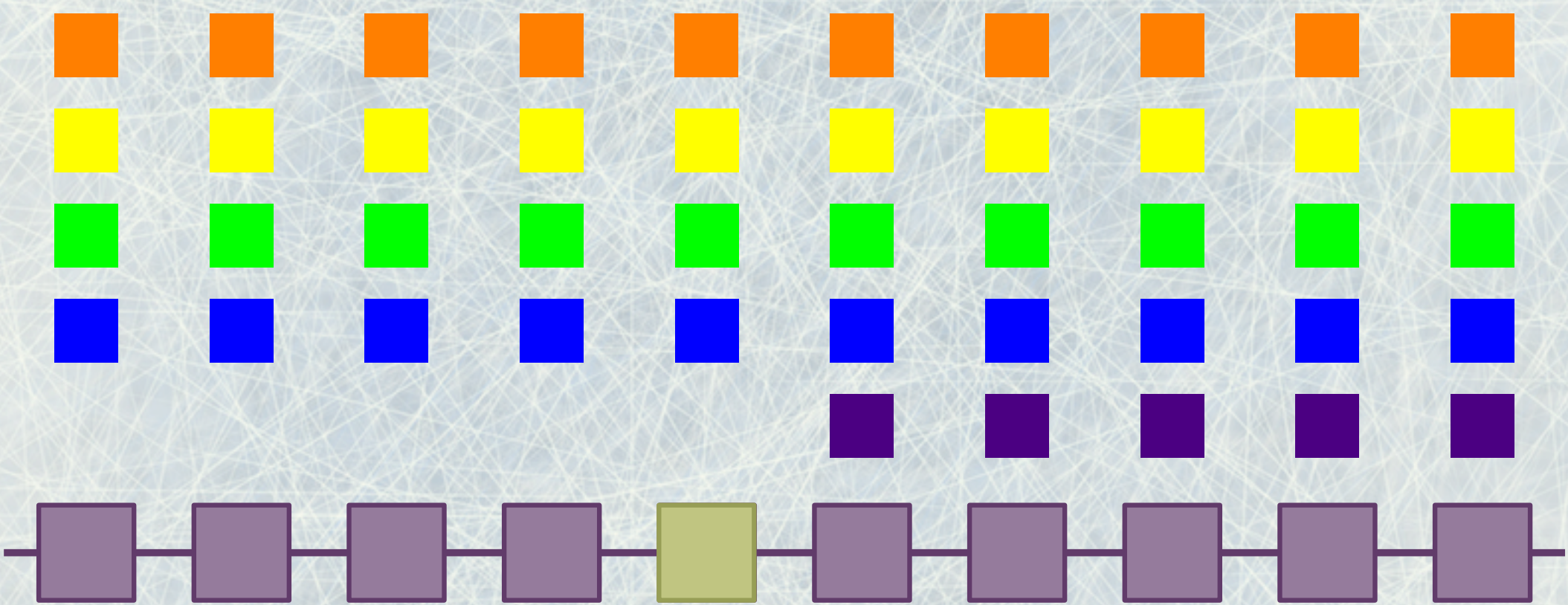
CD in Unbounded Reach Scenario



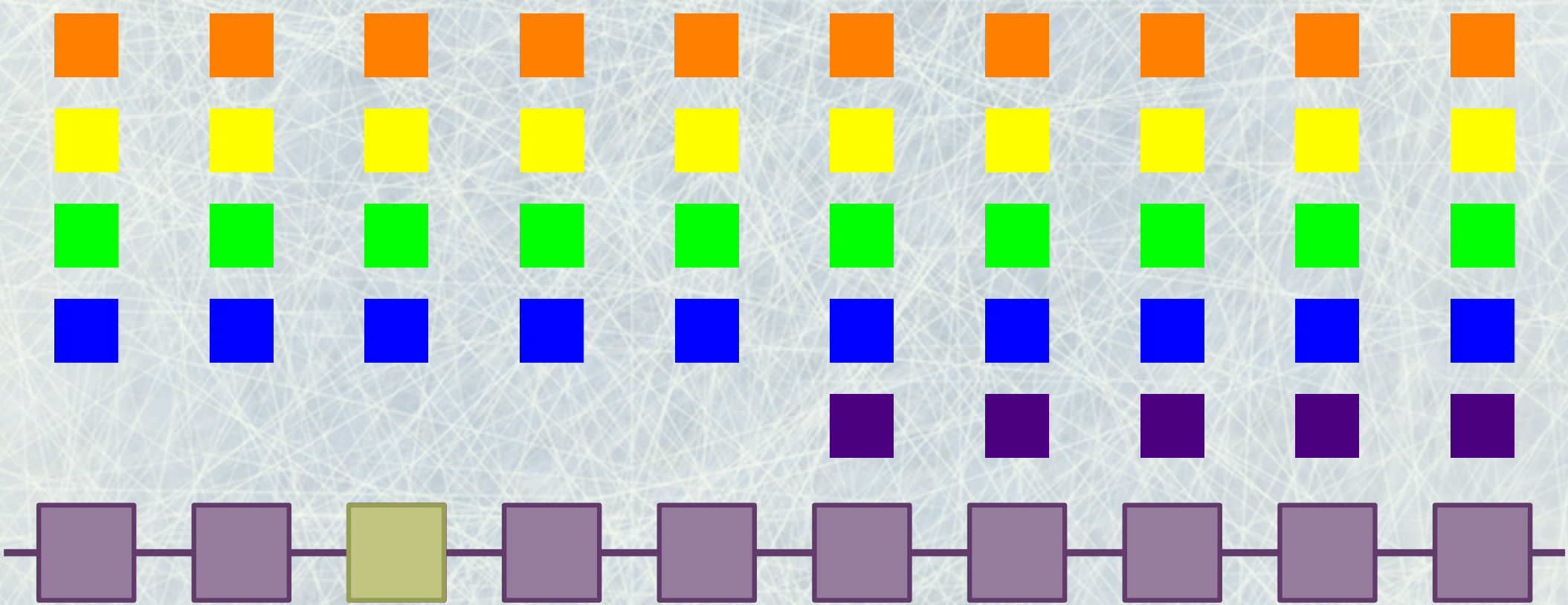
CD in Unbounded Reach Scenario



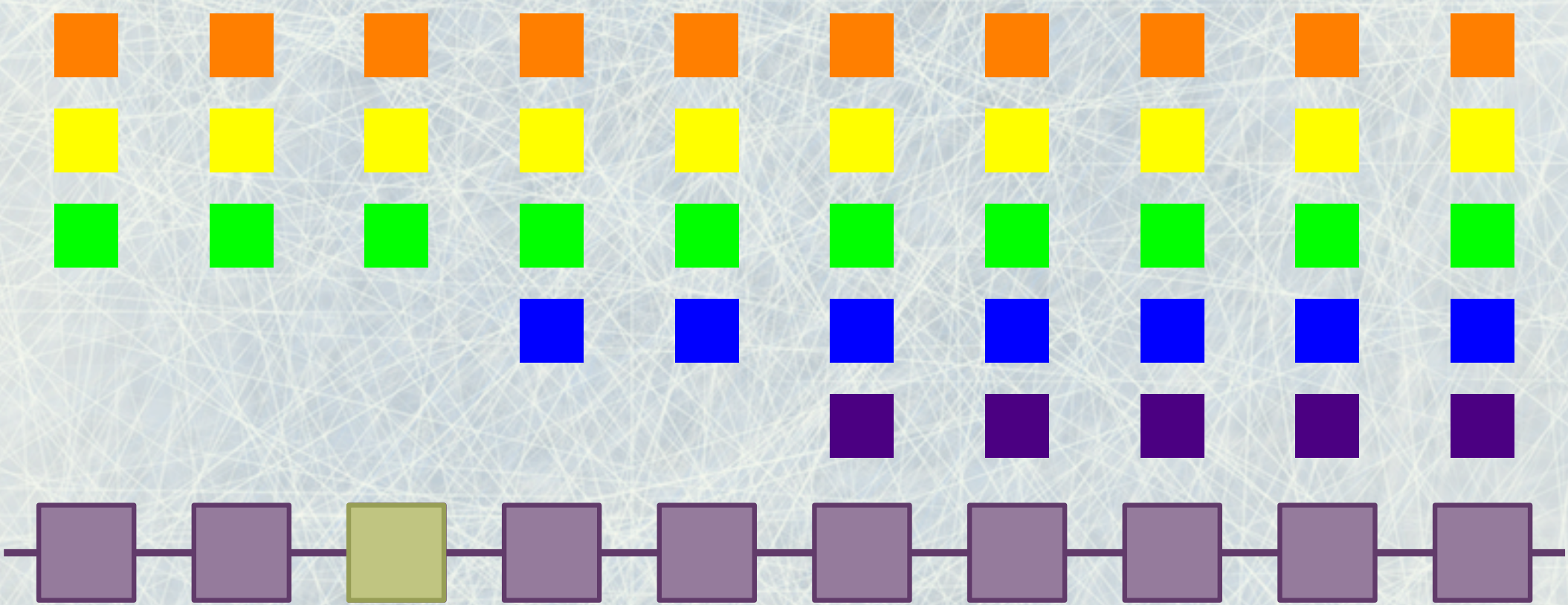
CD in Unbounded Reach Scenario



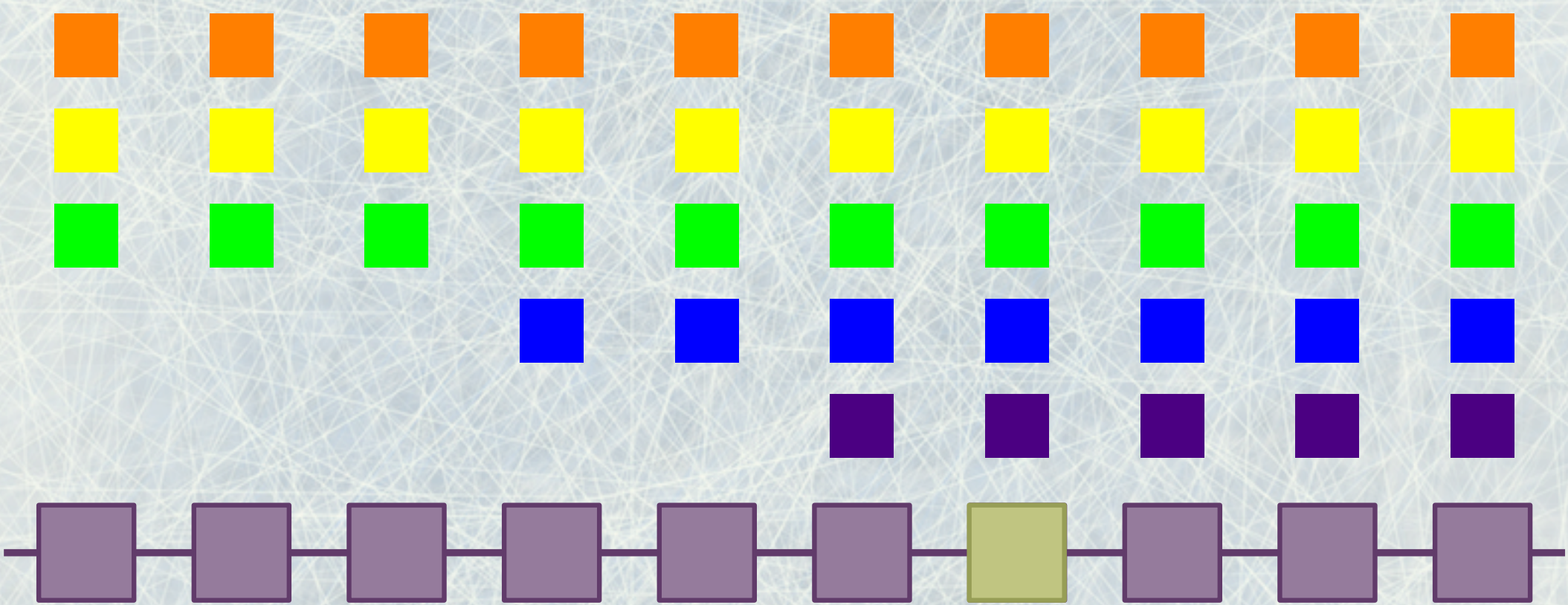
CD in Unbounded Reach Scenario



CD in Unbounded Reach Scenario



CD in Unbounded Reach Scenario



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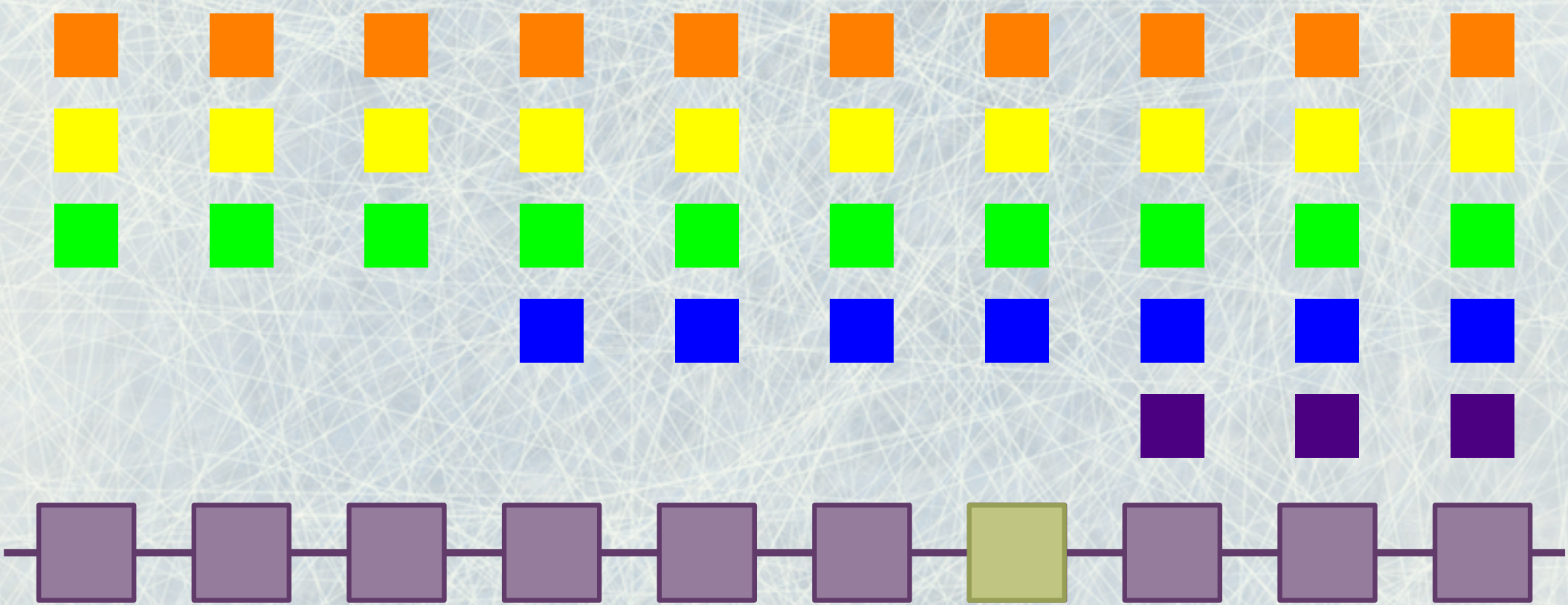

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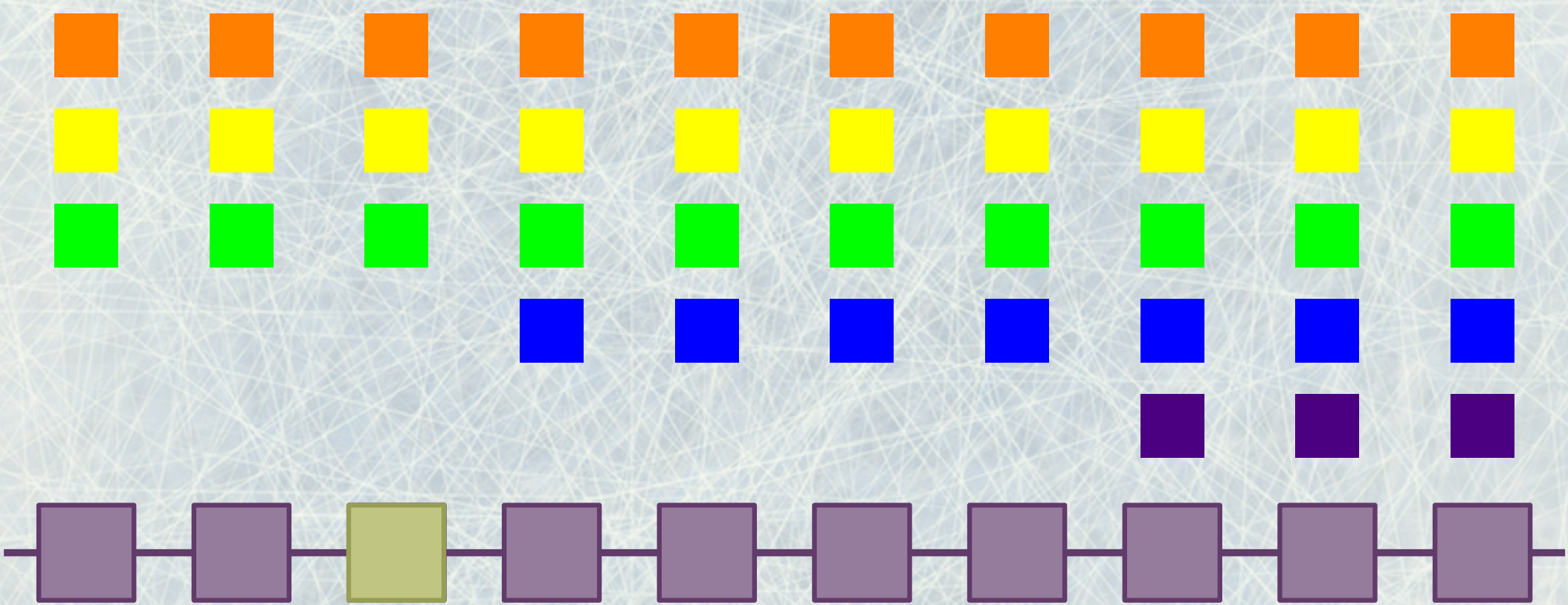

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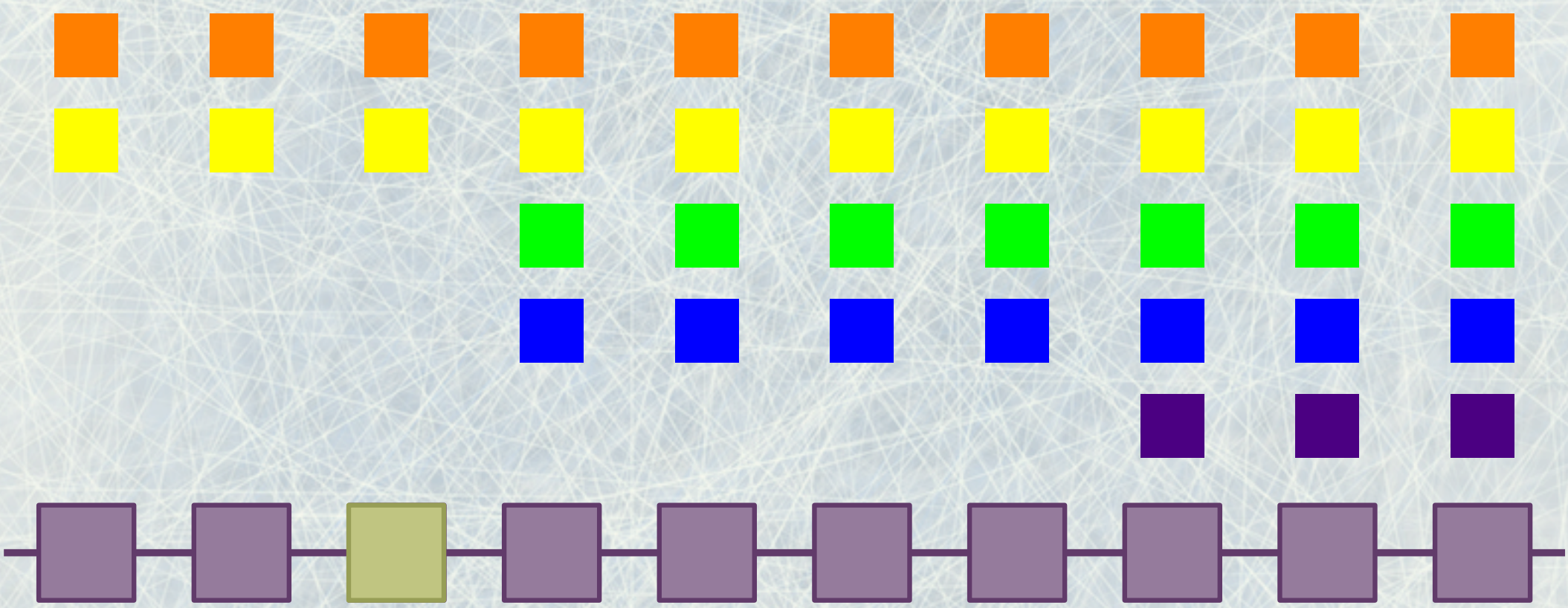

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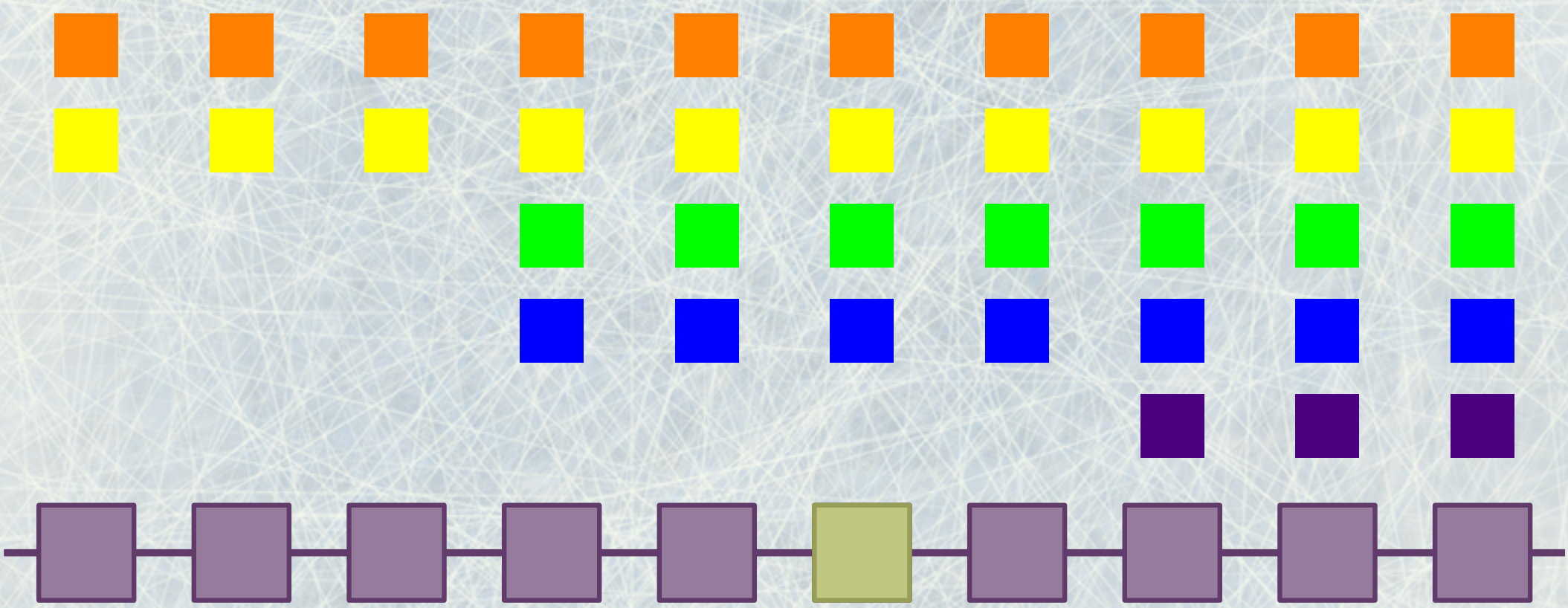

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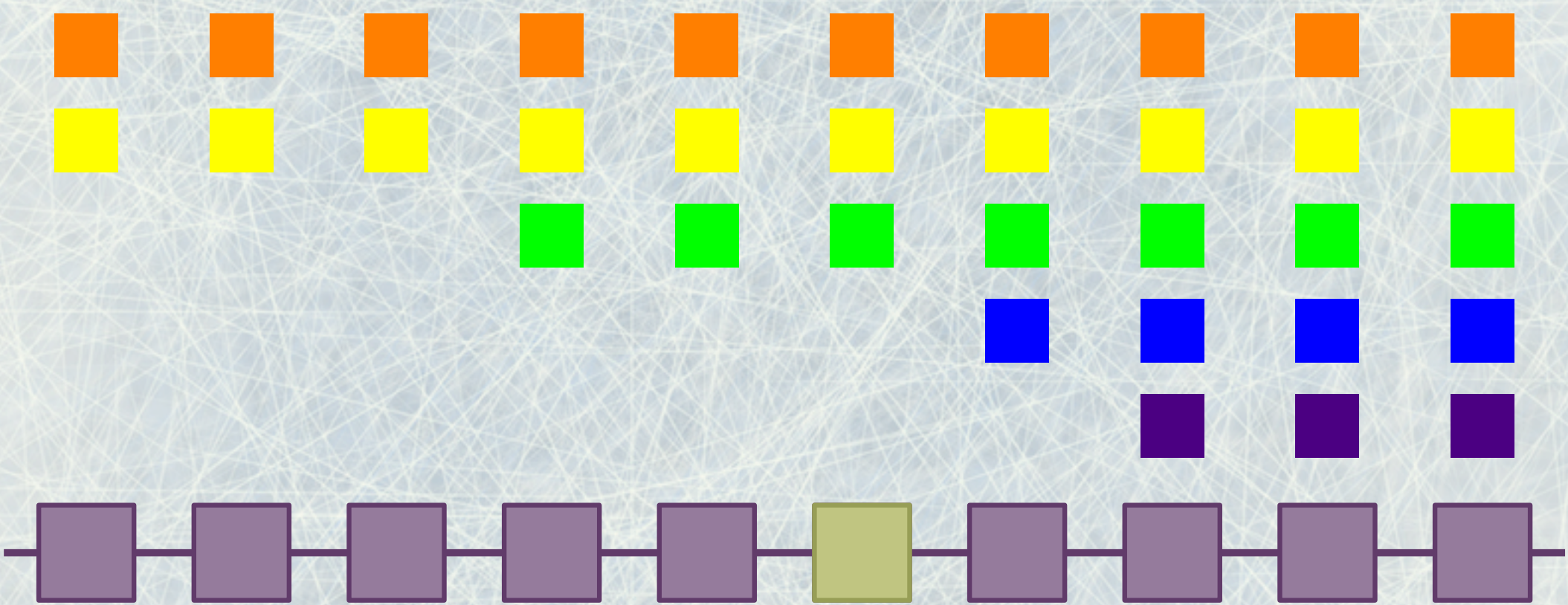

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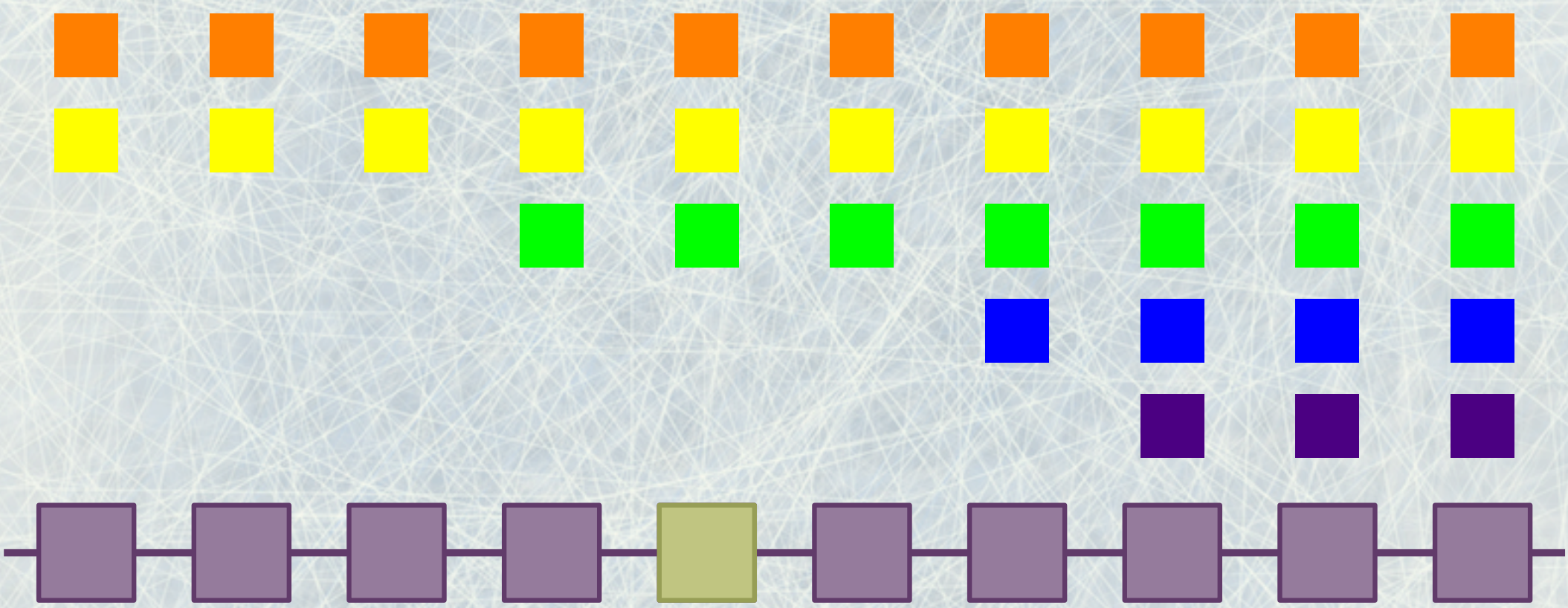

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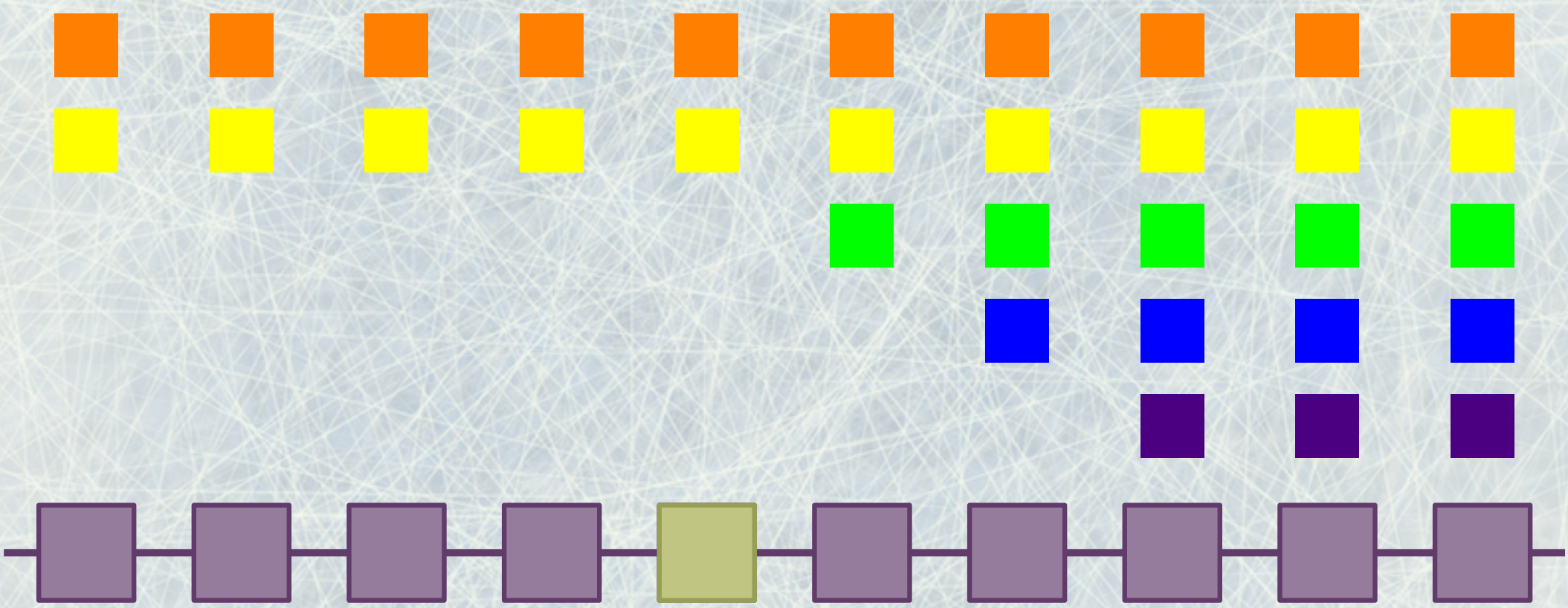

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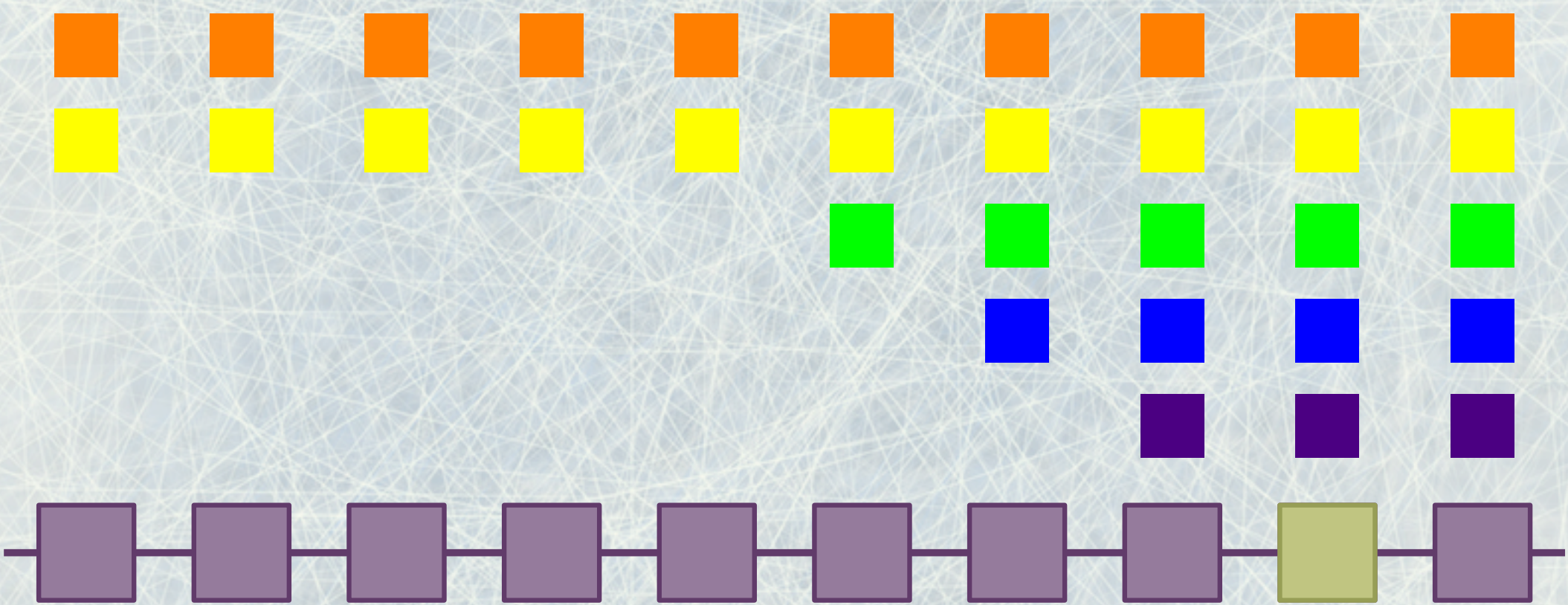

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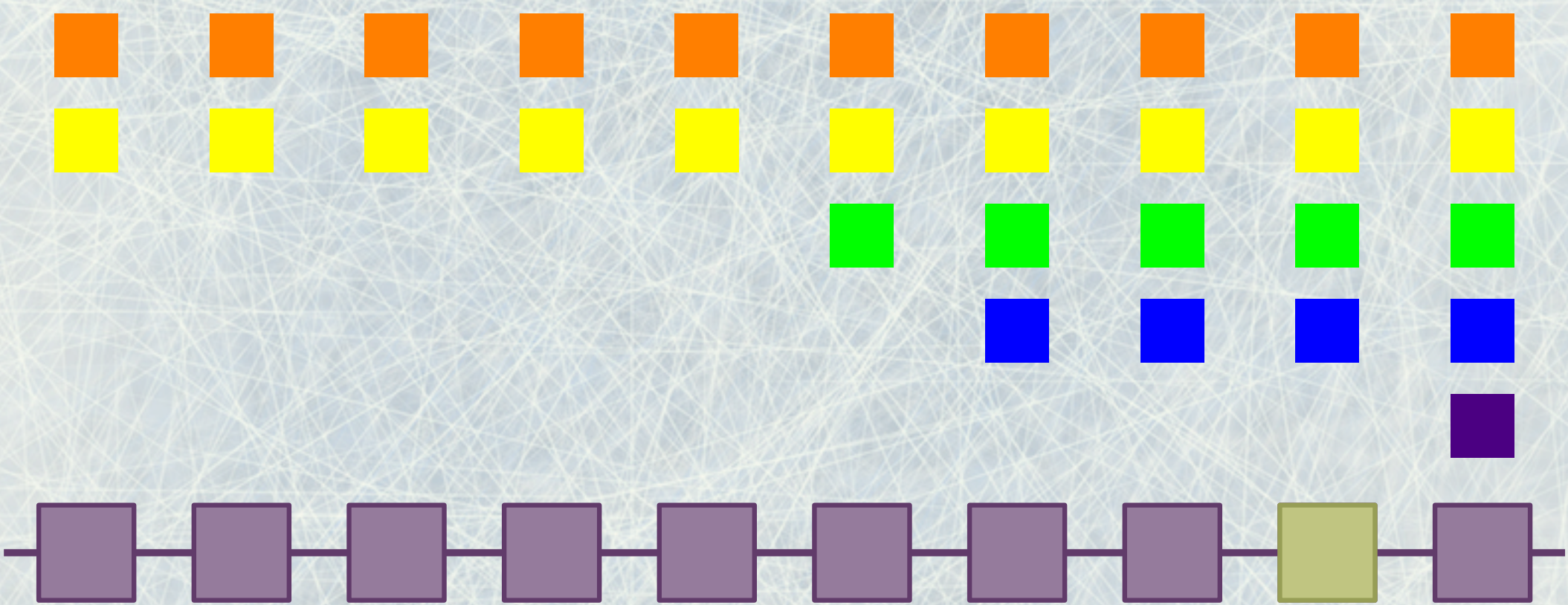

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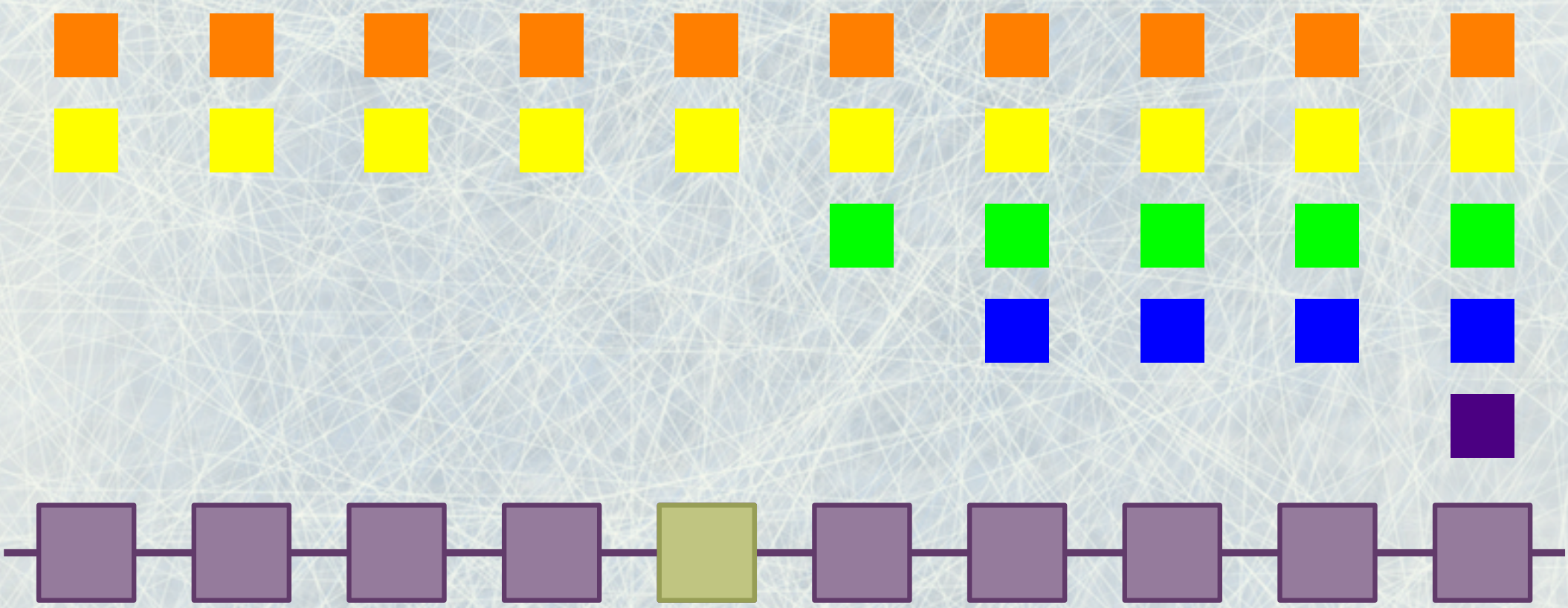

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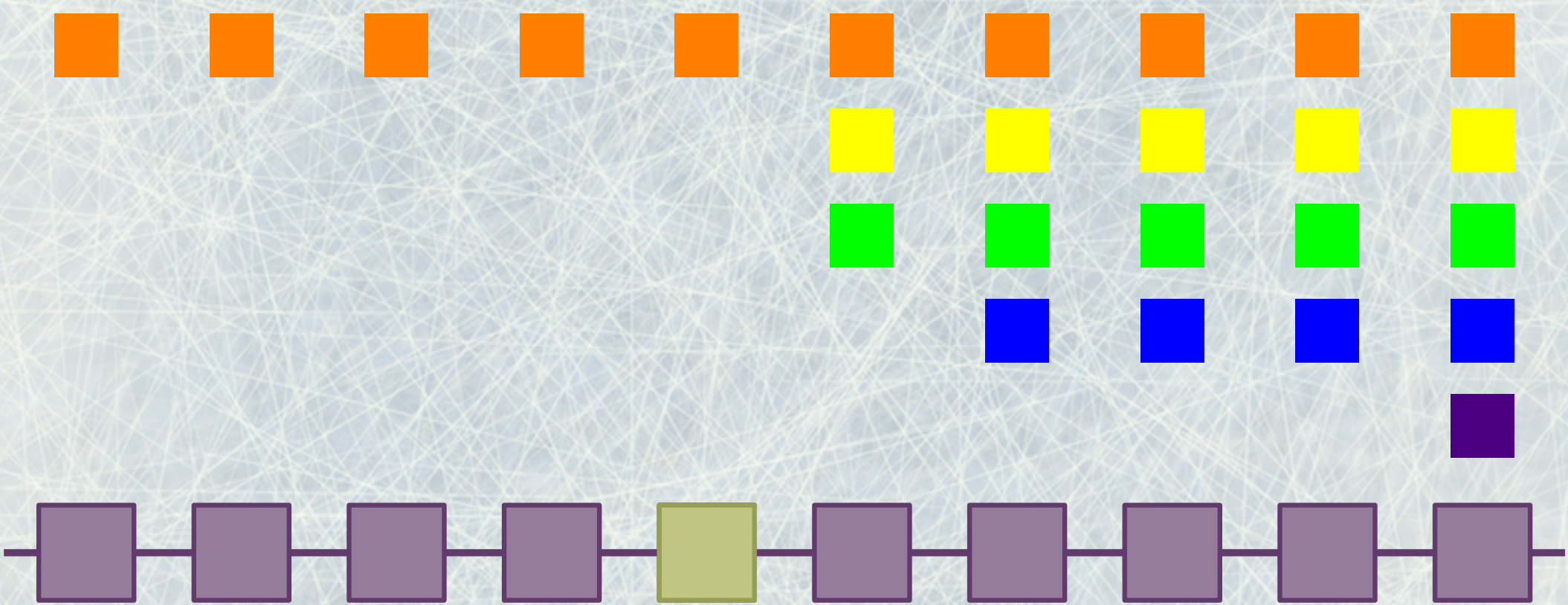

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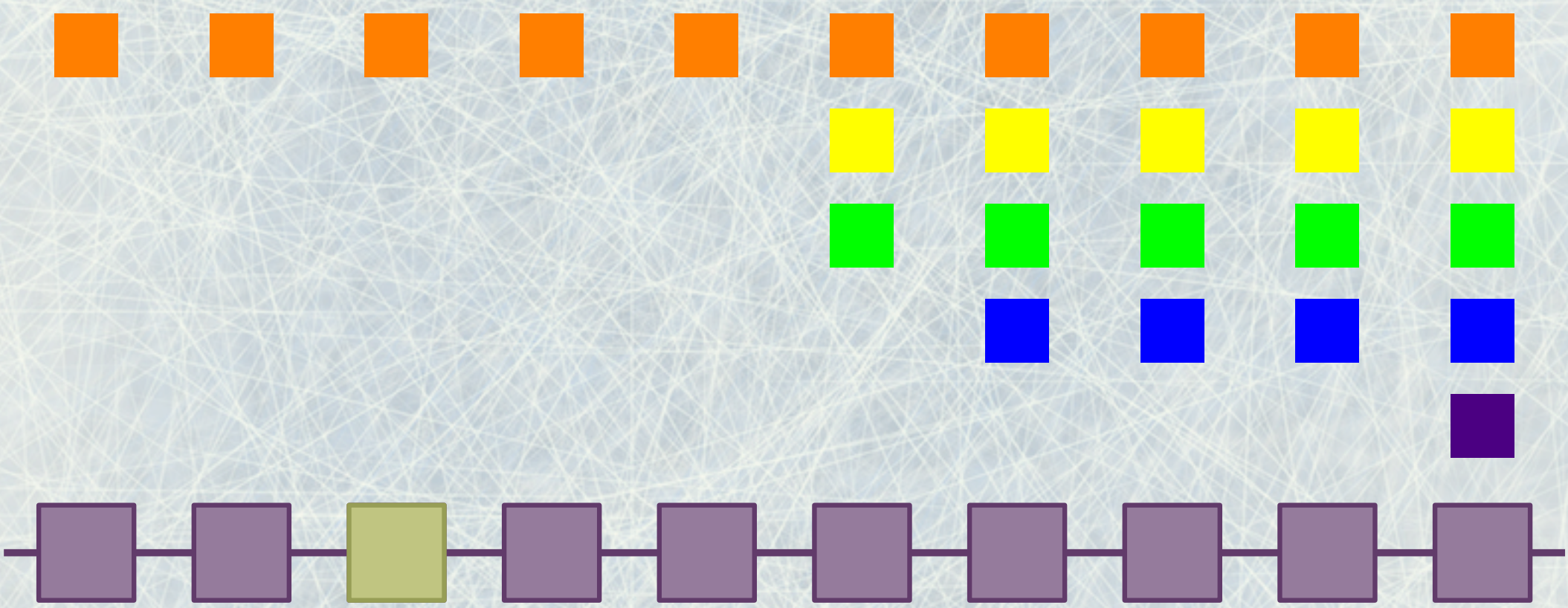

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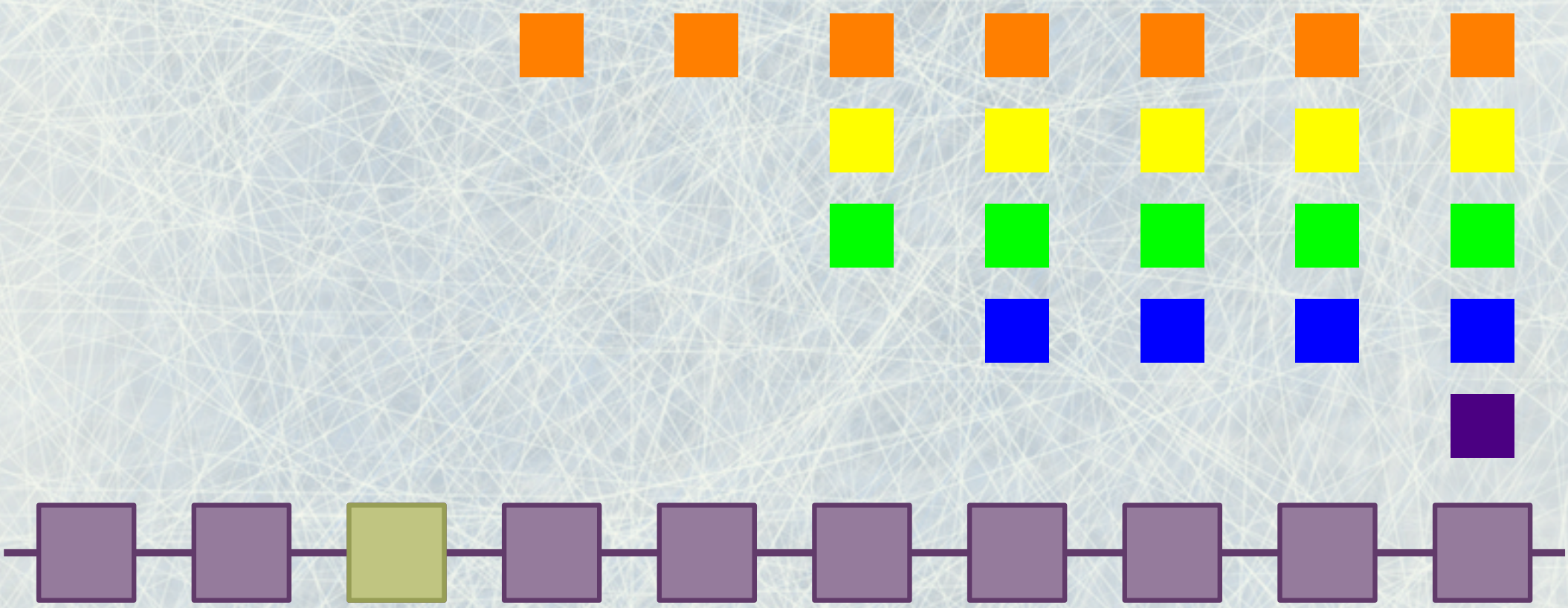
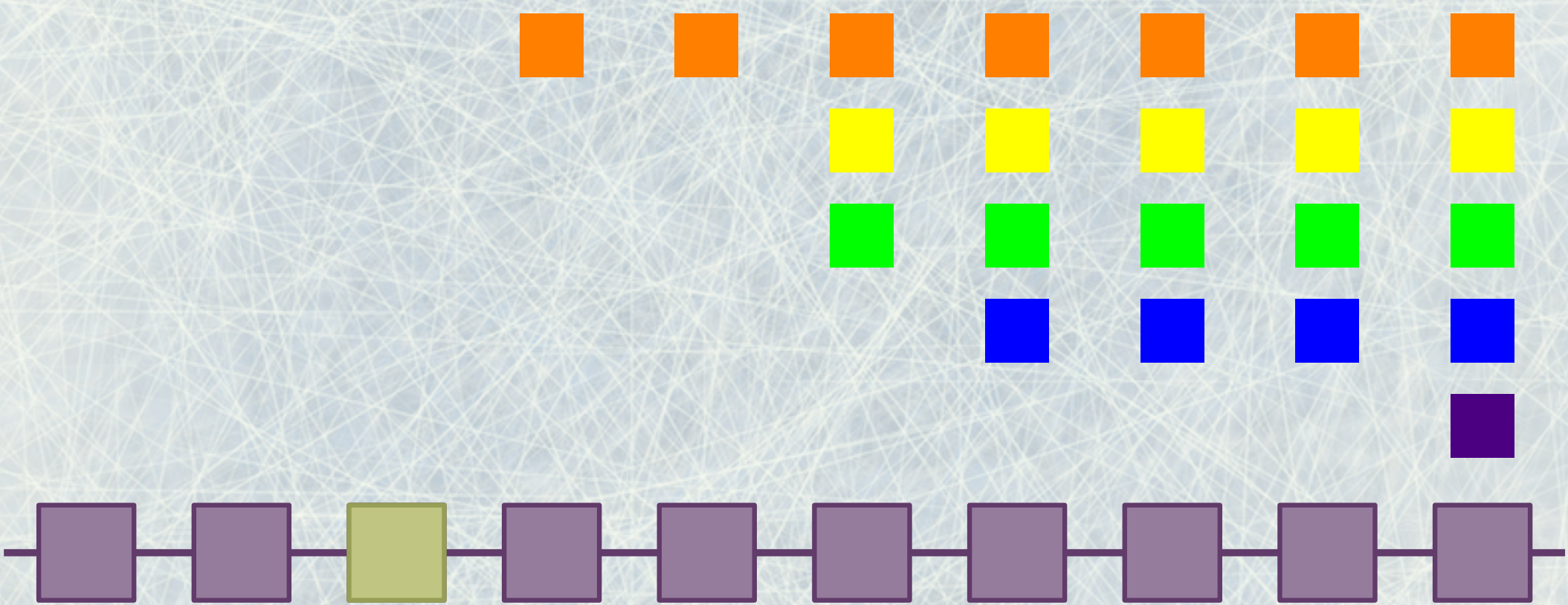


CD in Unbounded Reach Scenario

Probility of choosing each node changes with the number of non-empty nodes!



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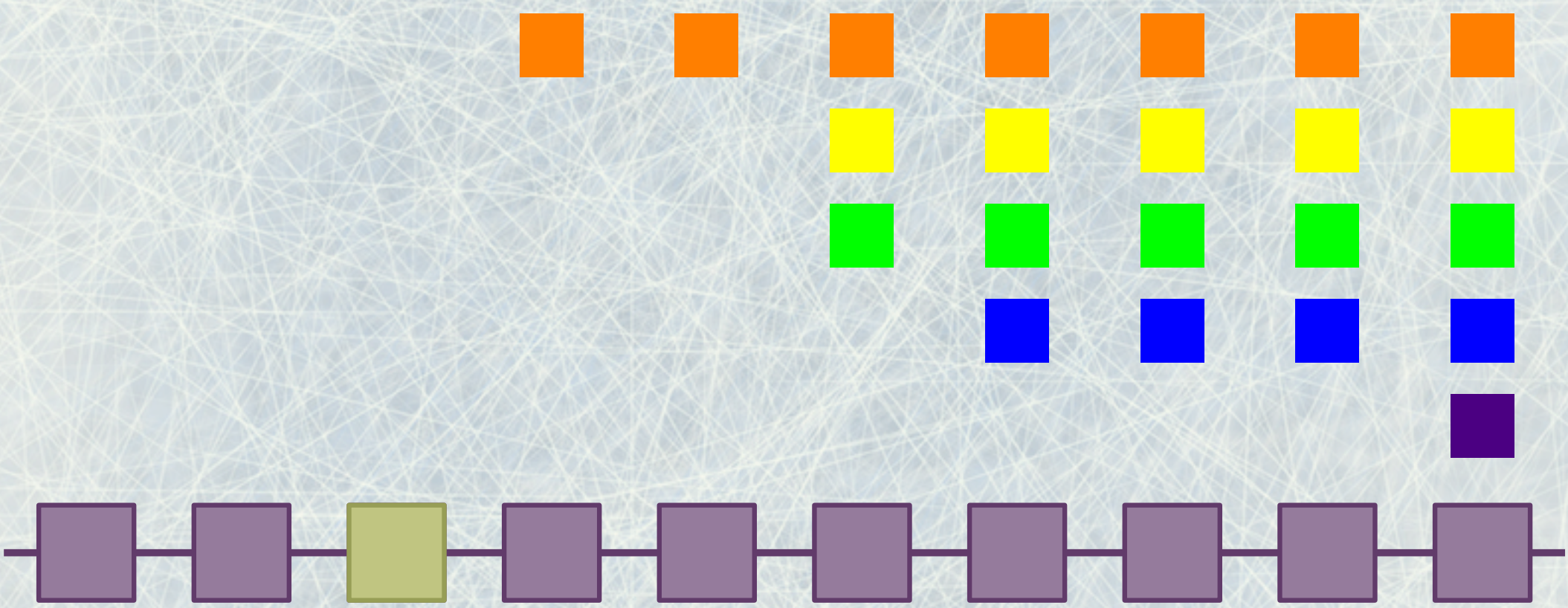

RecMess is equal to the number of steps before all nodes are empty.

CD in Unbounded Reach Scenario

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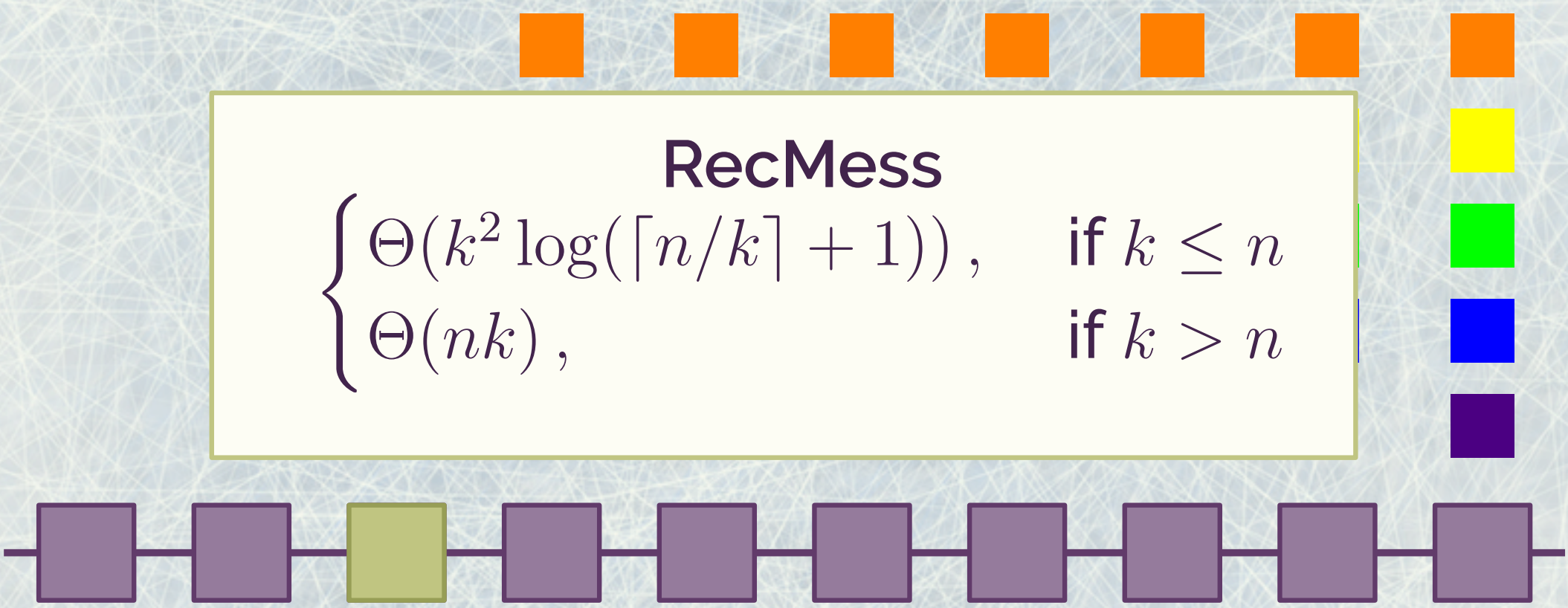

RecMess

$$\begin{cases} \Theta(k^2 \log(\lceil n/k \rceil + 1)), & \text{if } k \leq n \\ \Theta(nk), & \text{if } k > n \end{cases}$$

RecMess is equal to the number of steps before all nodes are empty.

Summary and Future Work

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Conclusion: beaconless geocast protocols are interesting in 1D!

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2D scenarios

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Conclusion: beaconless geocast protocols are interesting in 1D!

1D scenarios

- improve bounds
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2D scenarios

- dense networks

Summary and Future Work

Conclusion: beaconless geocast protocols are interesting in 1D!

1D scenarios

- improve bounds
- non-uniform bounded reach scenario

2D scenarios

- dense networks
- bottleneck scenarios

Thank You!