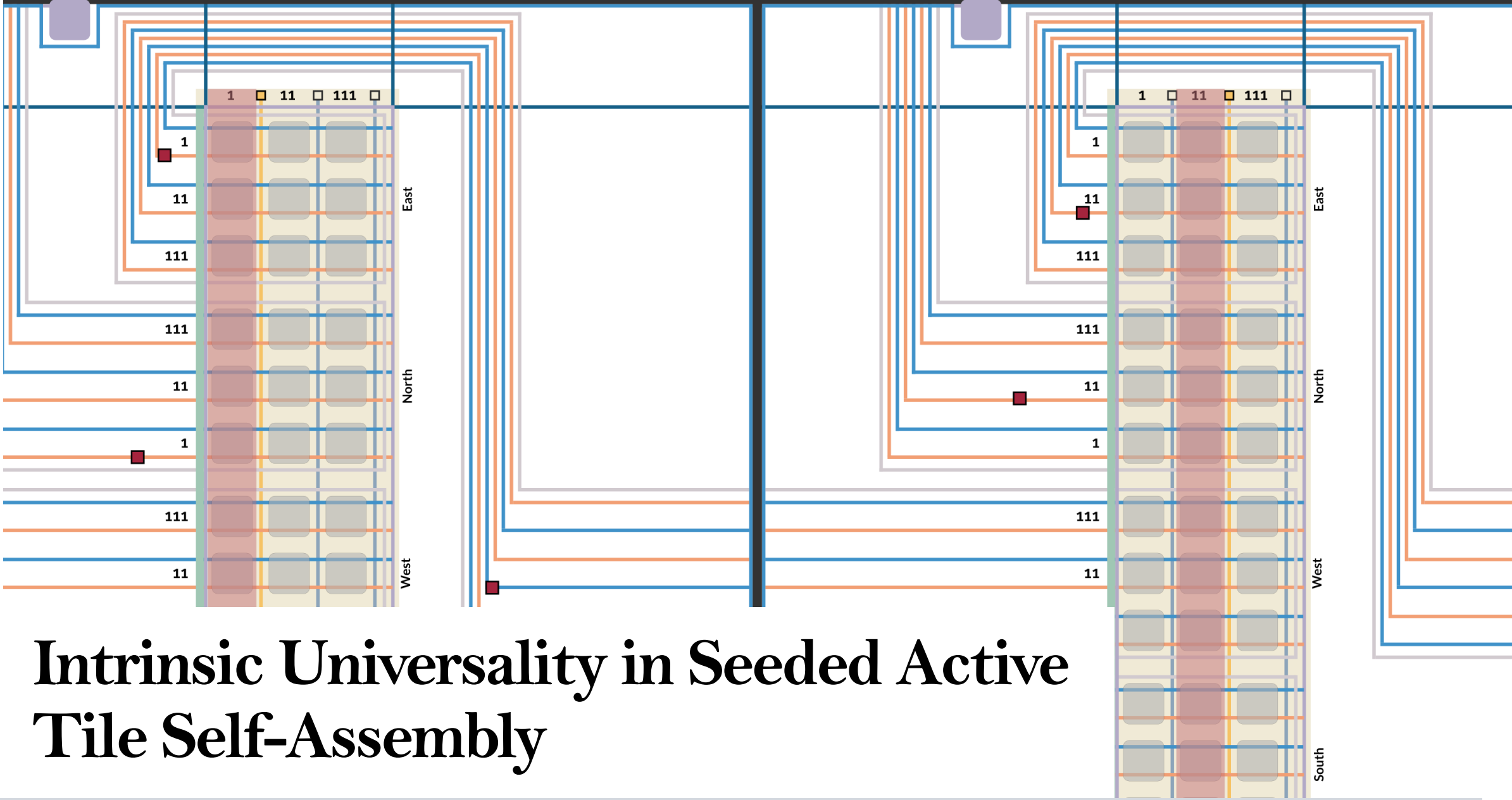


Intrinsic Universality in Seeded Active Tile Self-Assembly

Timothy Gomez[2], Elise Grizzell[1], Asher Haun[1], **Ryan Knobel[1]**, Tom Peters[3], Robert Schweller[1], Tim Wylie[1]

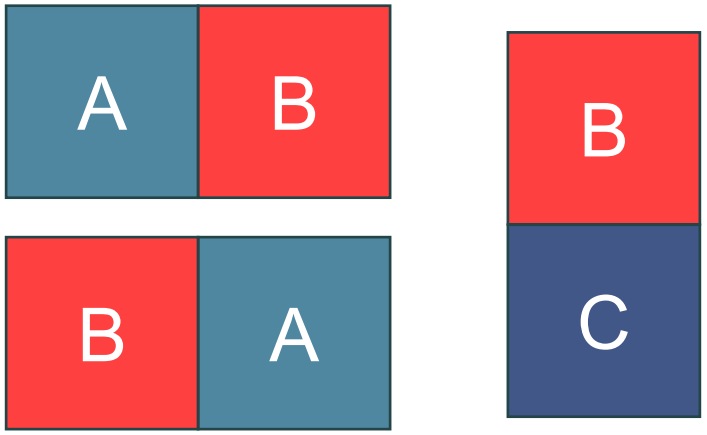
1 University of Texas Rio Grande Valley, 2 Massachusetts Institute of Technology, 3 TU Eindoven

Seeded TA

Tiles:

Affinities:

Temperature: τ



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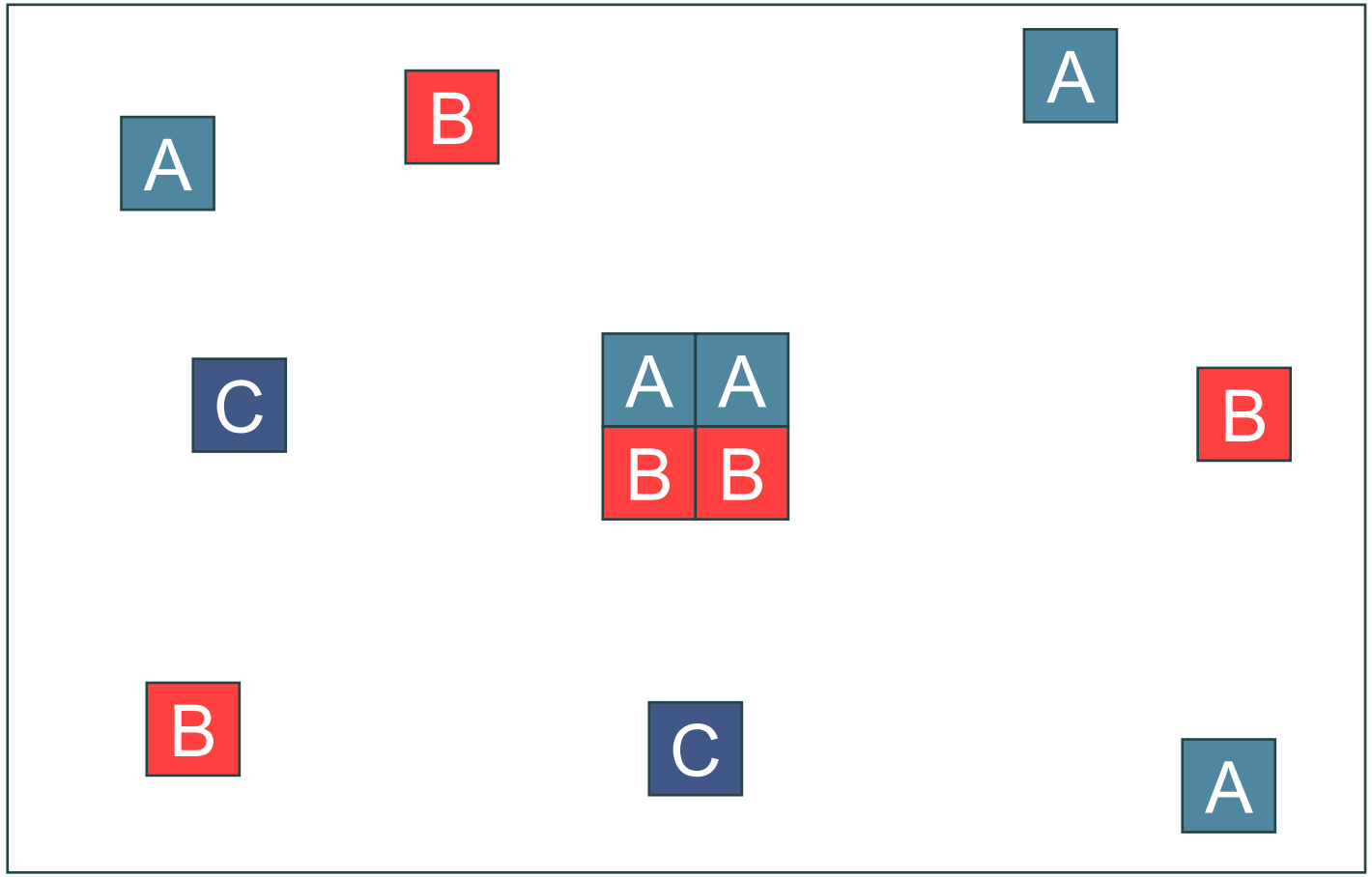
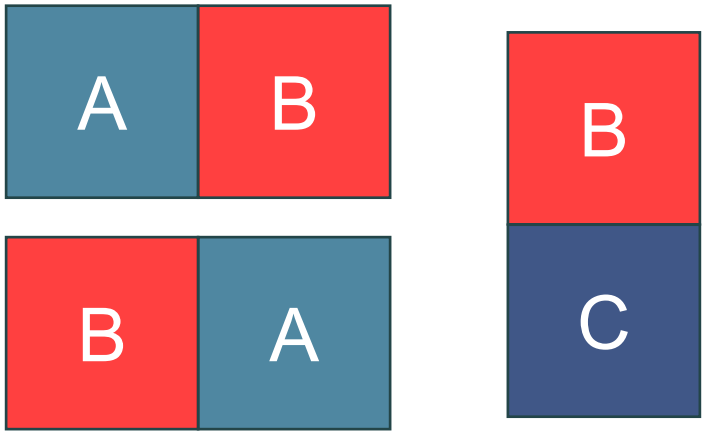


Seeded TA

Tiles:

Affinities:

Temperature: τ



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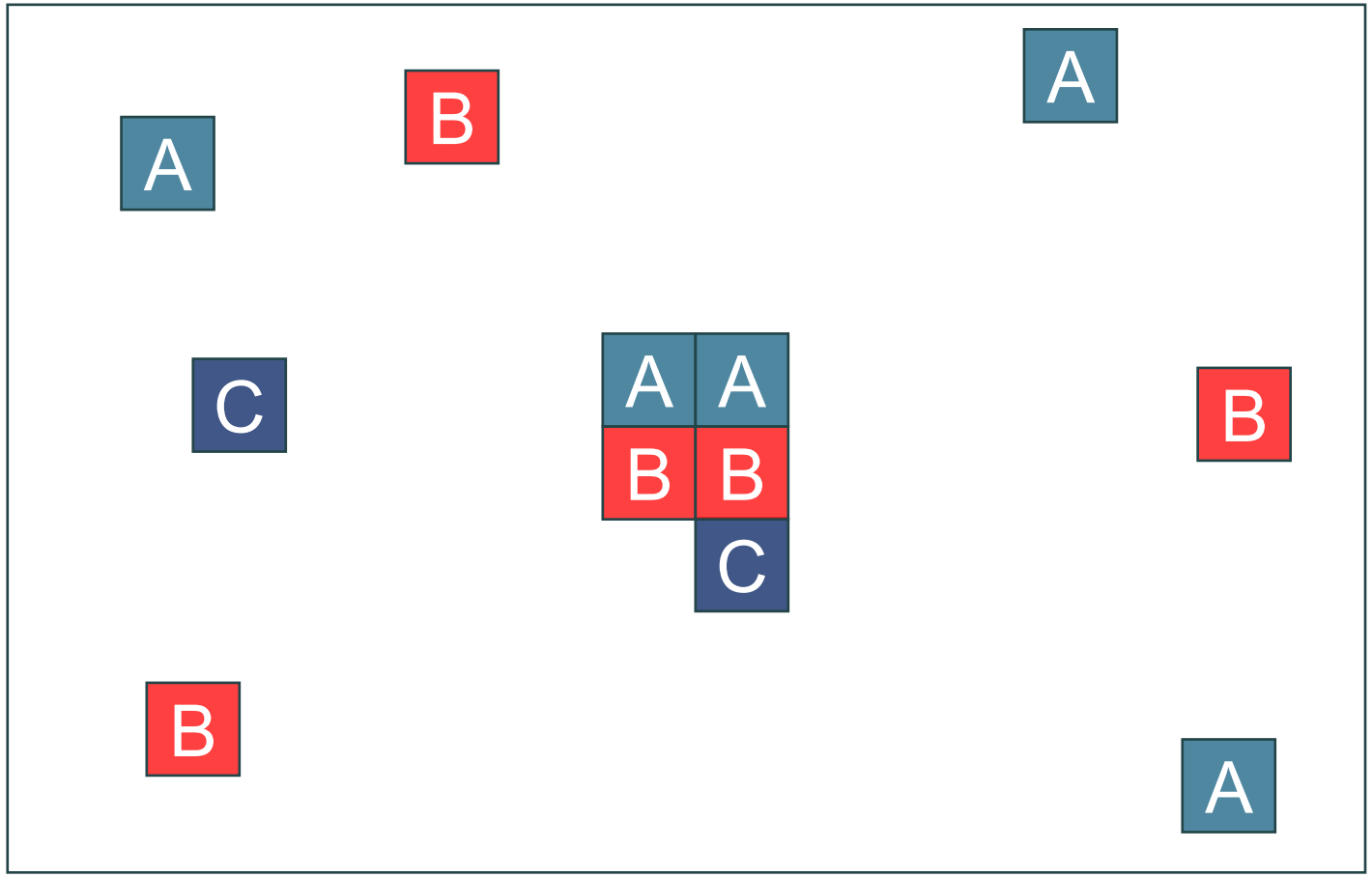
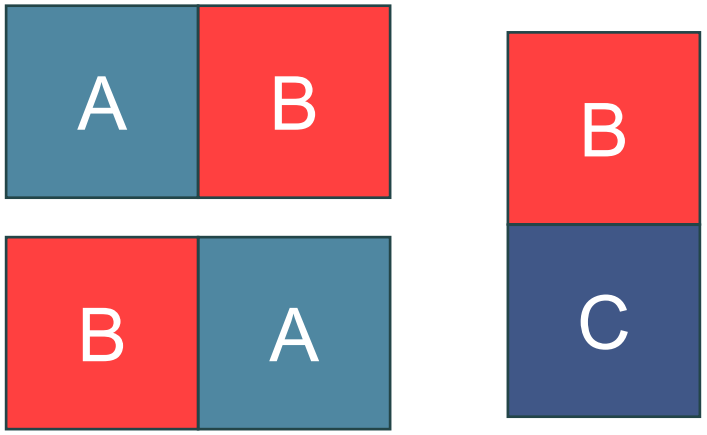


Seeded TA

Tiles:

Affinities:

Temperature: τ



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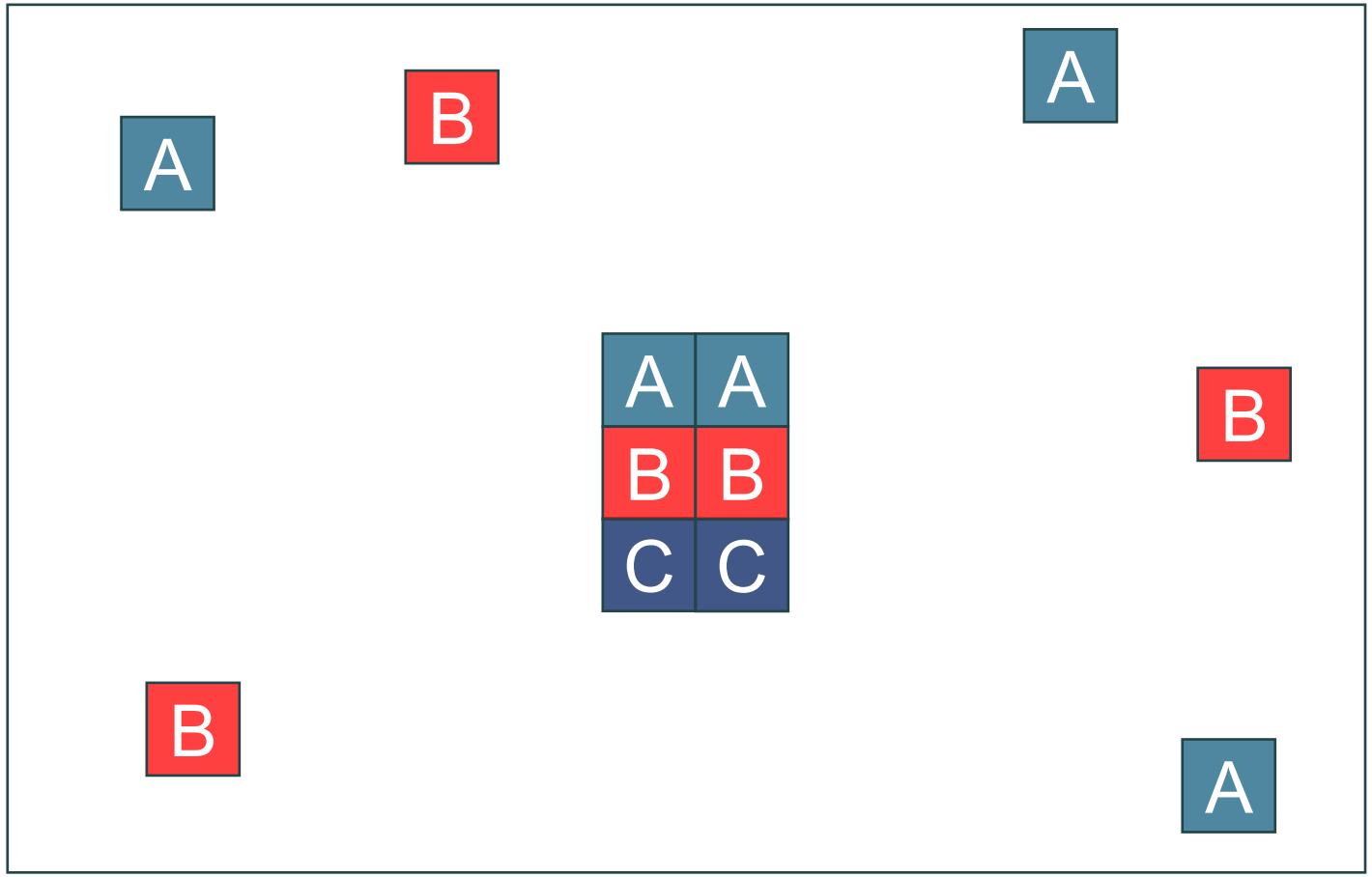
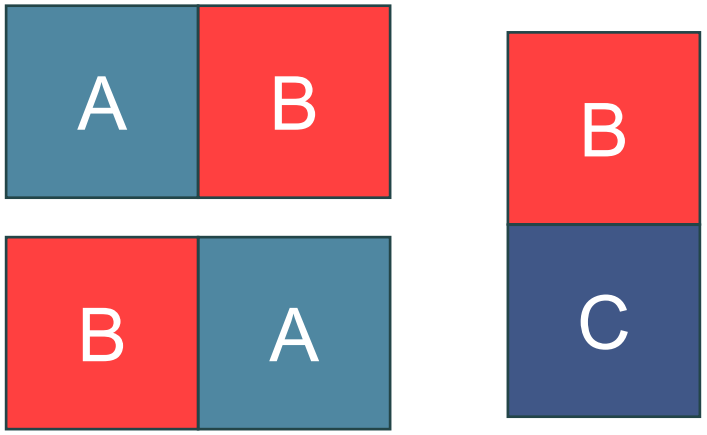


Seeded TA

Tiles:

Affinities:

Temperature: τ



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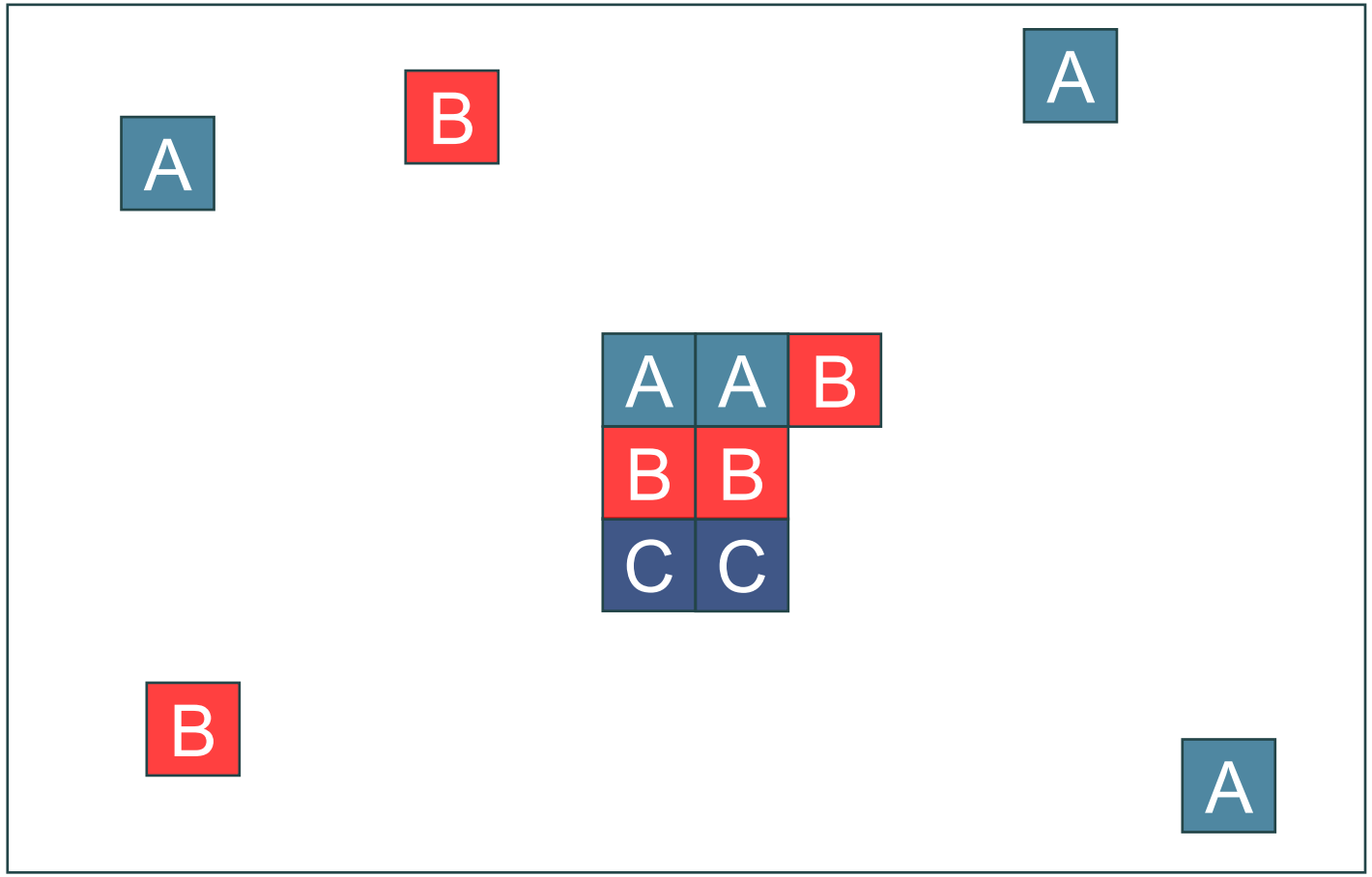
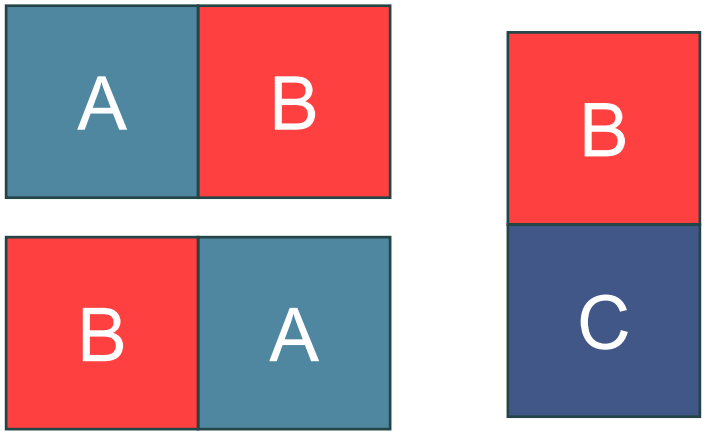


Seeded TA

Tiles:

Affinities:

Temperature: τ



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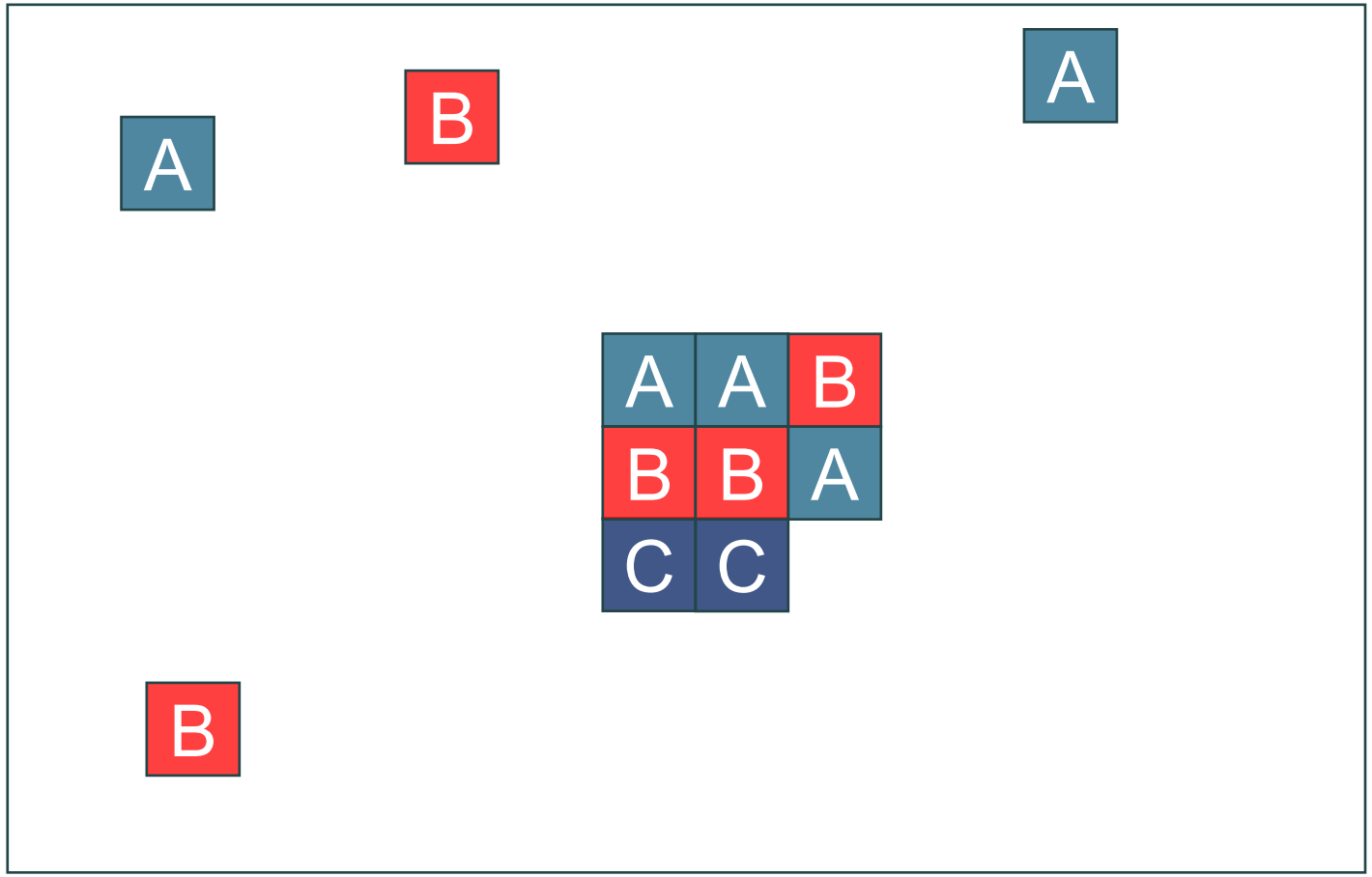
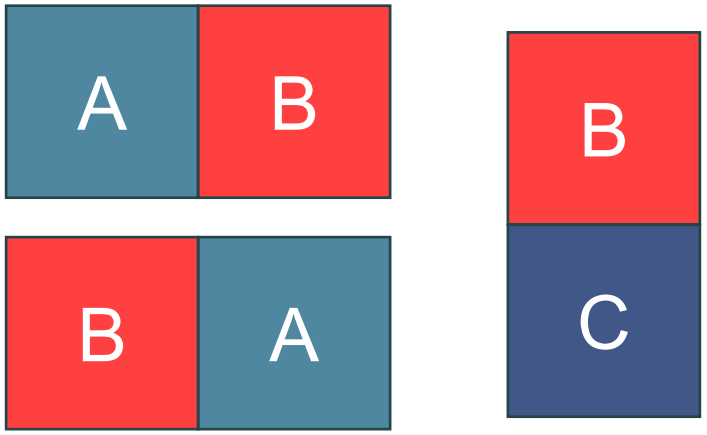


Seeded TA

Tiles:

Affinities:

Temperature: τ



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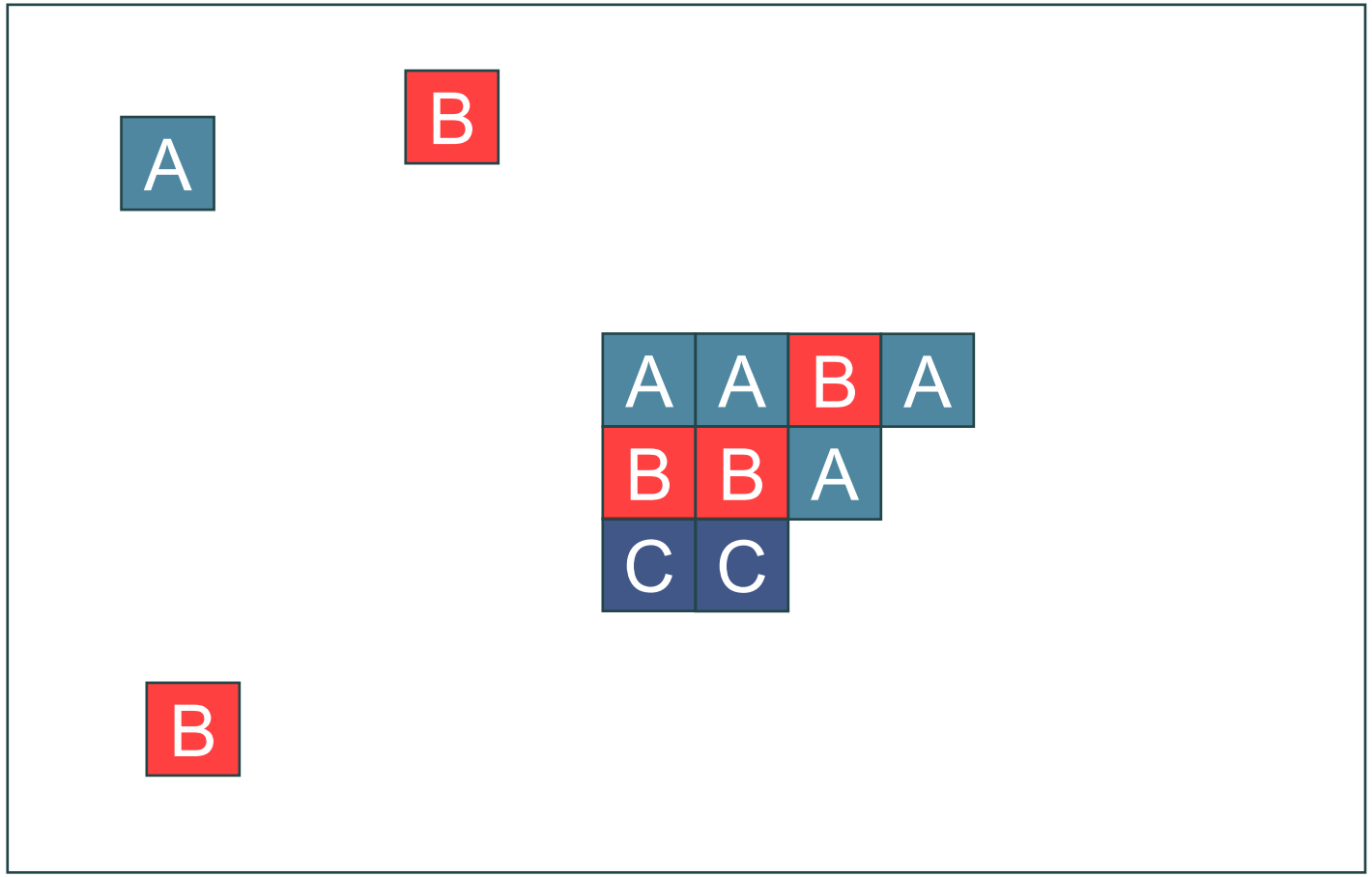
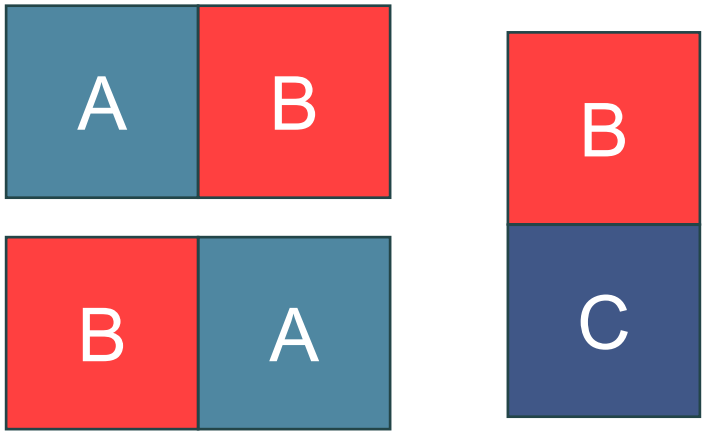


Seeded TA

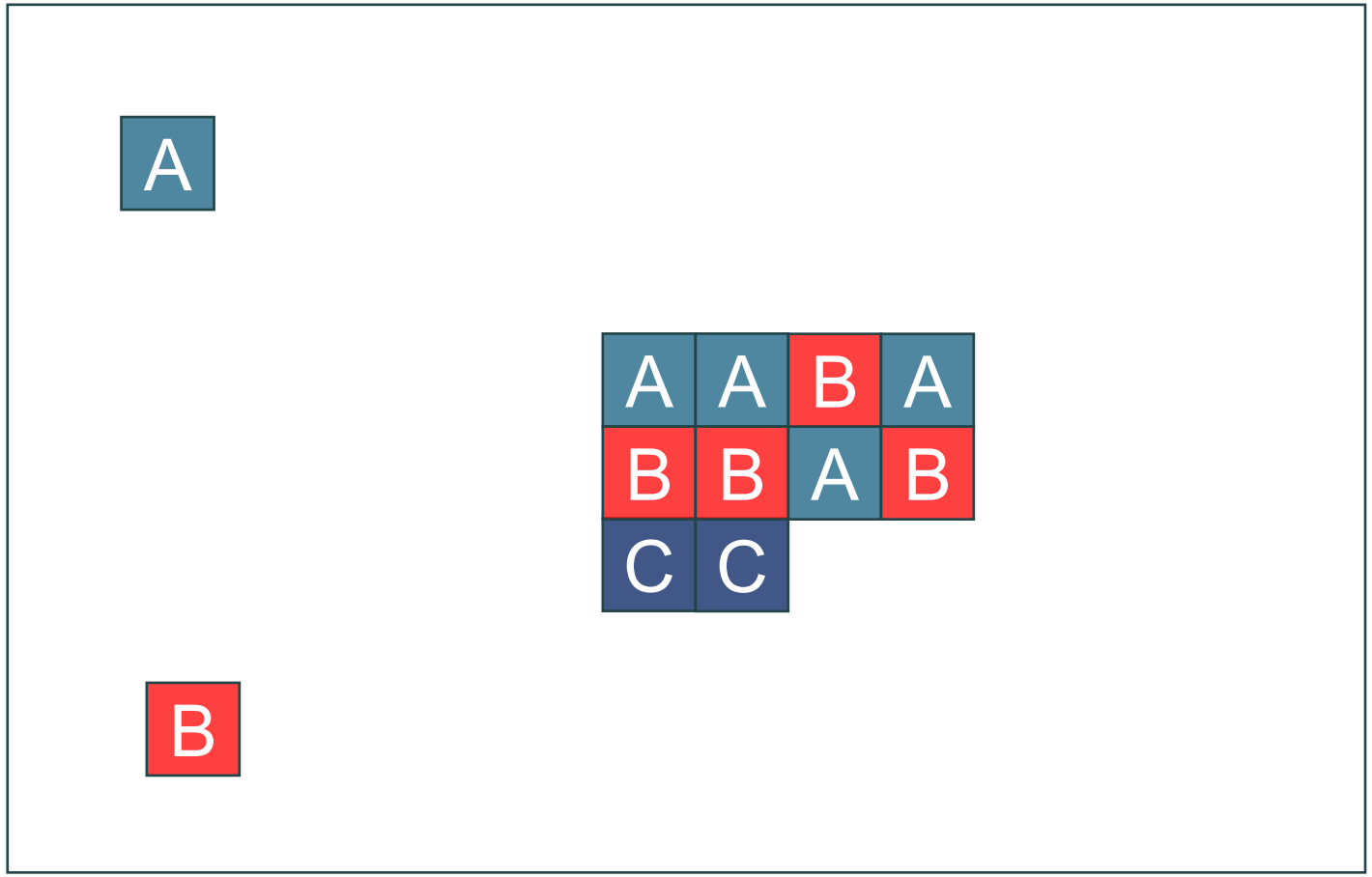
Tiles:

Affinities:

Temperature: τ

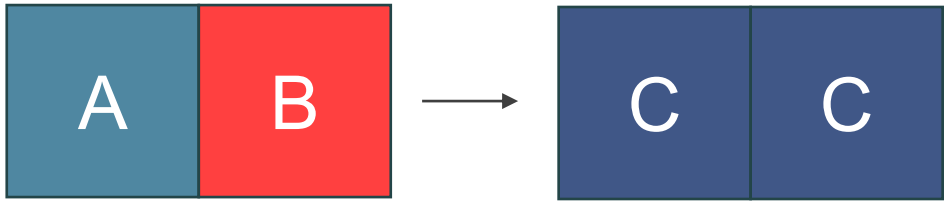


System:



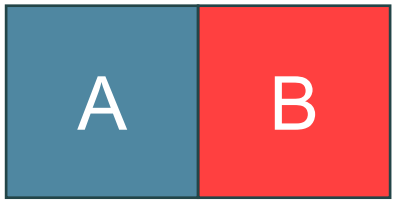
Seeded TA

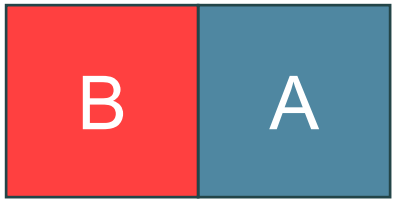
Transitions:

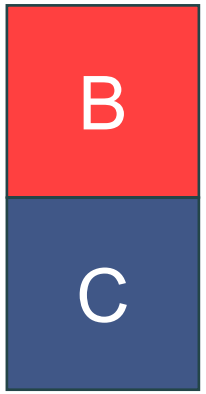


Affinities:

Temperature: τ







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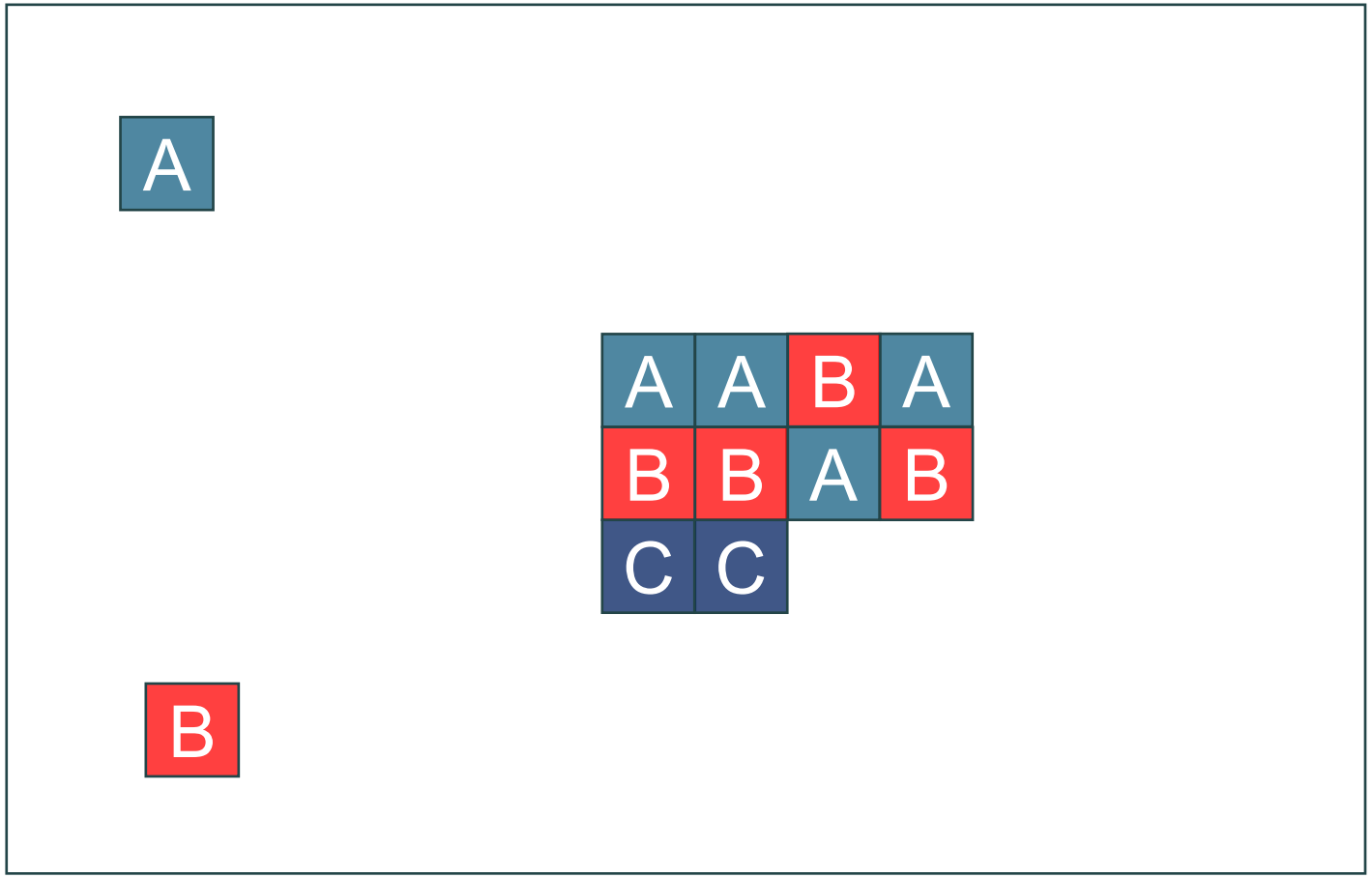

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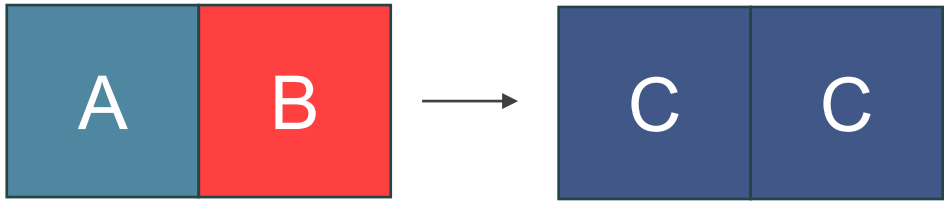
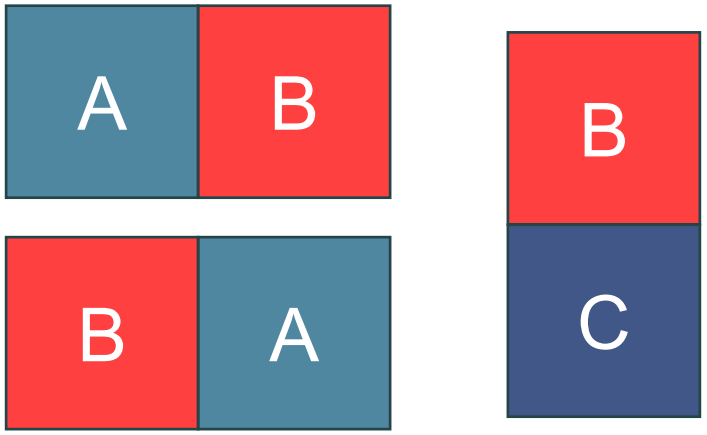
Transitions:

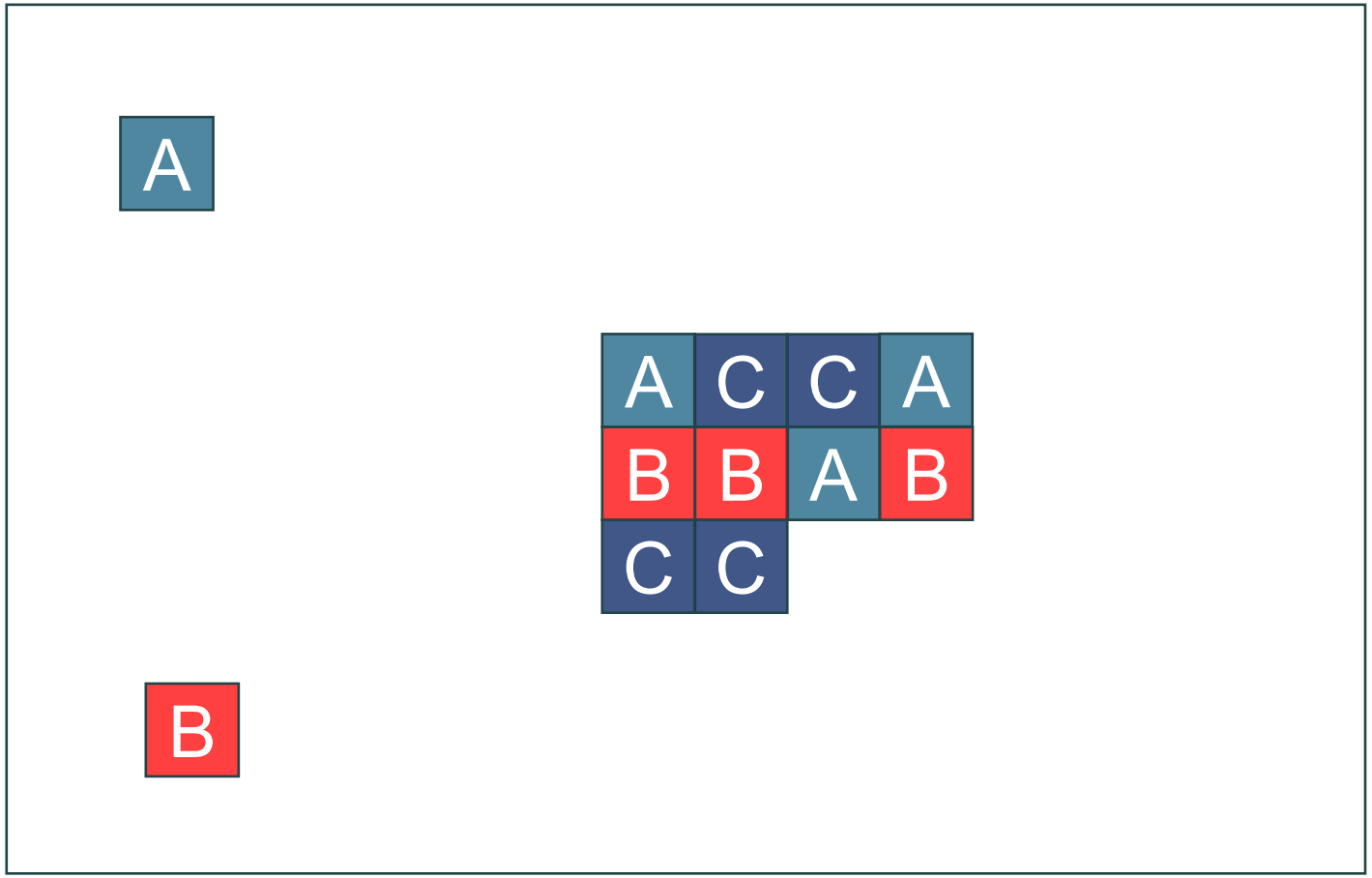


Affinities:

Temperature: τ

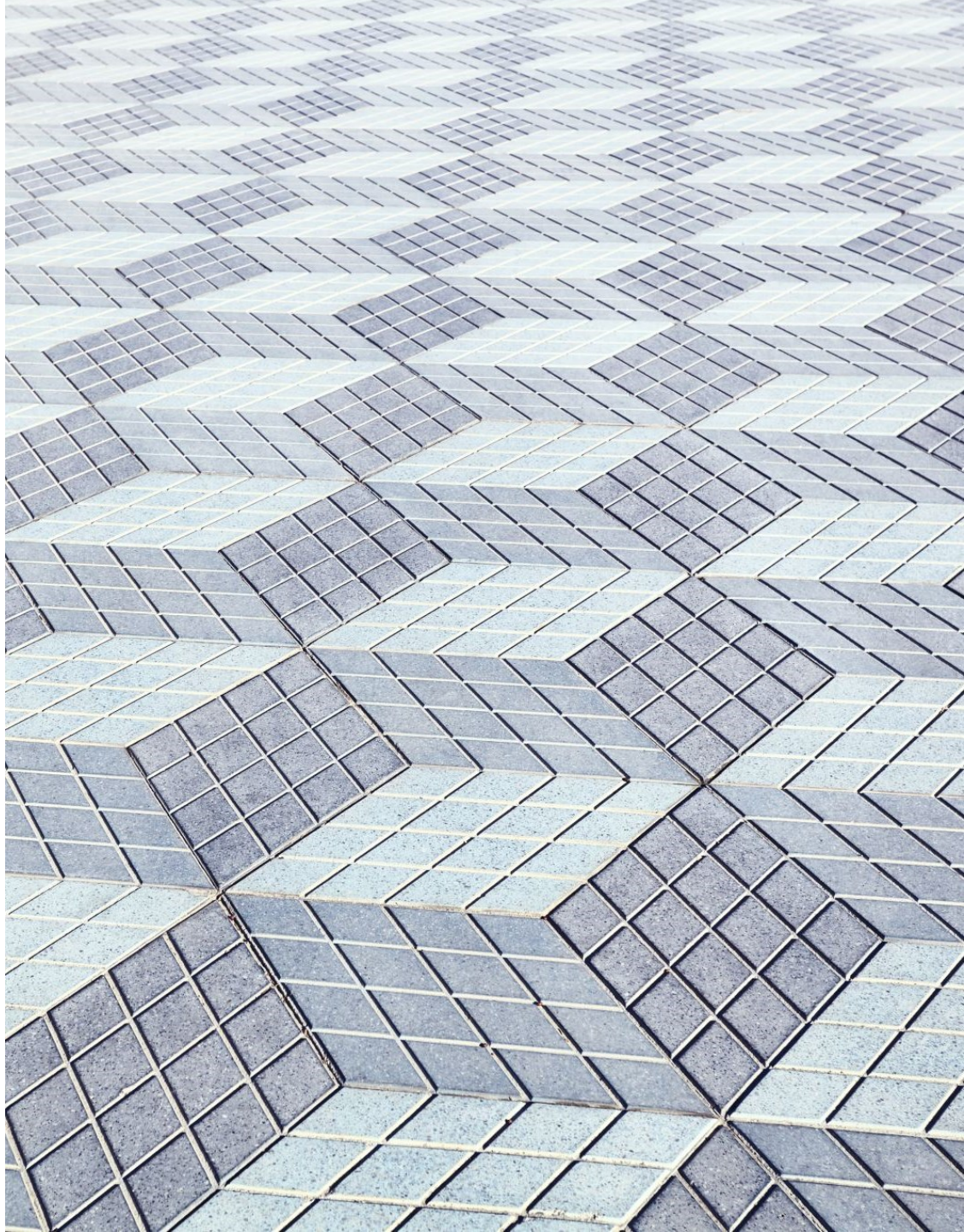


System:

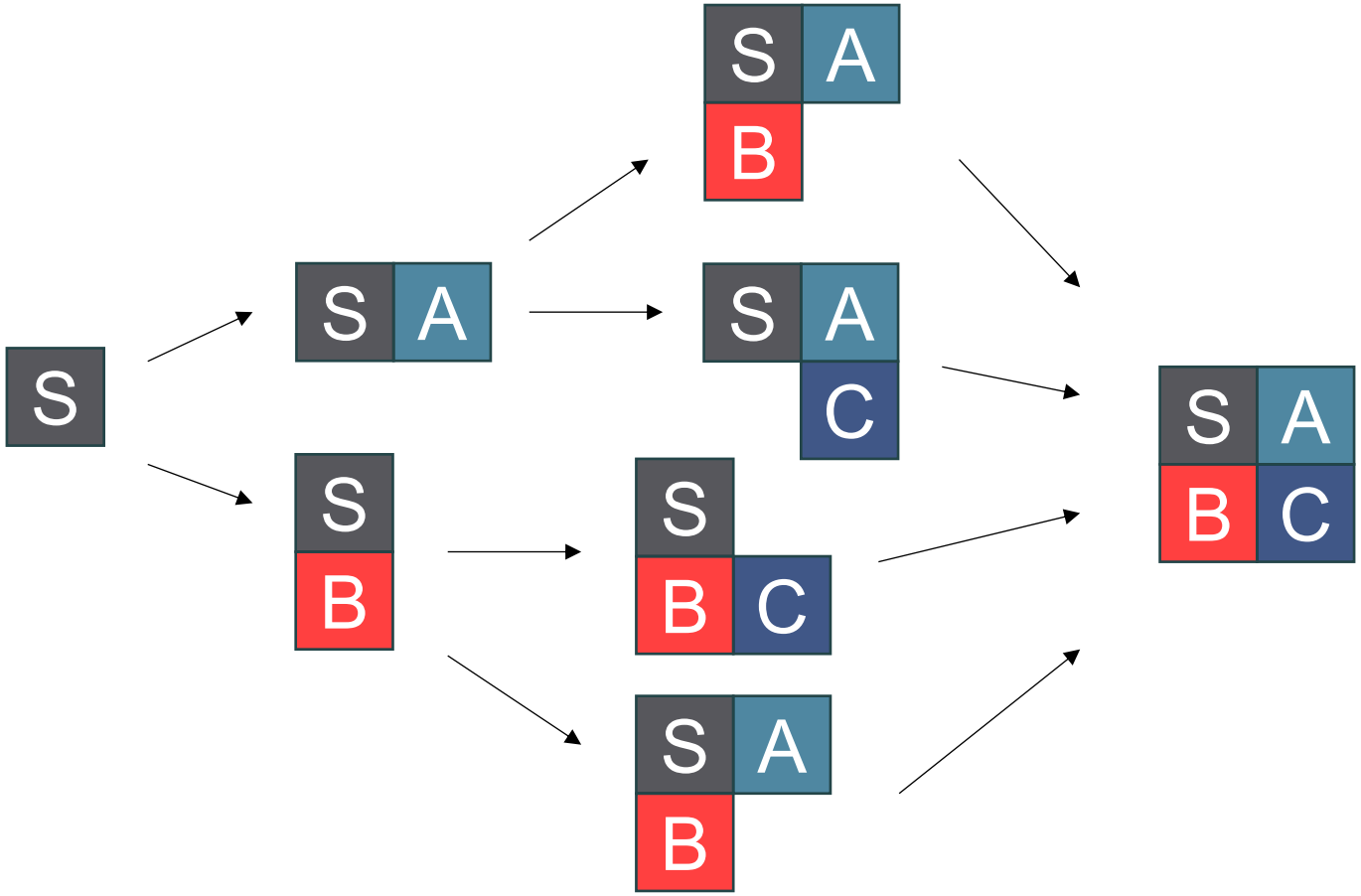


Intrinsic Universality in Self-Assembly

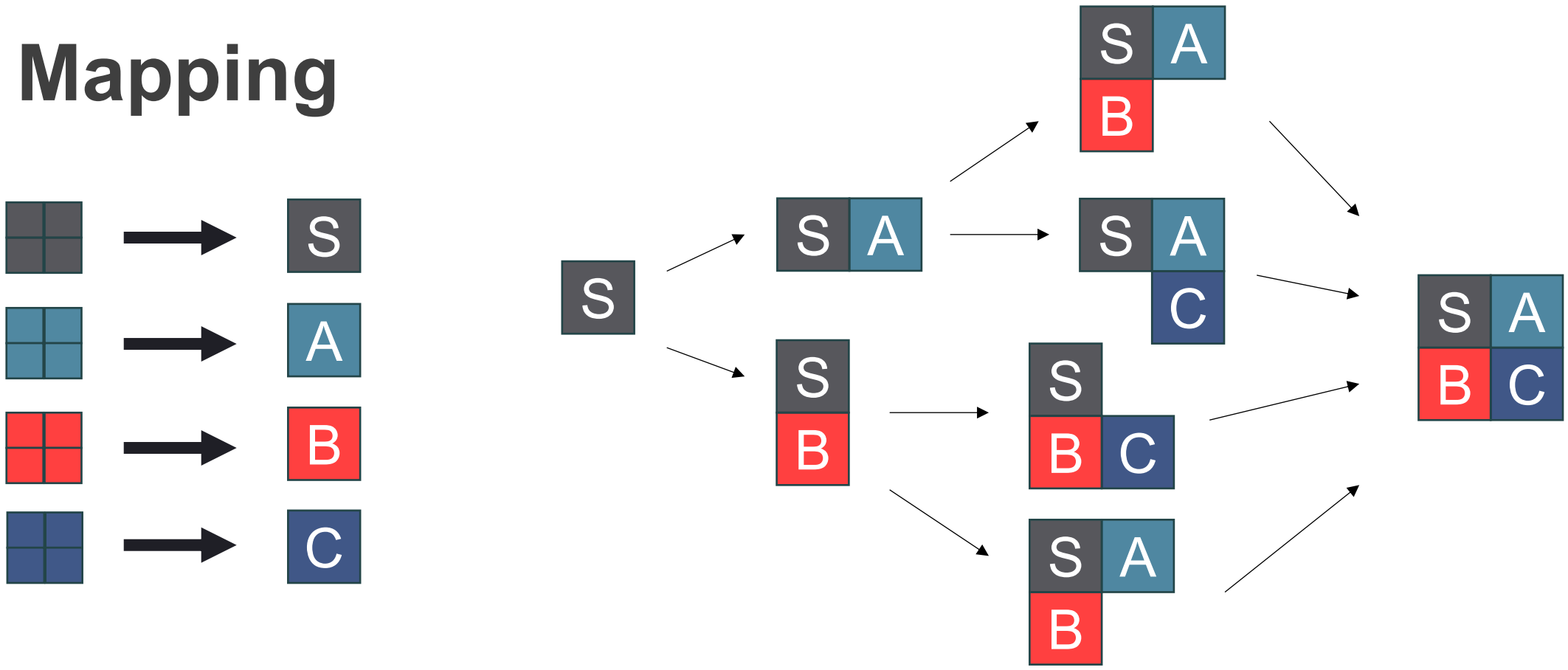
- An Intrinsically Universal Tile Set can be programmed to copy not only the shape(s) built by another system but also the ***dynamics*** of how the tile set we are ***simulating*** builds. This means it can build anything any other tile set can build in the same way.
- A class of tile assembly systems C is said to be *intrinsically universal* if there exists a single set of tiles U that simulates any instance of C.
- The entire tile assembly system T is itself encoded in the seed supertile(s) of U.



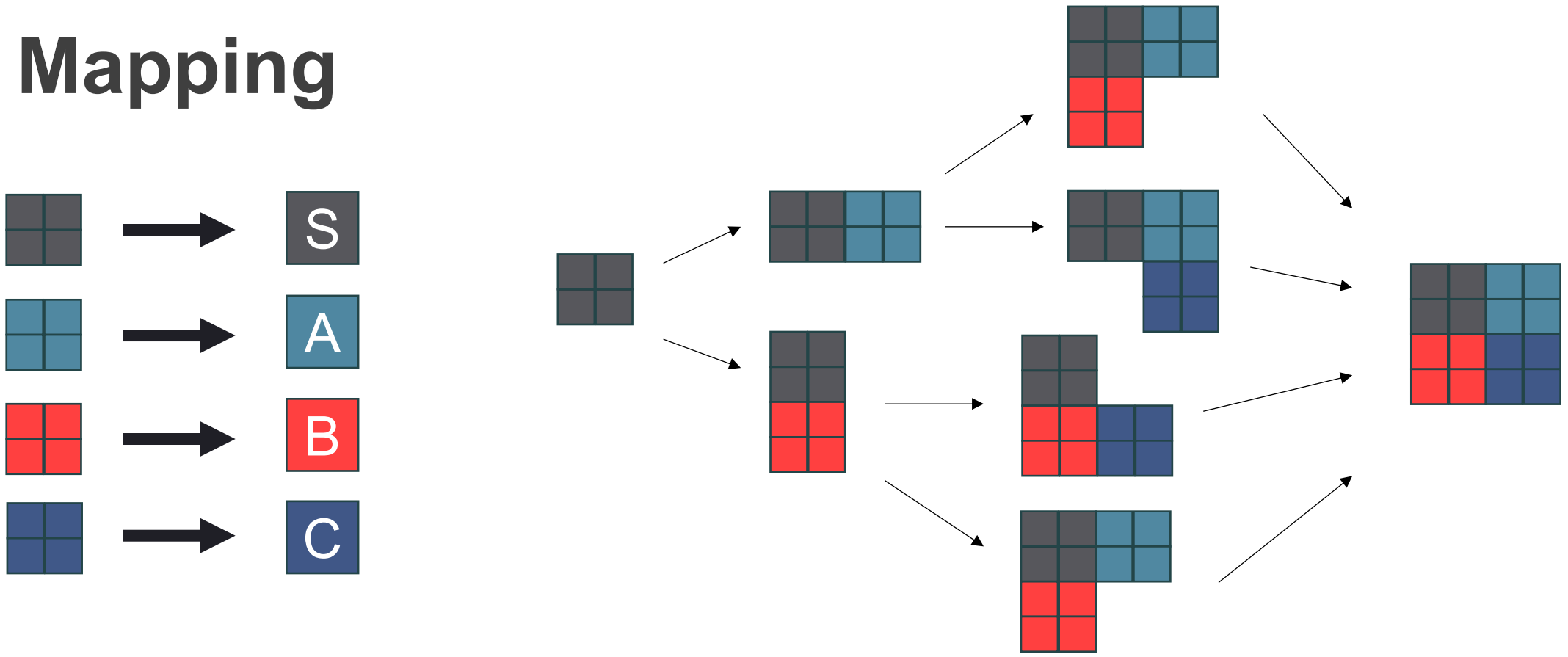
Scale-1 vs Scale-m

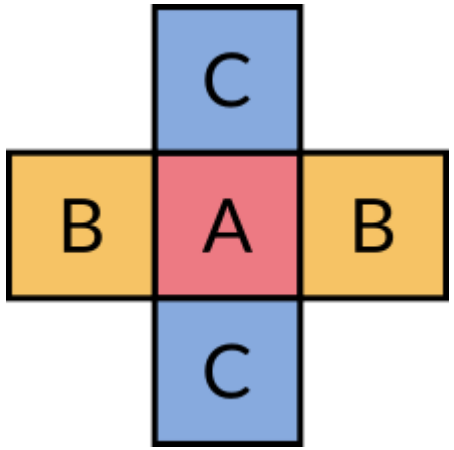


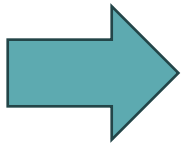
Scale-1 vs Scale-m

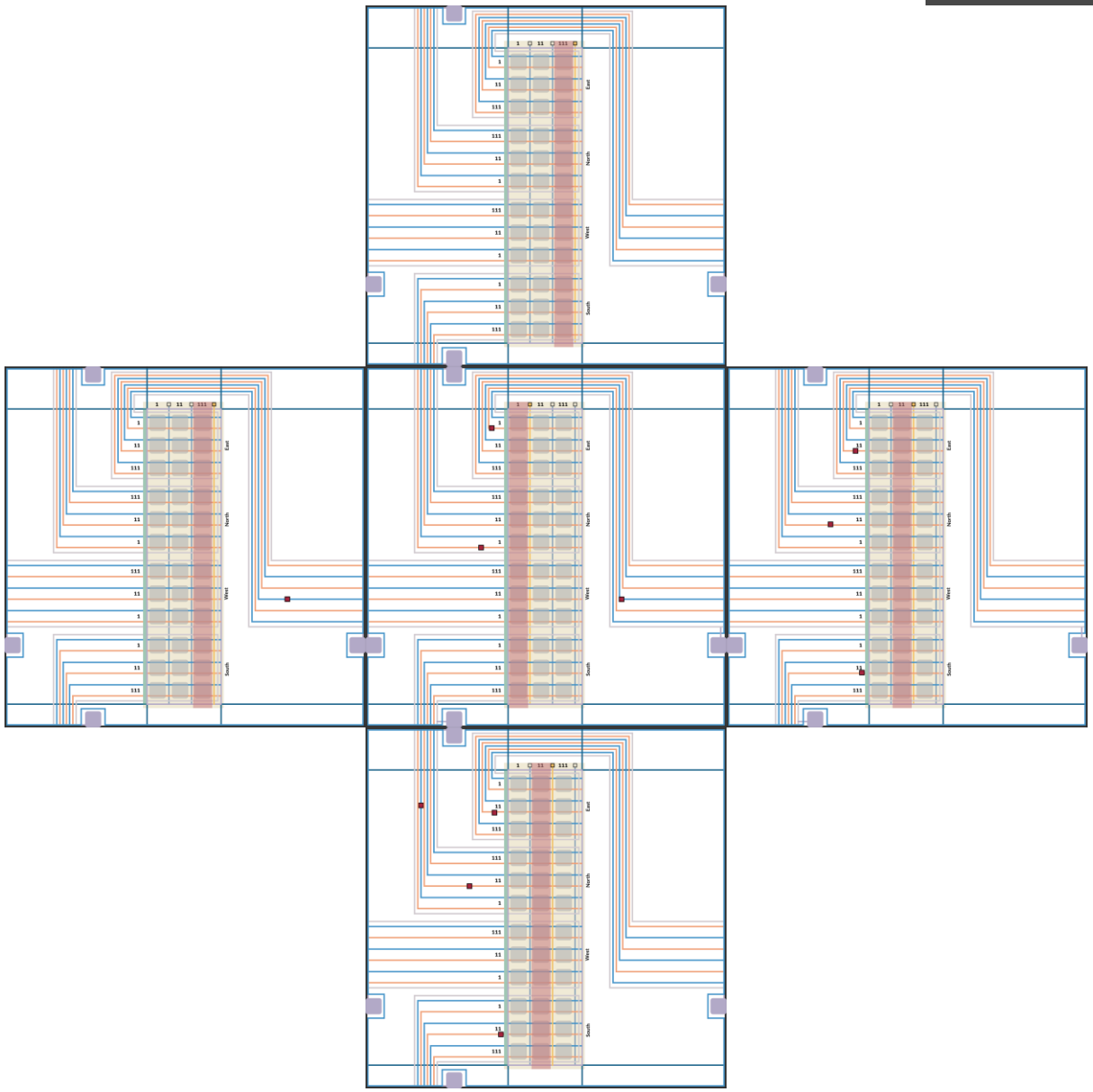


Scale-1 vs Scale-m




C
B
A
B
C





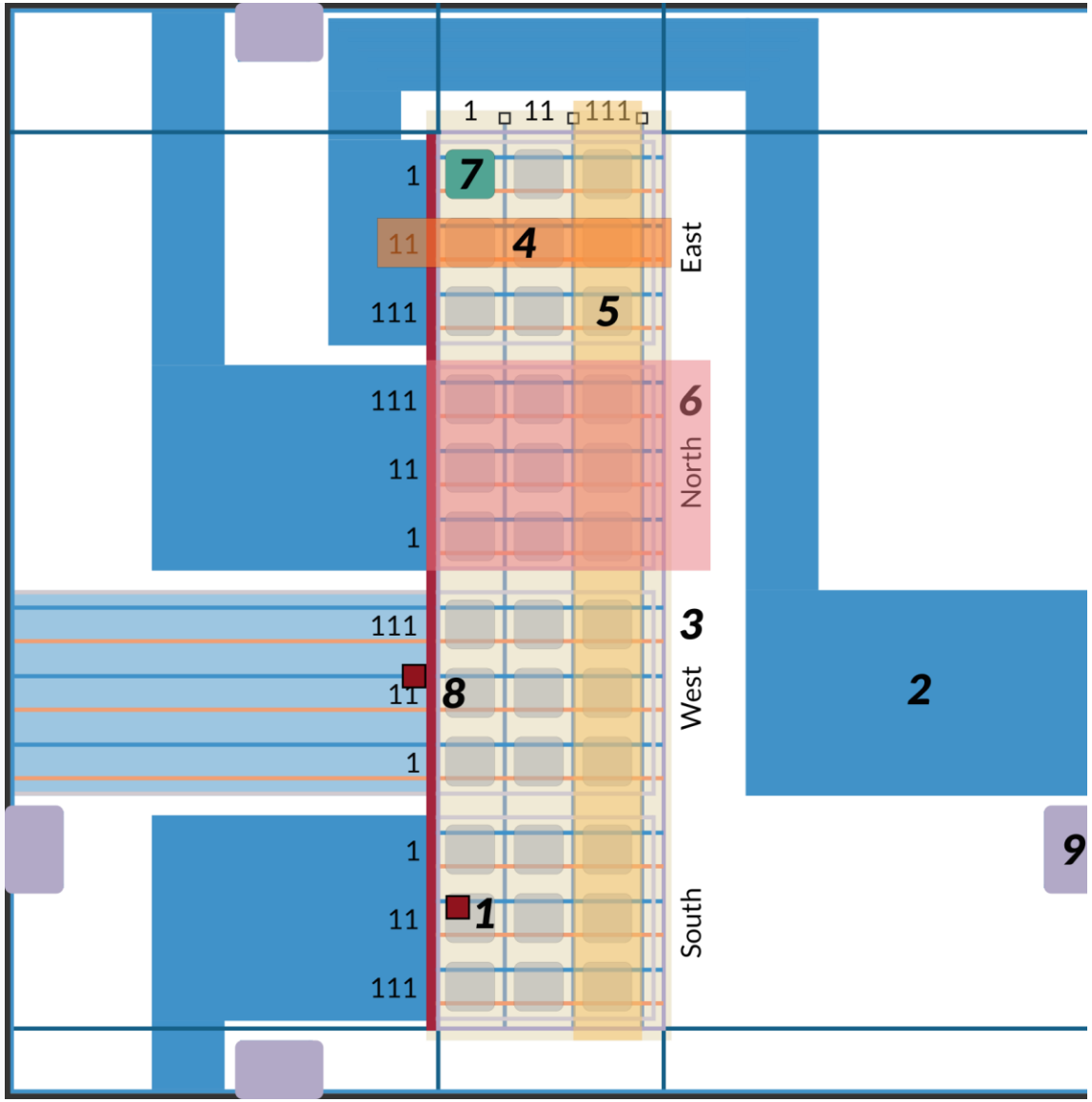
Our Results and Previous Work

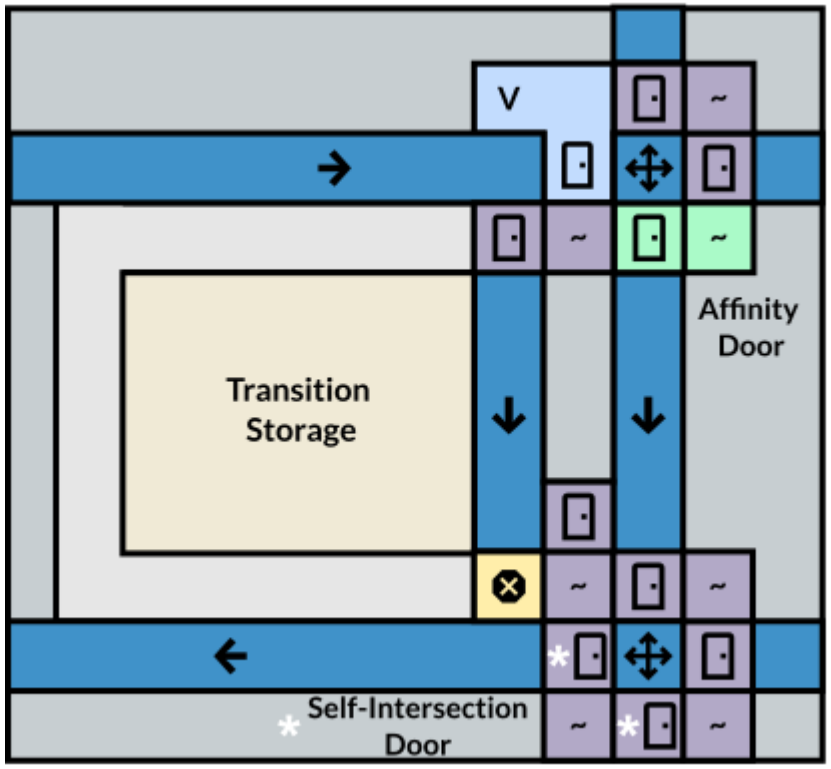
MODEL	D	N	TILE SET SIZE	SCALE	REF
aTAM	2D	5	$> 10\ million$	$\mathcal{O}(n^4 \log n)$	David Doty, Jack H. Lutz, Matthew J. Patitz, Robert T. Schweller, Scott M. Summers, and Damien Woods. The Tile Assembly Model is Intrinsically Universal. In 53rd Annual Symposium on Foundations of Computer Science, pages 302–310, 2012.
aTAM	3D	7	152,000	$\mathcal{O}(n^2 \log(n\tau))$	Daniel Hader, Aaron Koch, Matthew J. Patitz, and Michael Sharp. The Impacts of Dimensionality, Diffusion, and Directedness on Intrinsic Universality in the abstract Tile Assembly Model. In Symposium on Discrete Algorithms (SODA), pages 2607–2624, 2019
Seeded TA Temp-1	**2D**	**5**	**4600**	$\boldsymbol{\mathcal{O}(n^3)}$	**Thm. 6**
Seeded TA	**2D**	**5**	**4600**	$\boldsymbol{\mathcal{O}(\min((\tau n)^3, n^9)))}$	**Thm. 9**
Async. Cellular Automata	1D	3	$\mathcal{O}(1)$	$unknown$	Thomas Worsch. Towards intrinsically universal asynchronous CA. Natural Computing,494 12:539–550, 2013. doi:10.1007/s11047-013-9388-3.495
Block-Pairwise ACA	**2D**	**2**	**2600**	$\boldsymbol{\mathcal{O}(\min(n^3, n^9))}$	**Thm. 29**
Pairwise ACA	**2D**	**2**	$\boldsymbol{\mathcal{O}(1)}$	$\boldsymbol{\mathcal{O}(\min(n^3, n^9))}$	**Thm. 31**

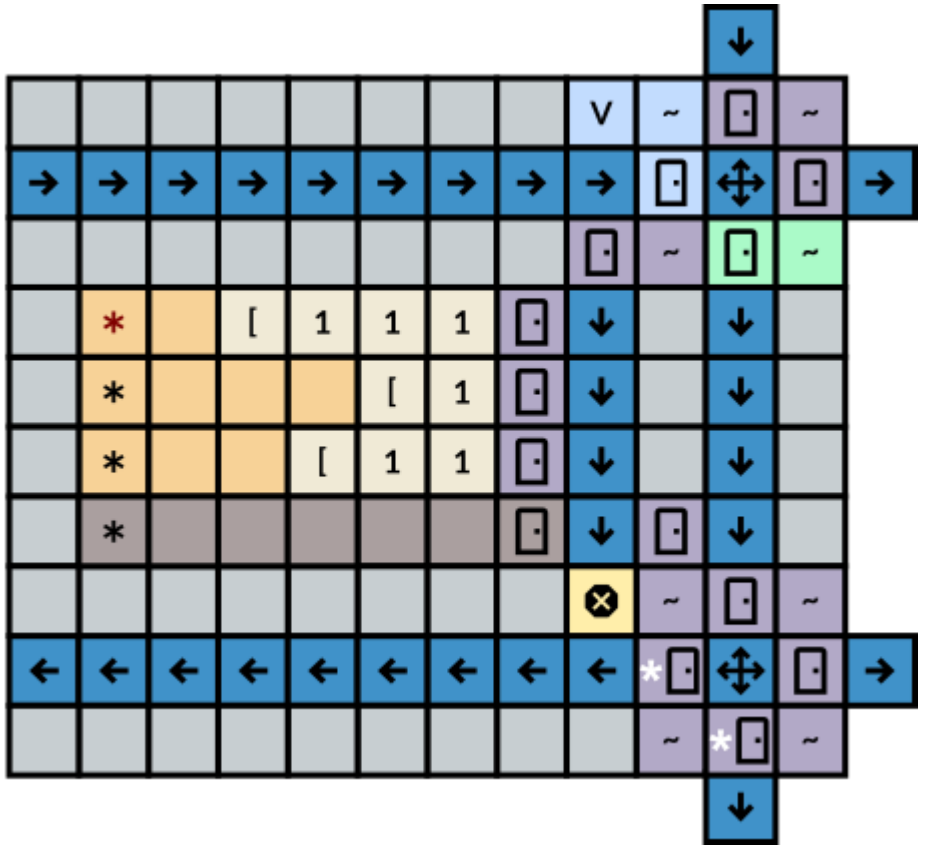
Gadgets

C

The Supertile

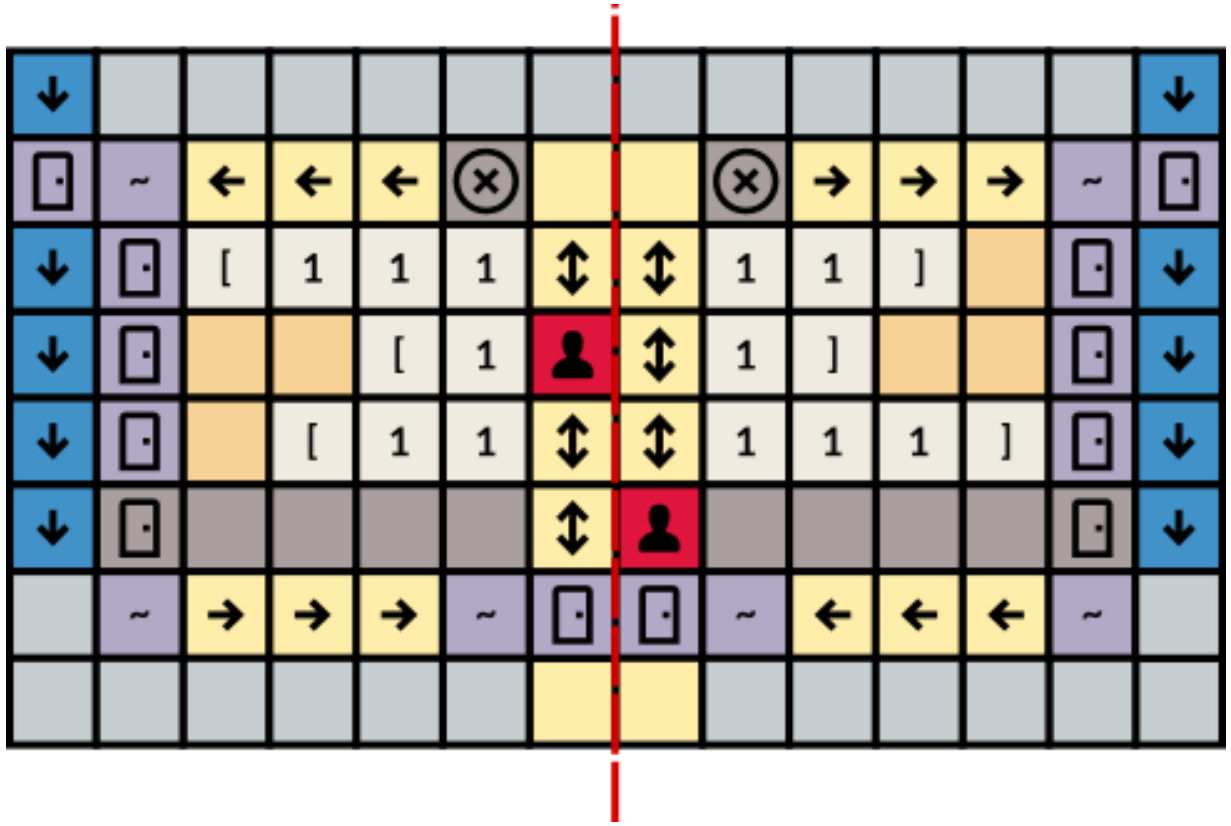


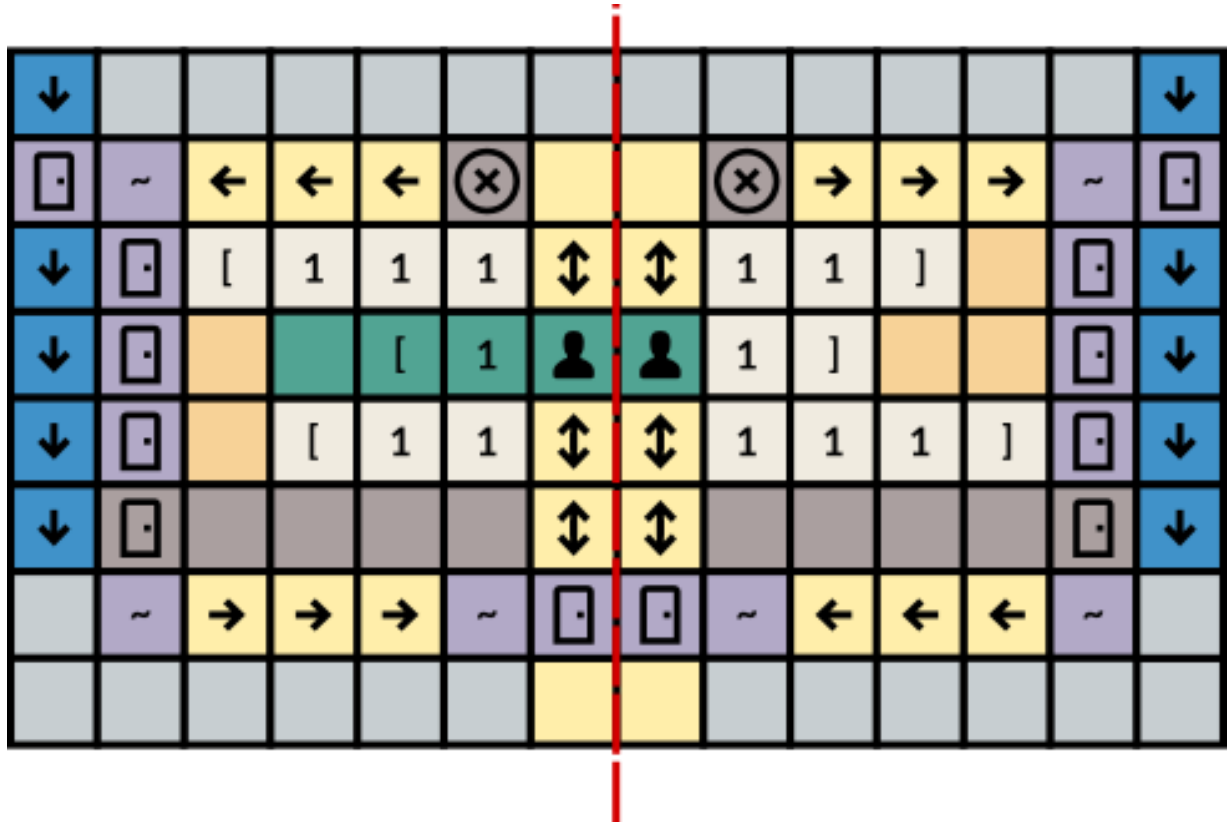




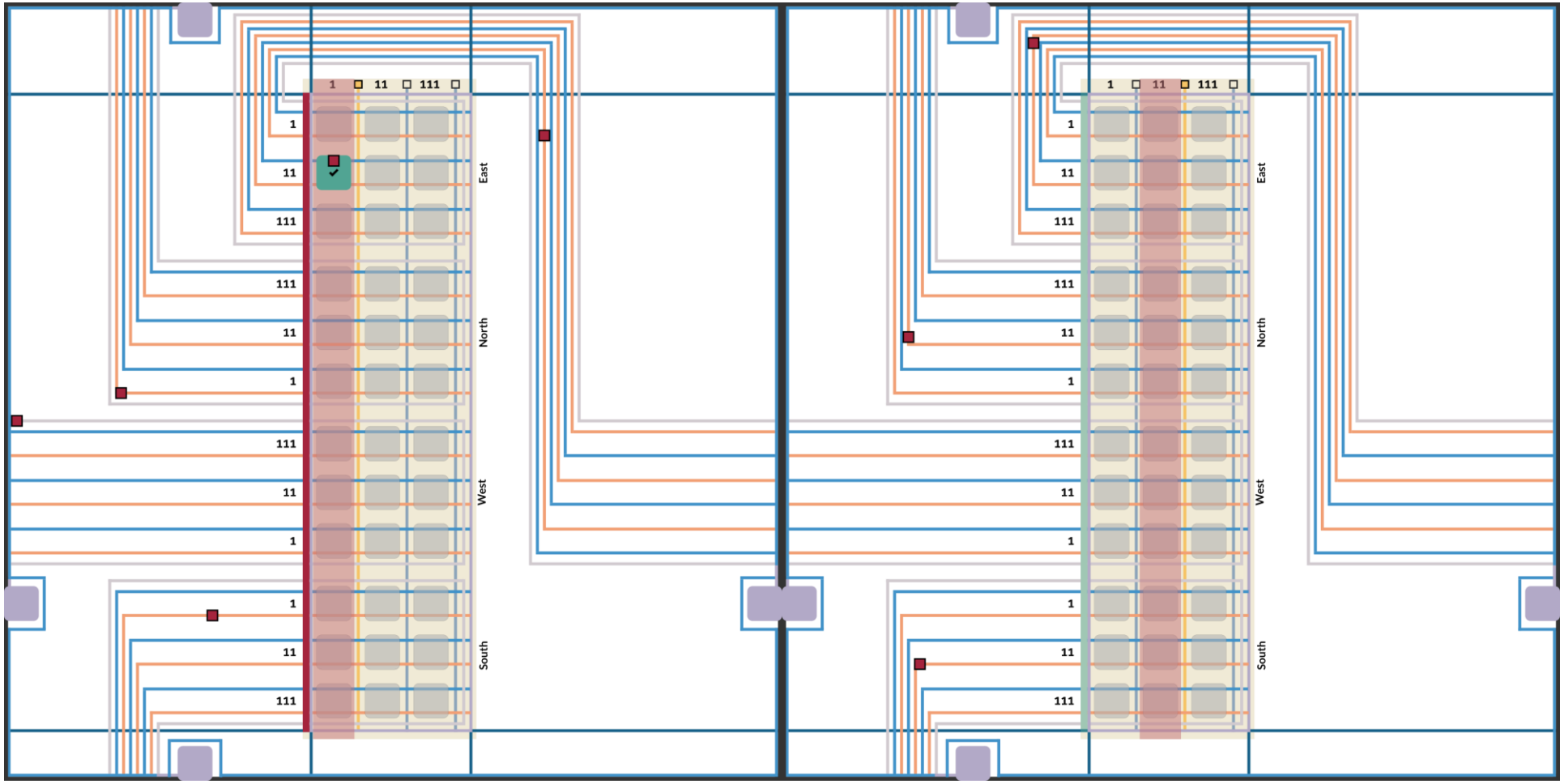
The Datacell

Transition Selection Gadget

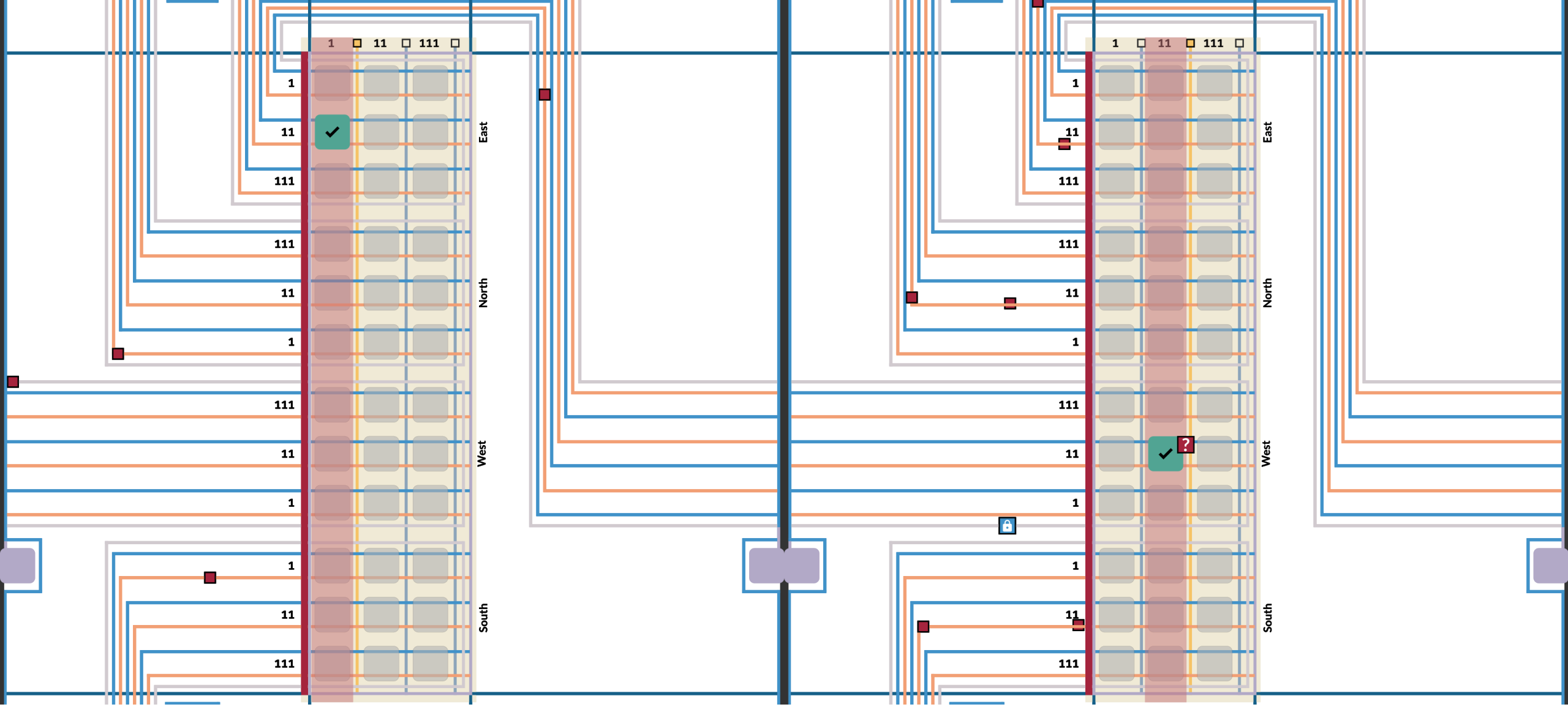




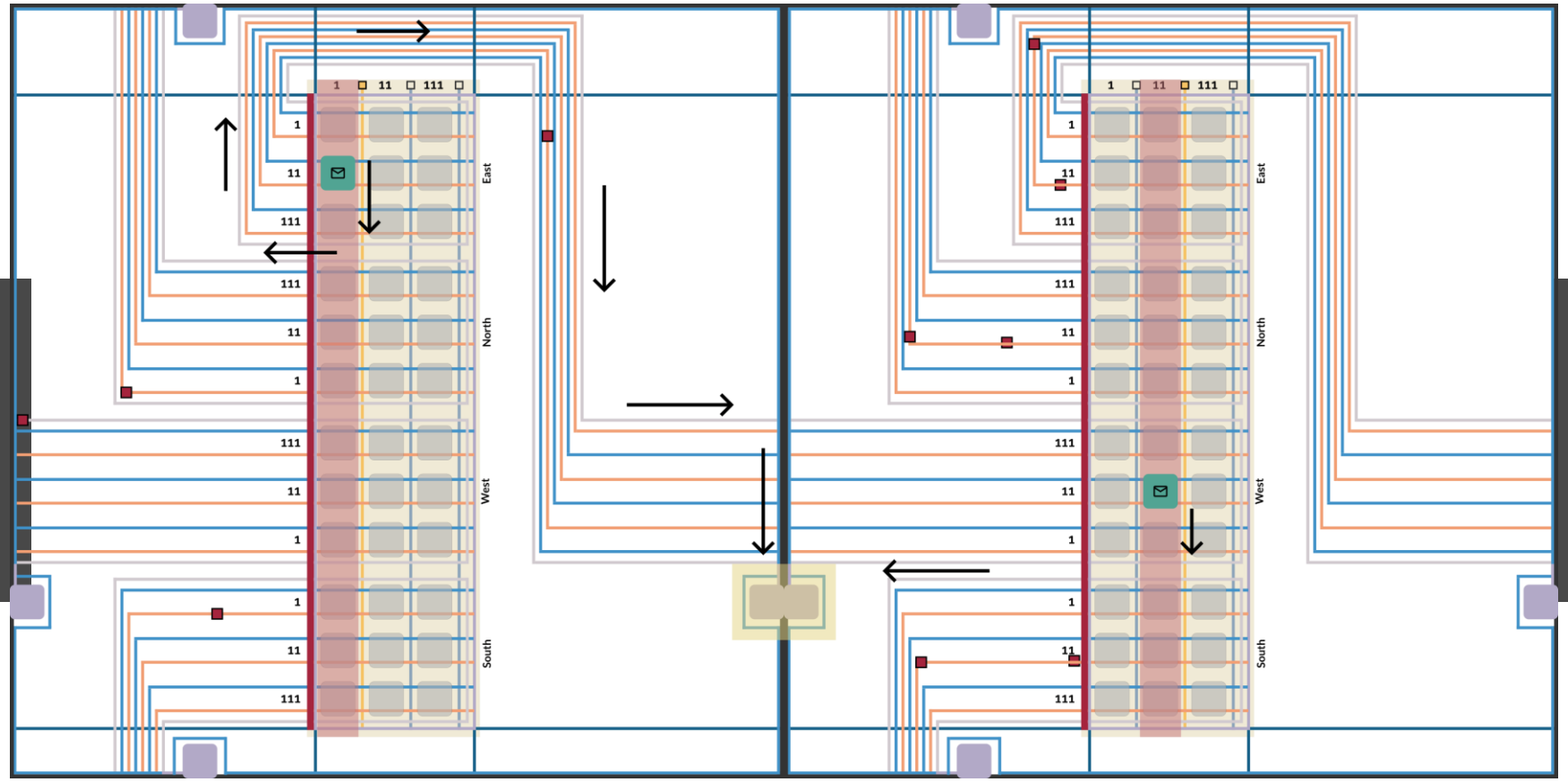
Transitioning Supertiles



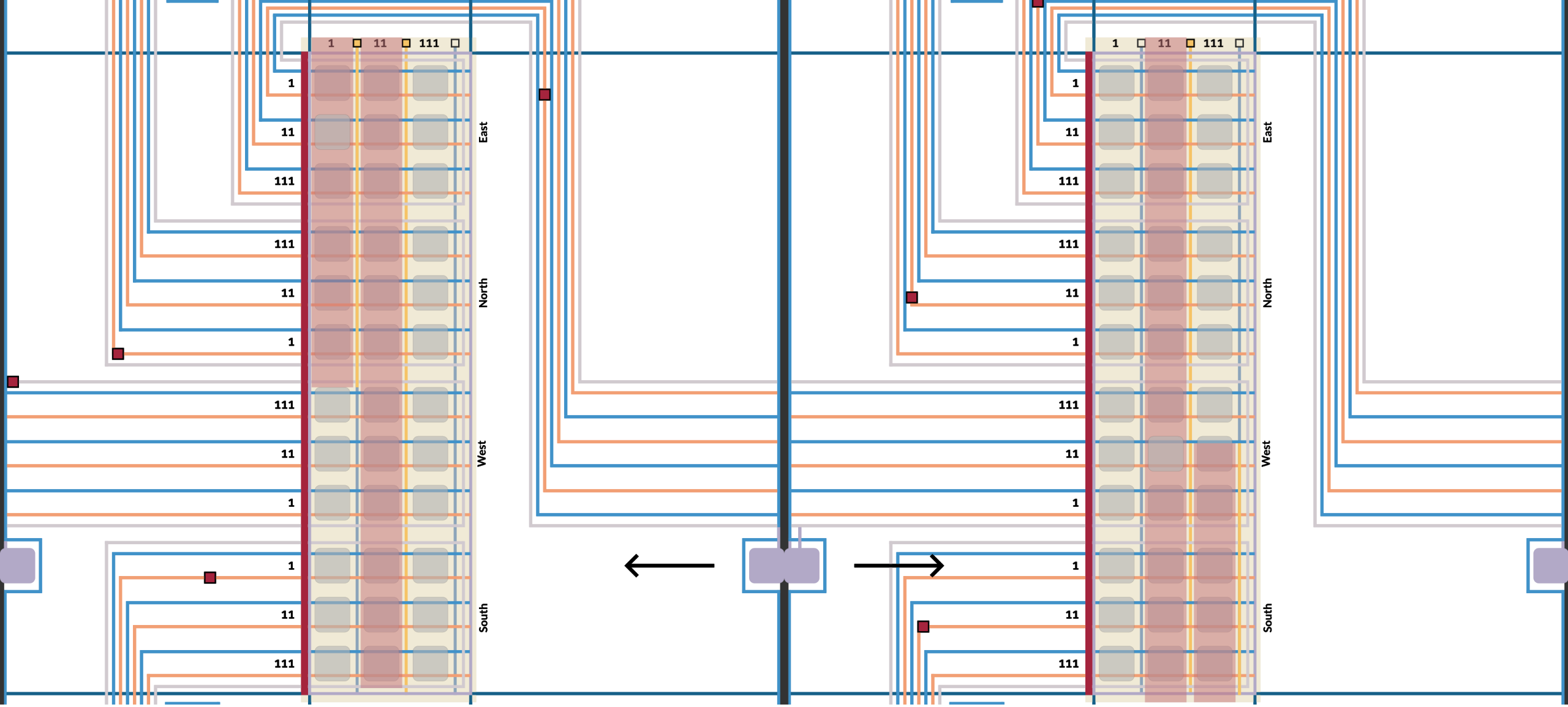
Checking for Available Transition



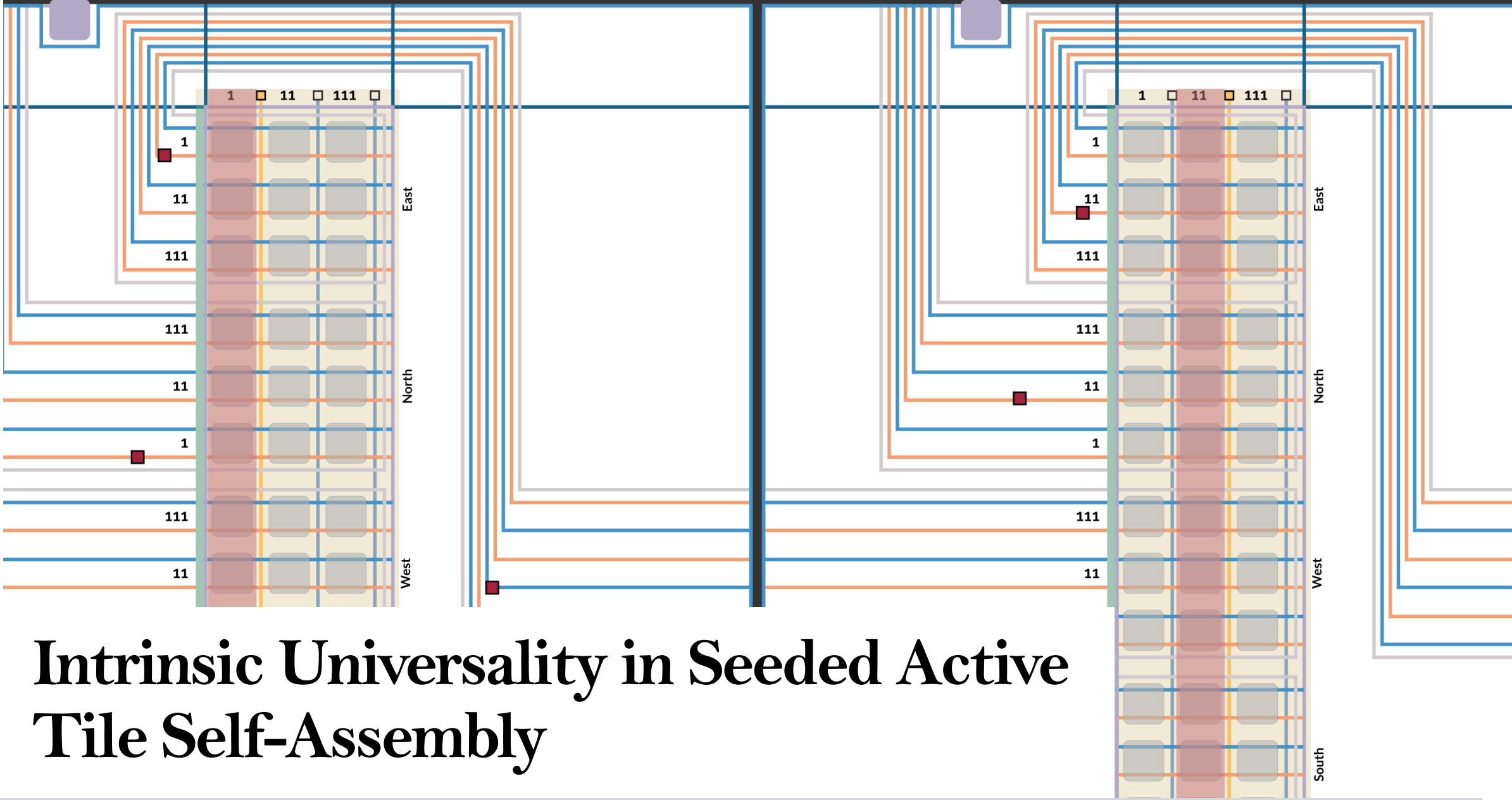
Confirming Neighbors State



Sending Transition Rule Data Strings



Selecting and Deselecting Columns



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