

Solving a Rubik's Cube by Sequentially Restricting the Rotation of Faces

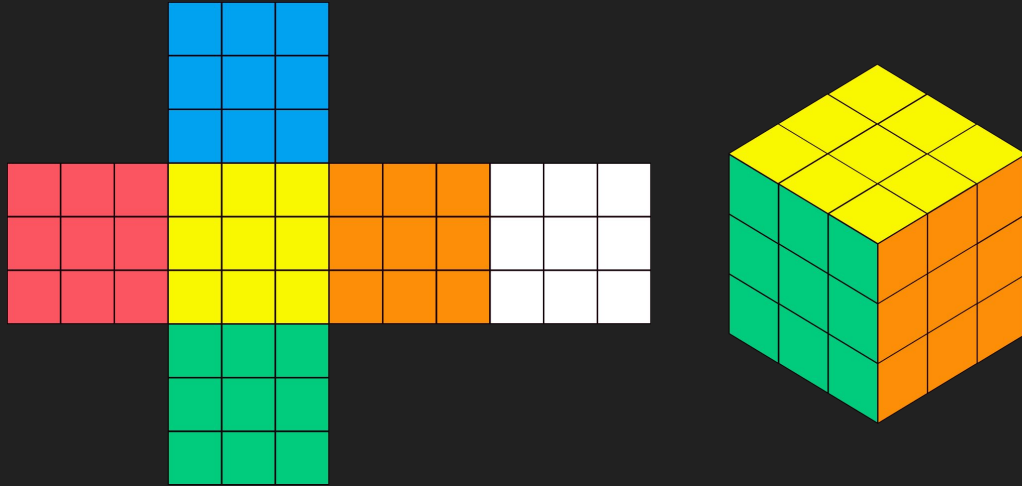
Joseph Parker

Supervised by Gethin Norman

What is a Rubik's Cube?

What is a Rubik's Cube?

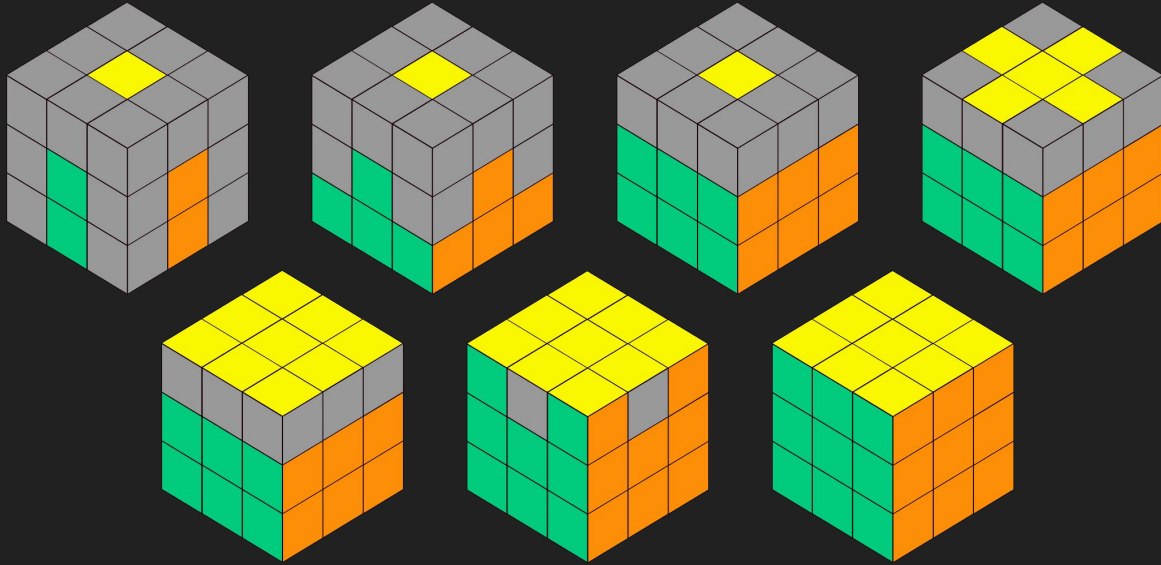
- A 3-D combination puzzle invented in 1974 by Ernő Rubik
- 43,252,003,274,489,856,000 possible combinations



Existing Solving Methods

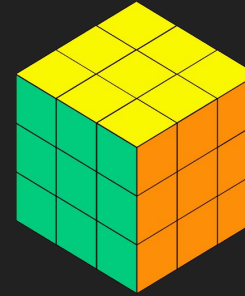
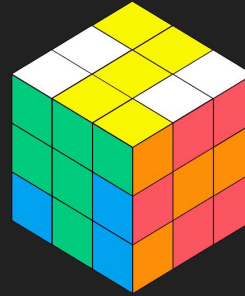
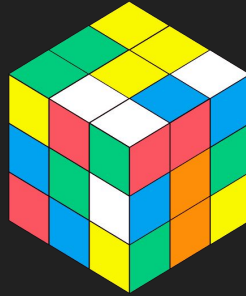
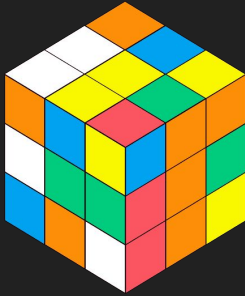
Existing Solving Methods

The Beginner Method



Existing Solving Methods

The Thistlethwaite Method

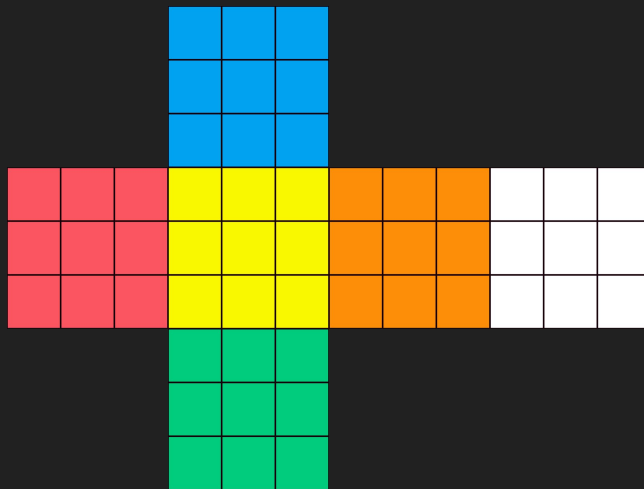


Demonstration of the Solving Method

Representing a Permutation

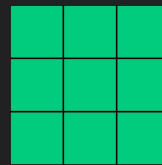
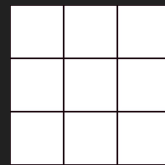
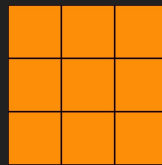
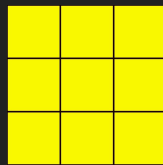
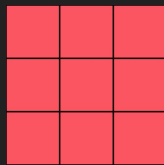
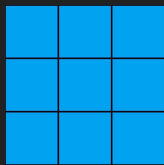
Representing a Permutation

The Solved Cube



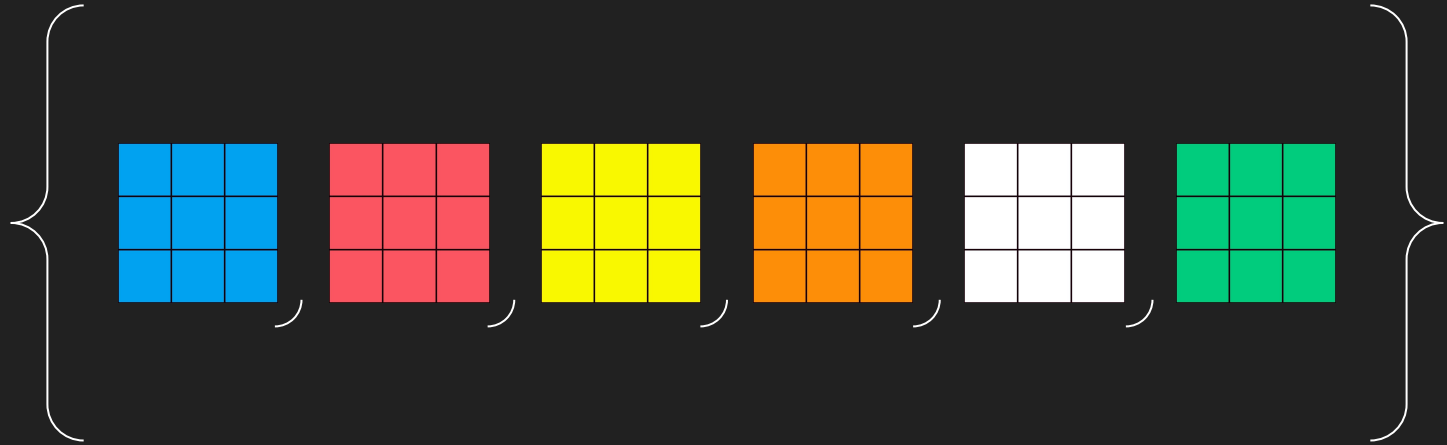
Representing a Permutation

Split by Face



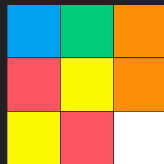
Representing a Permutation

Collect into an Array



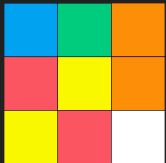
Representing a Permutation

An Example Face



Representing a Permutation

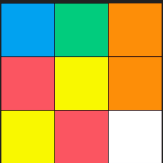
Order the Tiles



Representing a Permutation

Assign Values to the Tiles

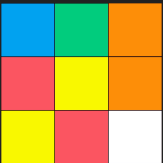
0110	1001	0101	0101	1010	0011	1100	0011
------	------	------	------	------	------	------	------



Implementation

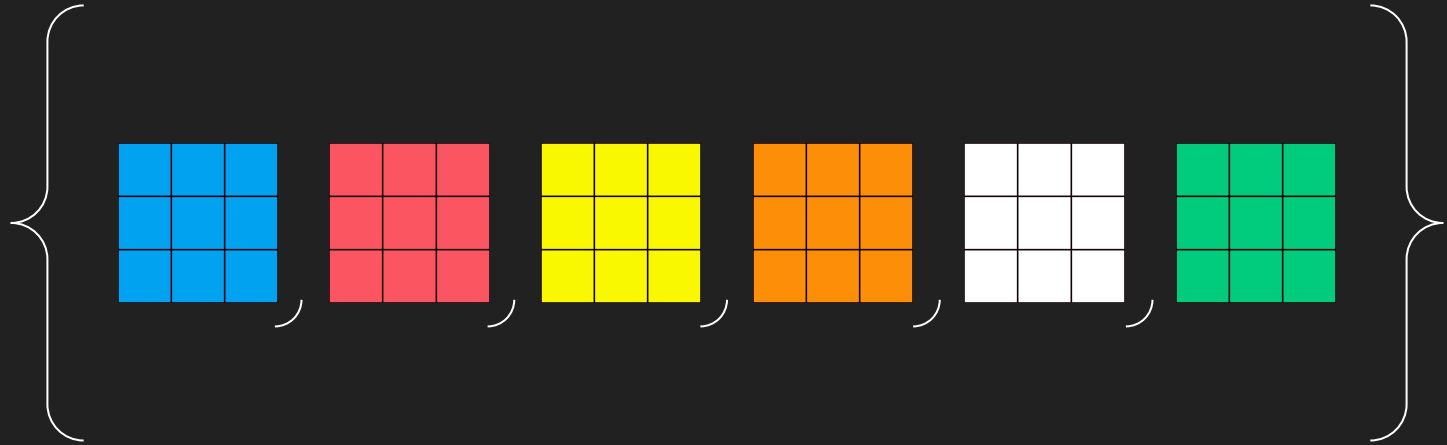
Concatenate Values into an Integer

01101001010101011010001111000011
(1,767,220,163)



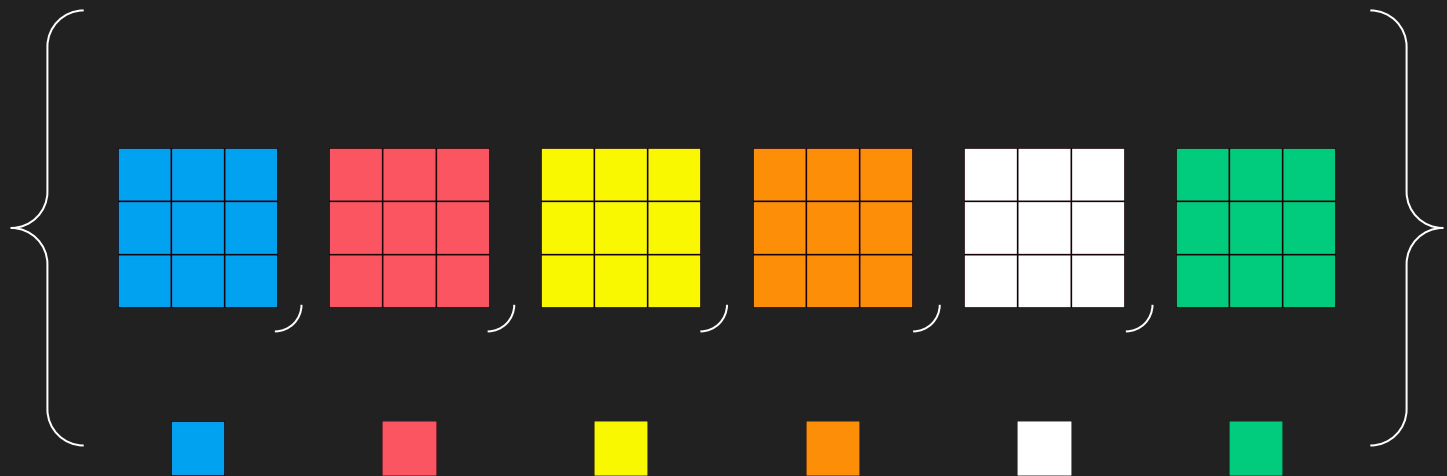
Representing a Permutation

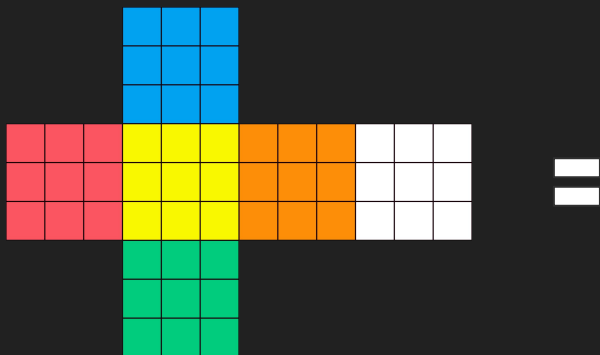
What About the Centers?



Representing a Permutation

Infer Center from Index





=

{
01100110011001100110011001100110,
00110011001100110011001100110011,
11001100110011001100110011001100,
01010101010101010101010101010101,
10101010101010101010101010101010,
10011001100110011001100110011001,
}

Storing Multiple Cubes

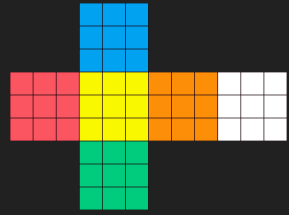
Storing Multiple Cubes

The Cube Tree



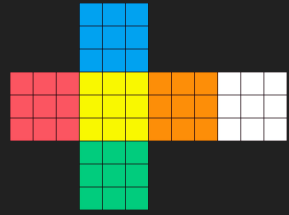
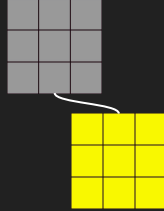
Storing Multiple Cubes

The Solved Cube



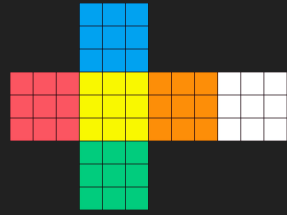
Storing Multiple Cubes

The Solved Cube



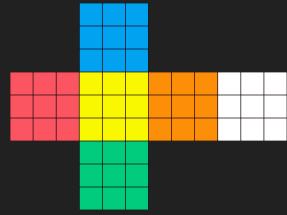
Storing Multiple Cubes

The Solved Cube



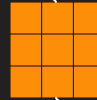
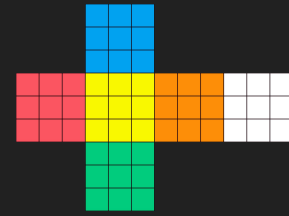
Storing Multiple Cubes

The Solved Cube



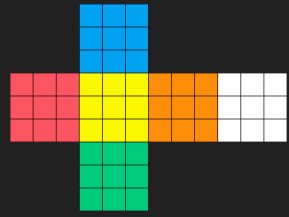
Storing Multiple Cubes

The Solved Cube



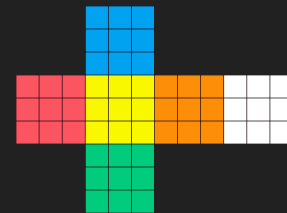
Storing Multiple Cubes

The Solved Cube



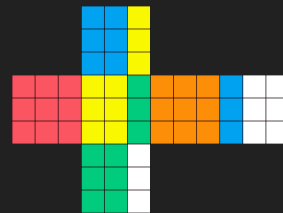
Storing Multiple Cubes

The Solved Cube



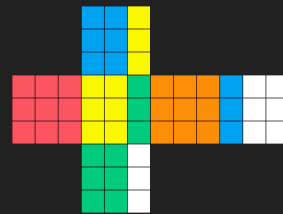
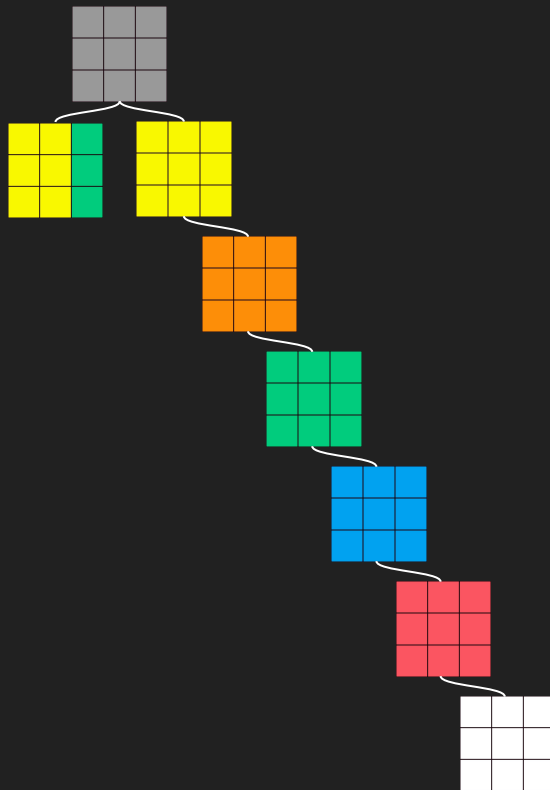
Storing Multiple Cubes

A Cube Rotated by (R)



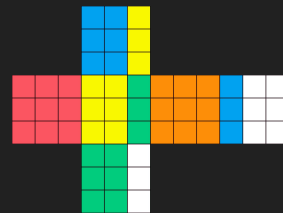
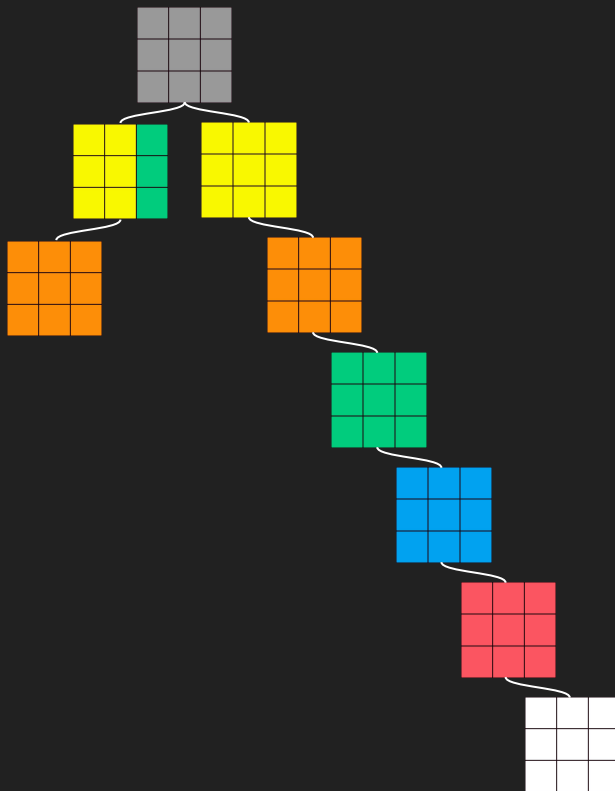
Storing Multiple Cubes

A Cube Rotated by (R)



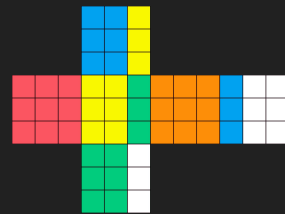
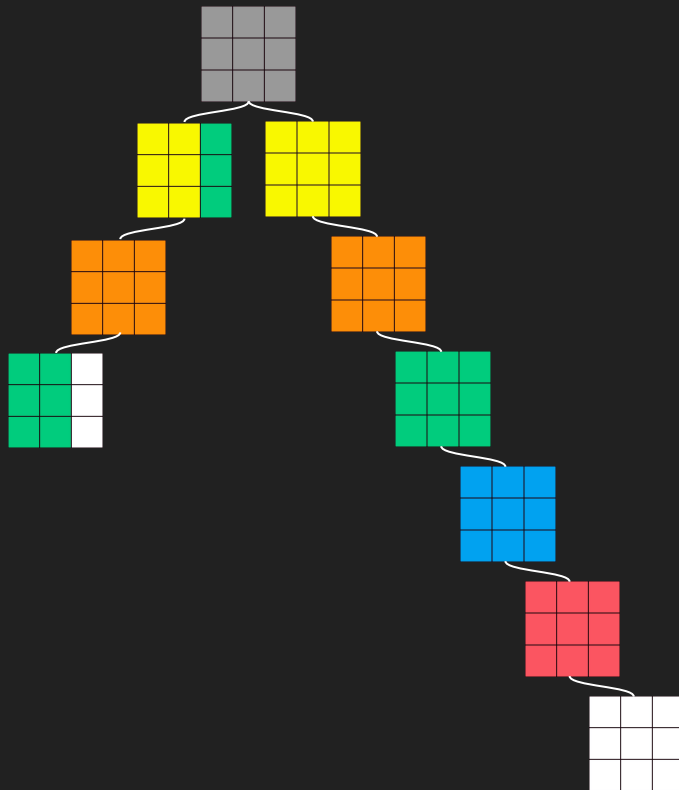
Storing Multiple Cubes

A Cube Rotated by (R)



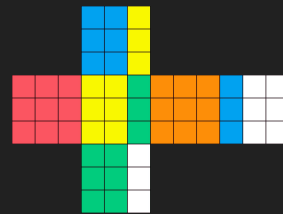
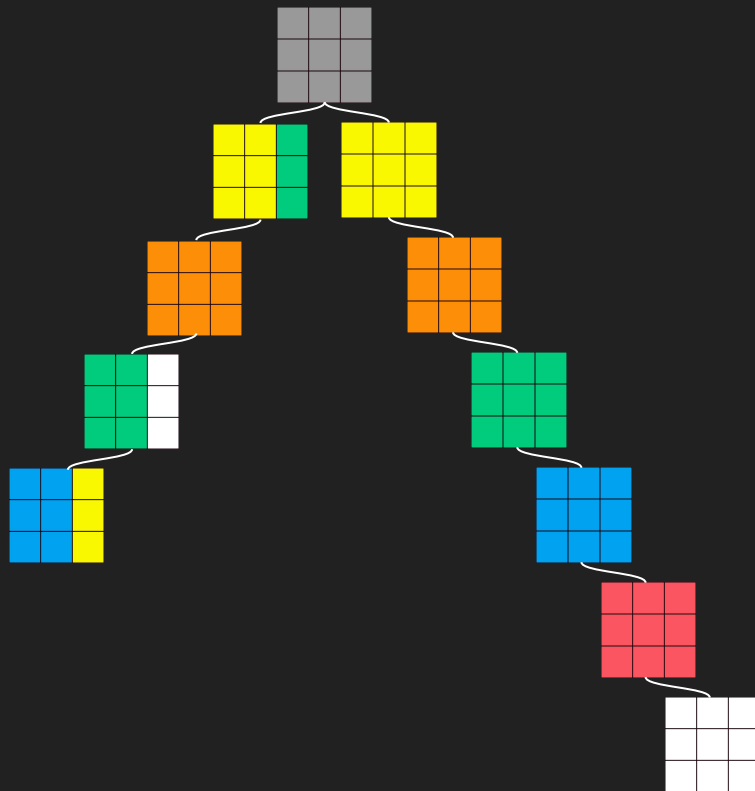
Storing Multiple Cubes

A Cube Rotated by (R)



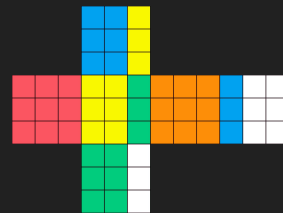
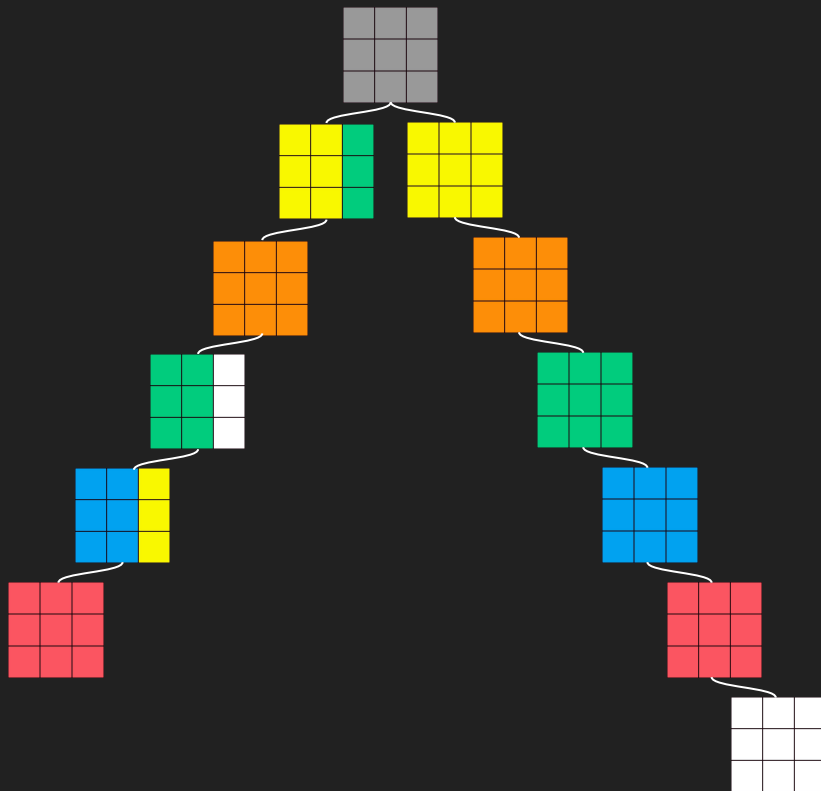
Storing Multiple Cubes

A Cube Rotated by (R)



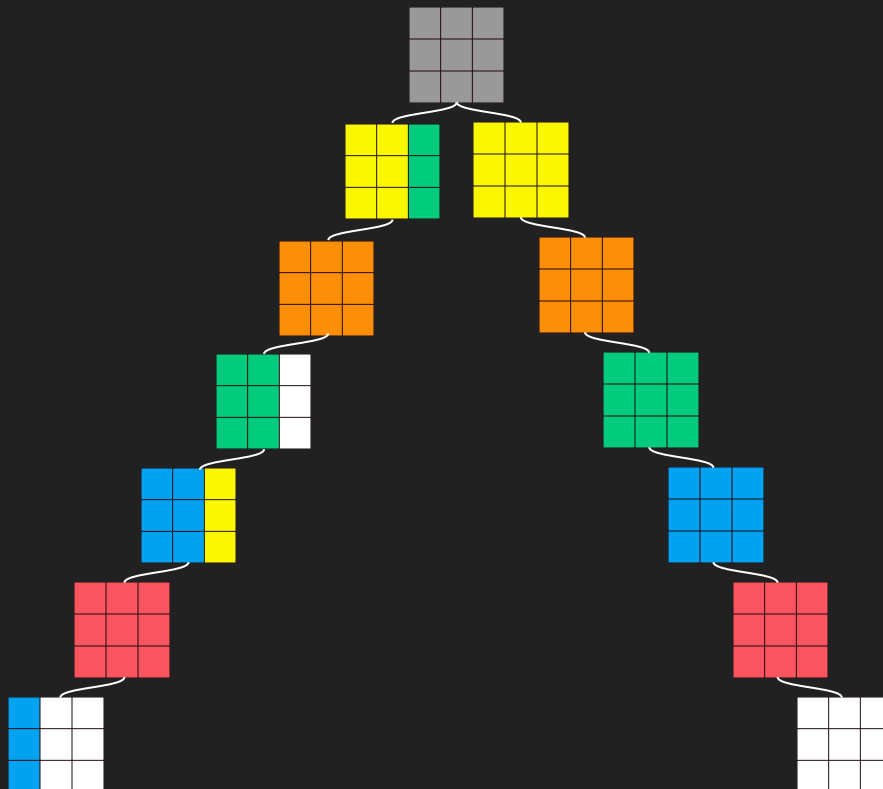
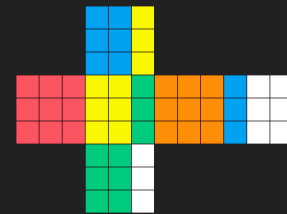
Storing Multiple Cubes

A Cube Rotated by (R)



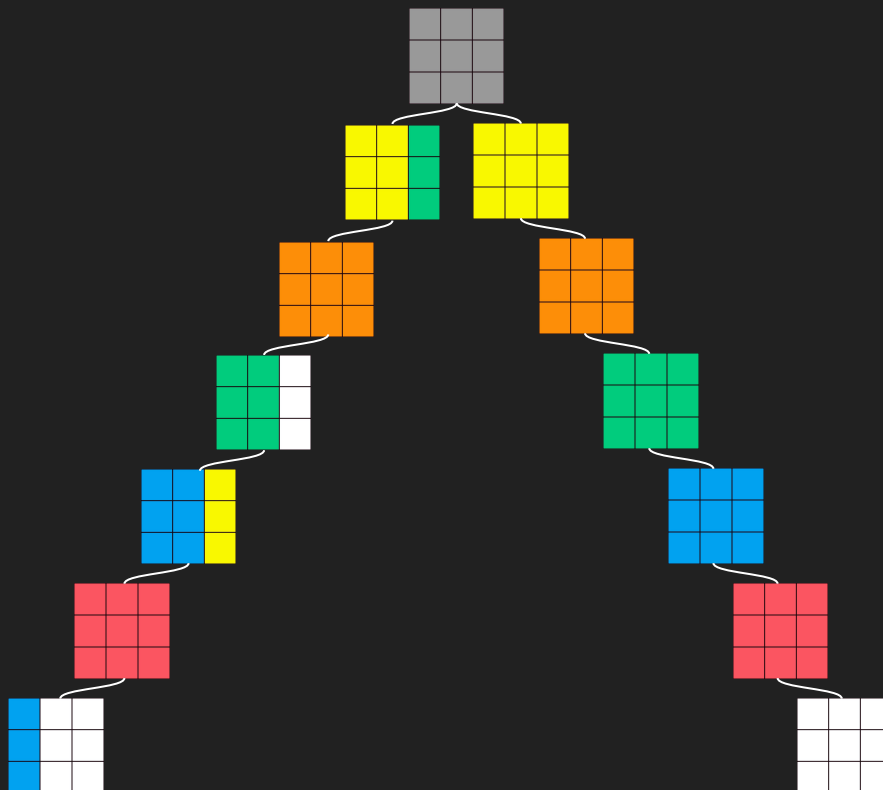
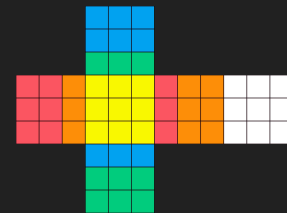
Storing Multiple Cubes

A Cube Rotated by (R)

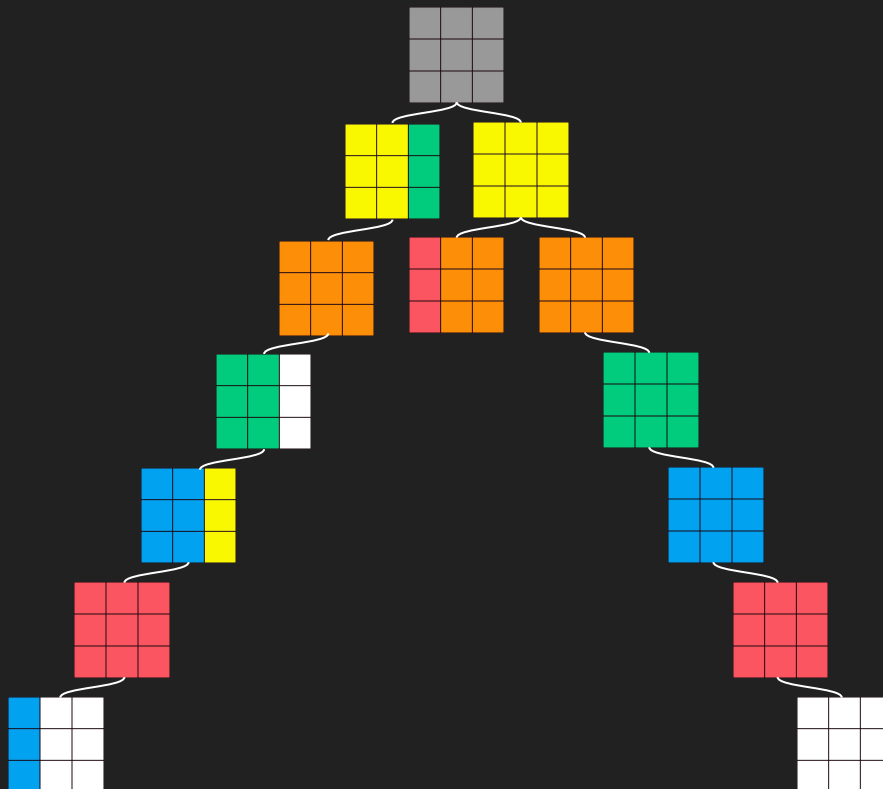
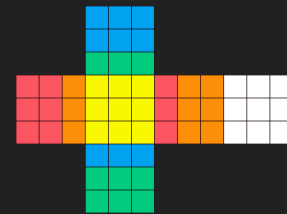


Storing Multiple Cubes

A Cube Rotated by (U2)

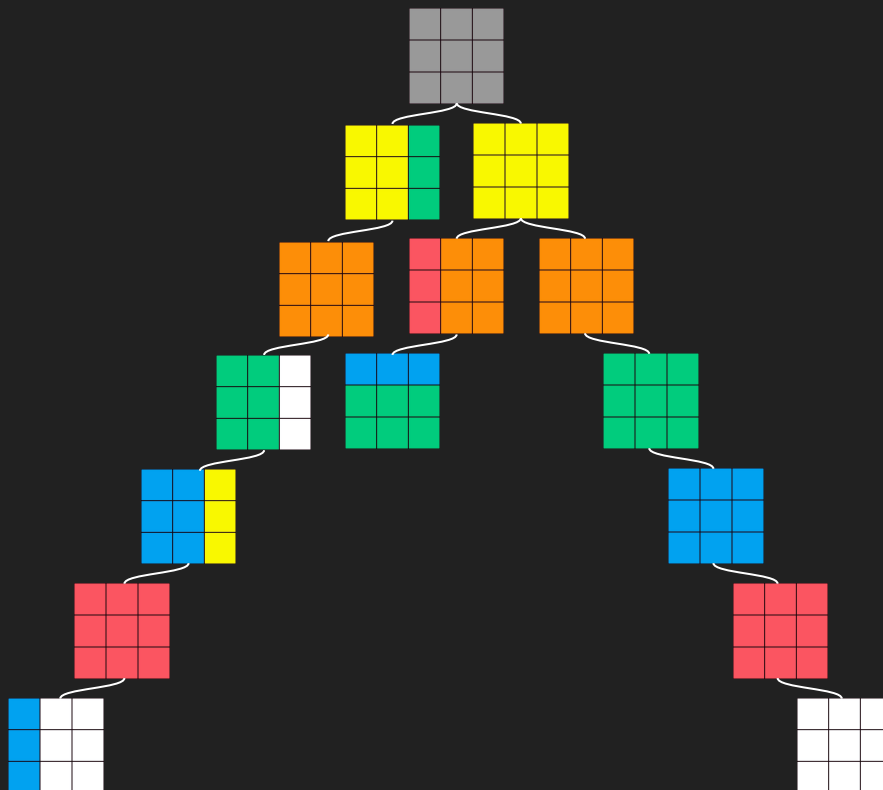
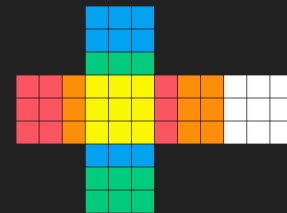


A Cube Rotated by (U2)



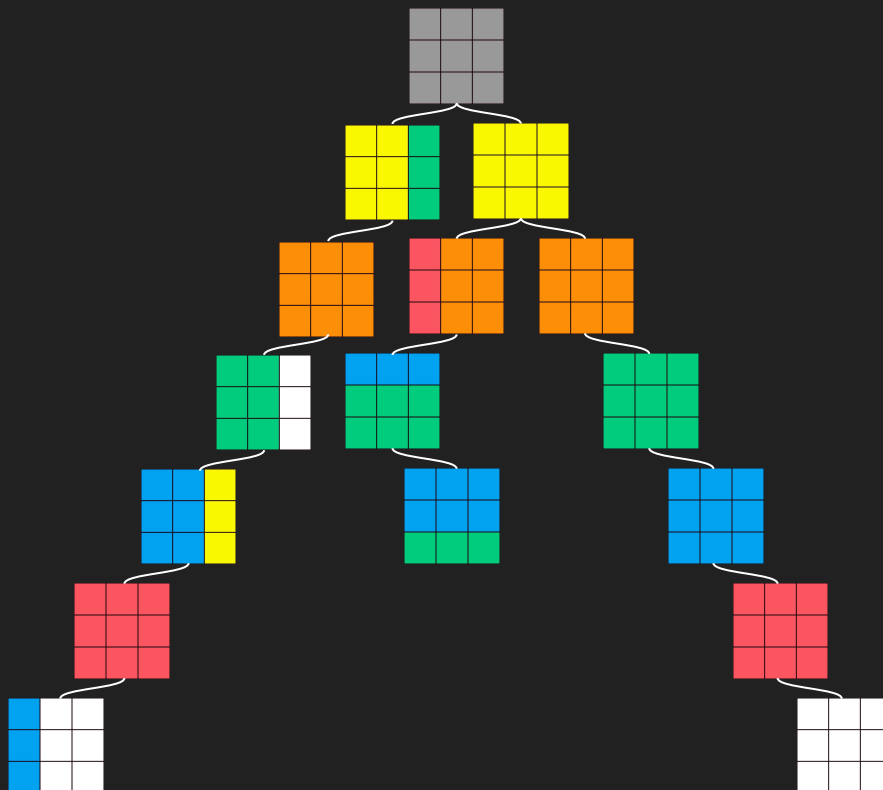
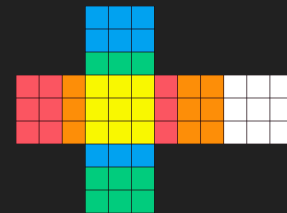
Storing Multiple Cubes

A Cube Rotated by (U2)



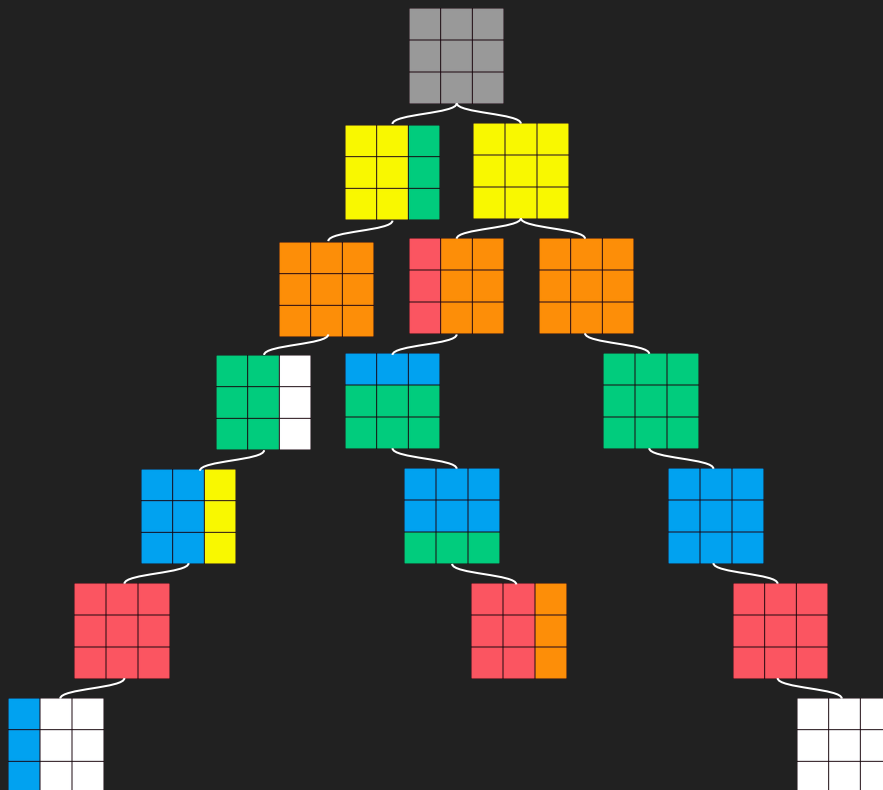
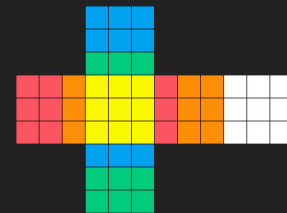
Storing Multiple Cubes

A Cube Rotated by (U2)

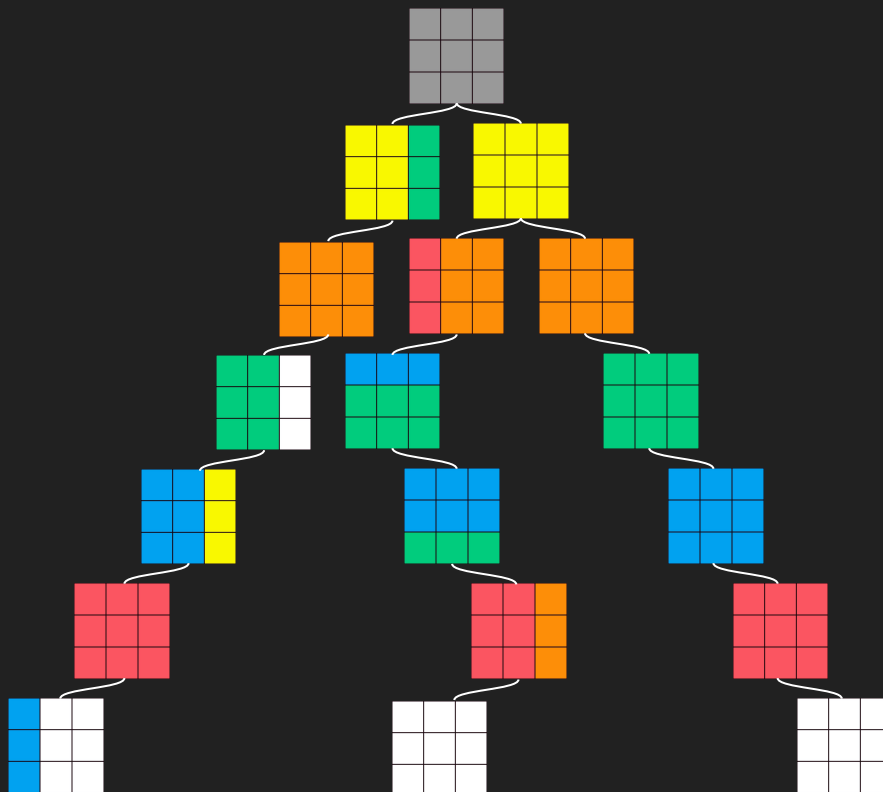
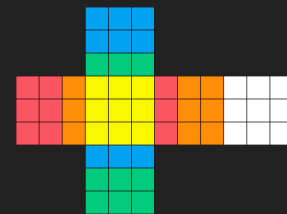


Storing Multiple Cubes

A Cube Rotated by (U2)

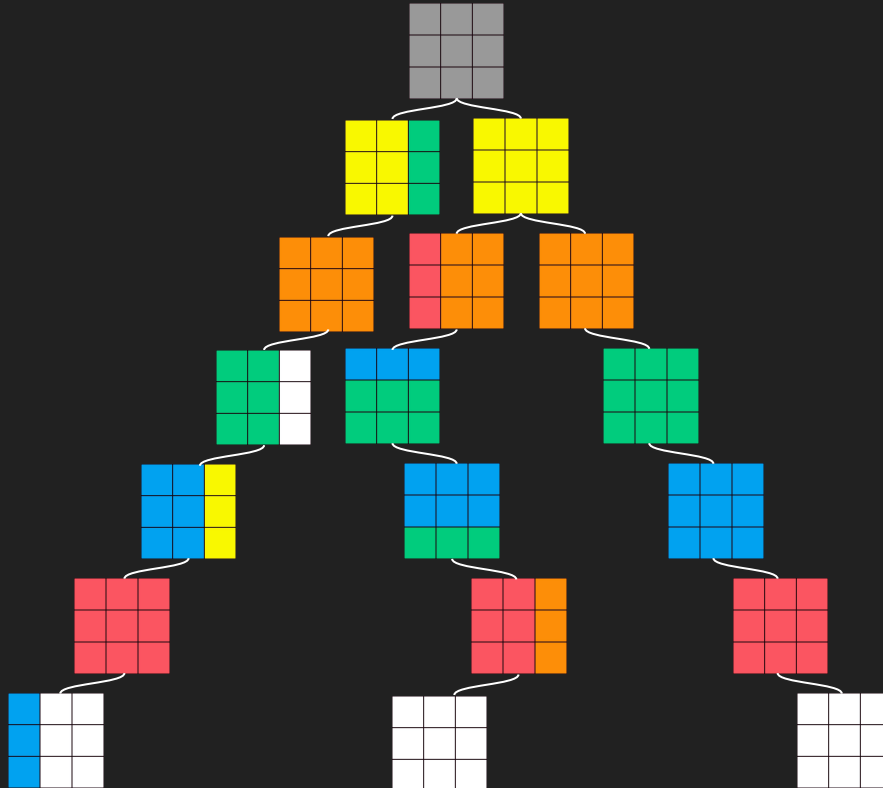


A Cube Rotated by (U2)



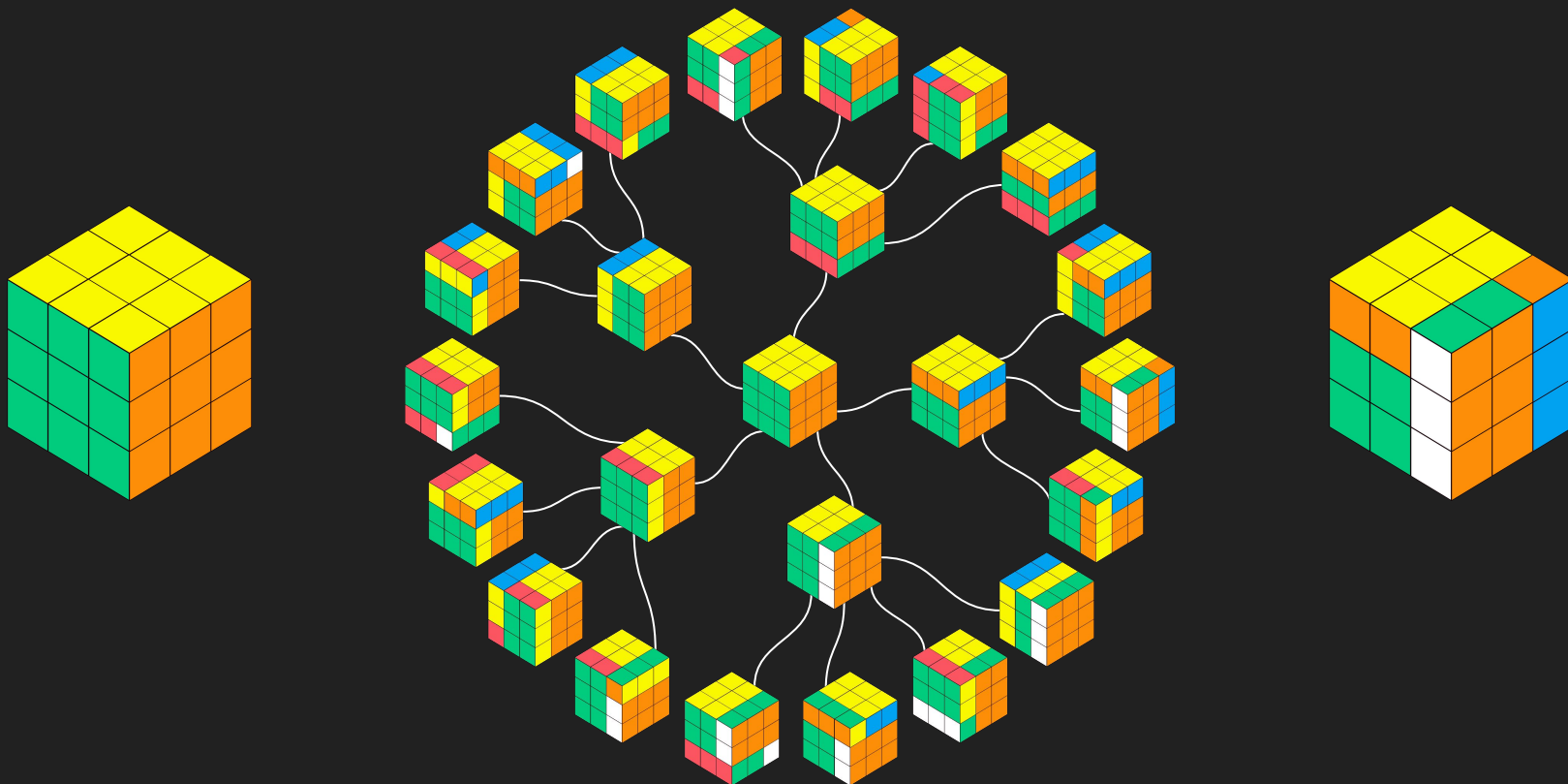
Storing Multiple Cubes

The Complete Tree

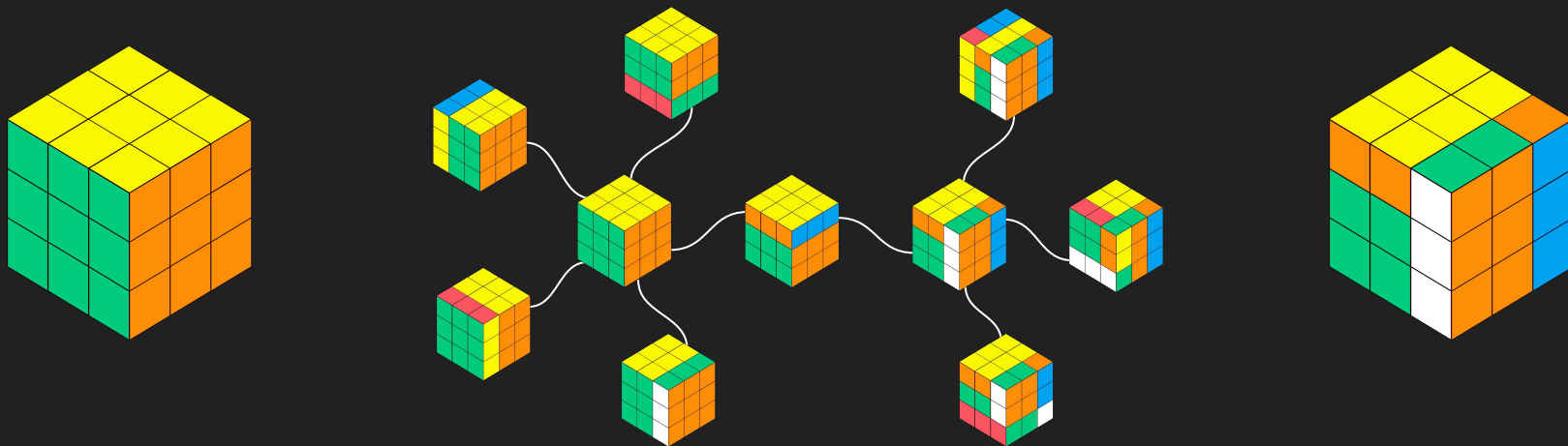


Searching for Sequences

Searching for Sequences



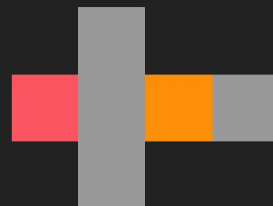
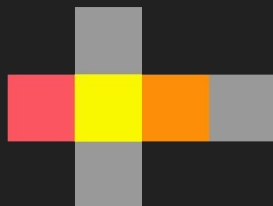
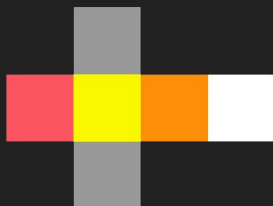
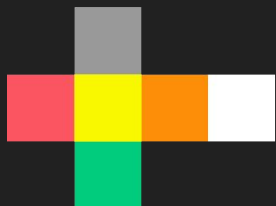
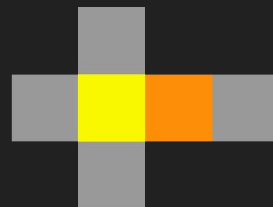
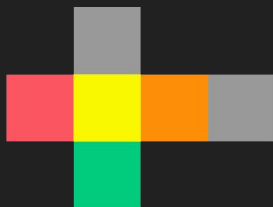
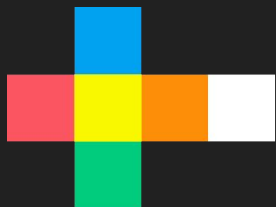
Searching for Sequences



Evaluation

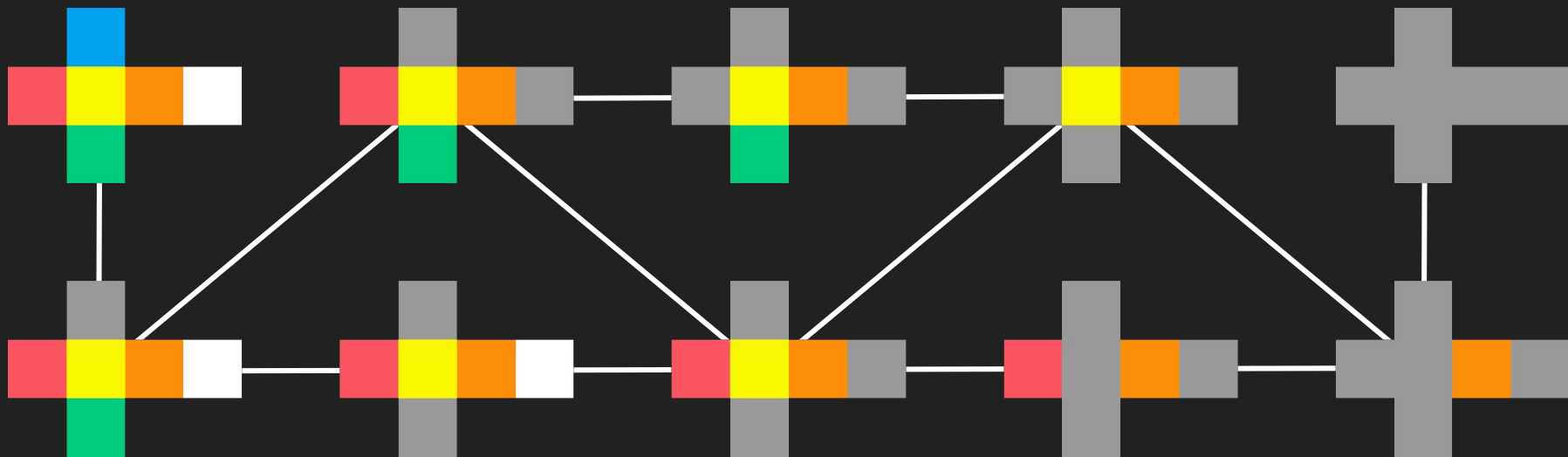
Evaluation

Which Subgroups Exist?



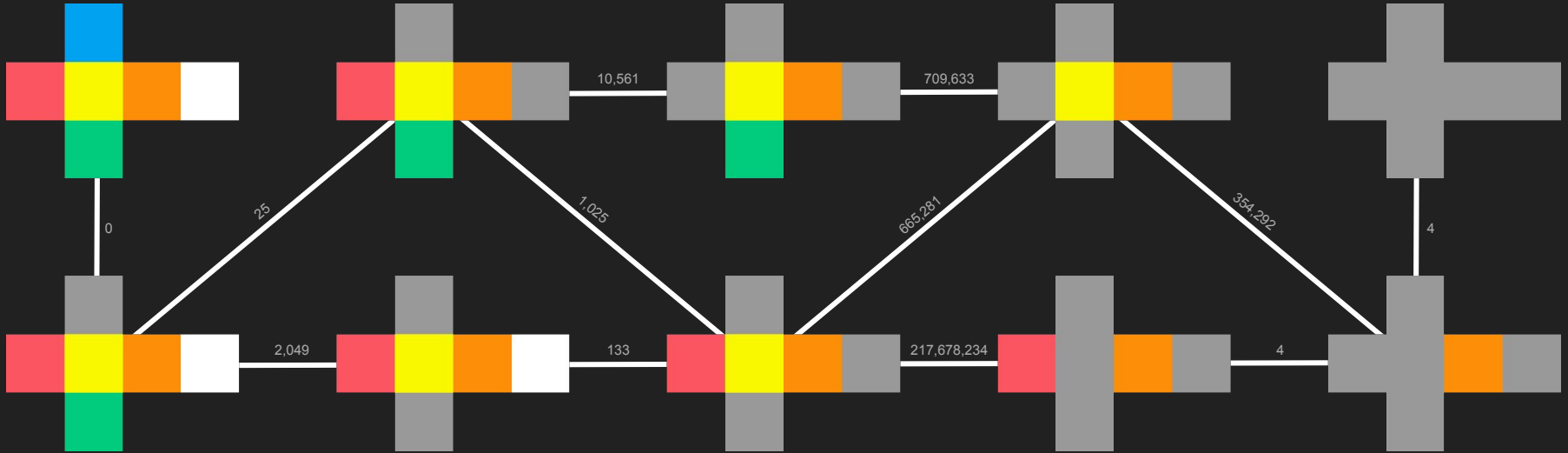
Evaluation

Group Restriction Graph



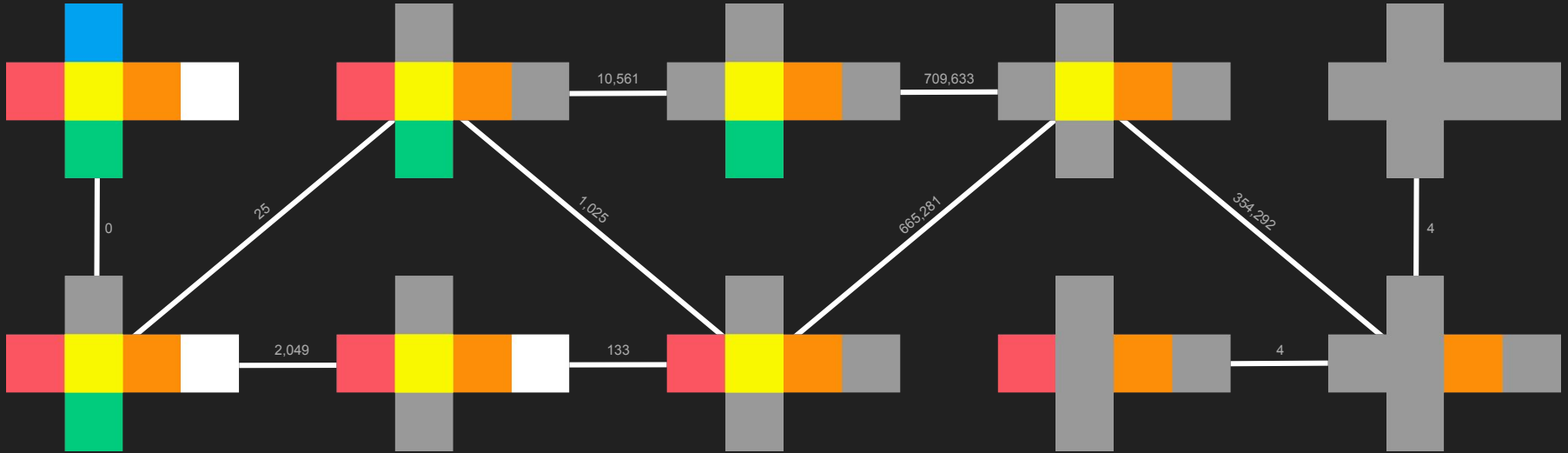
Evaluation

Which Order is the Most Efficient?



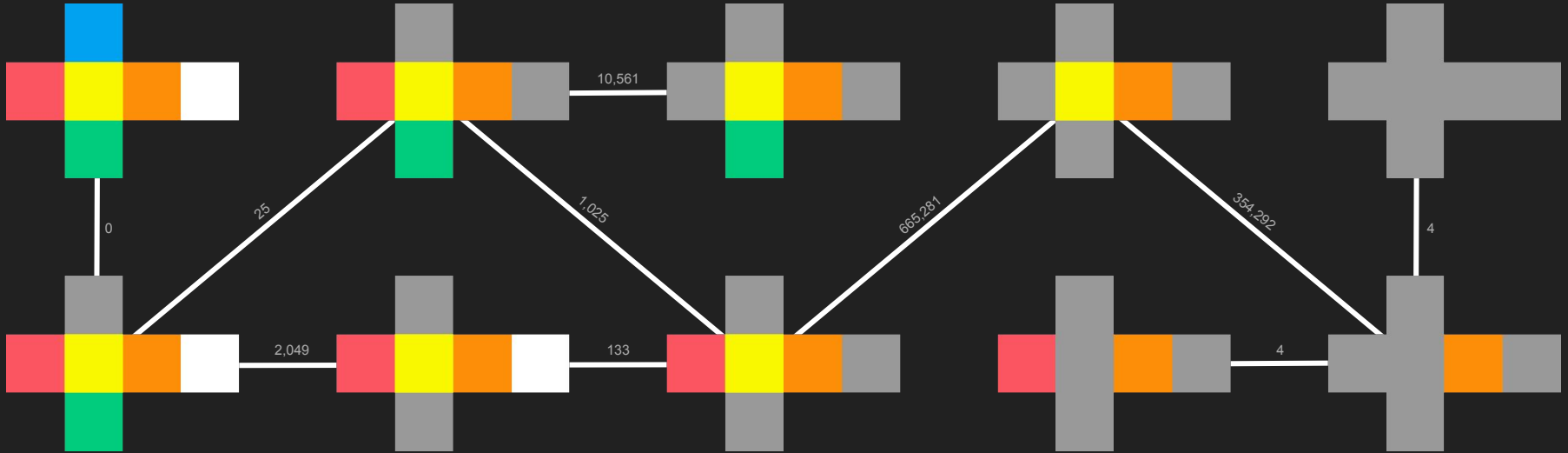
Evaluation

Which Order is the Most Efficient?



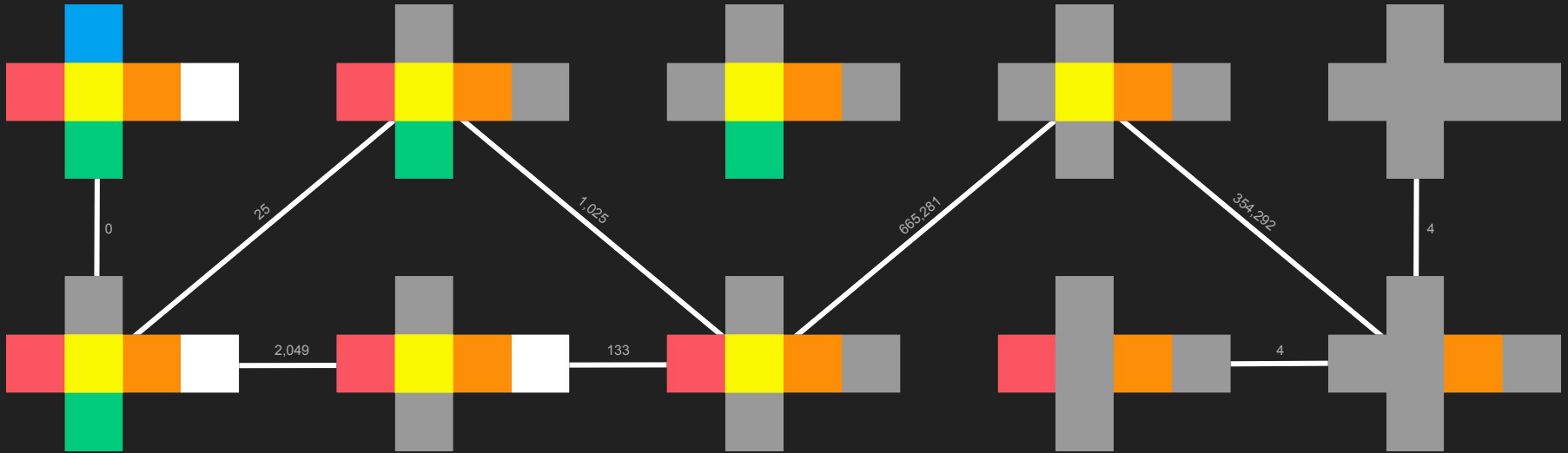
Evaluation

Which Order is the Most Efficient?



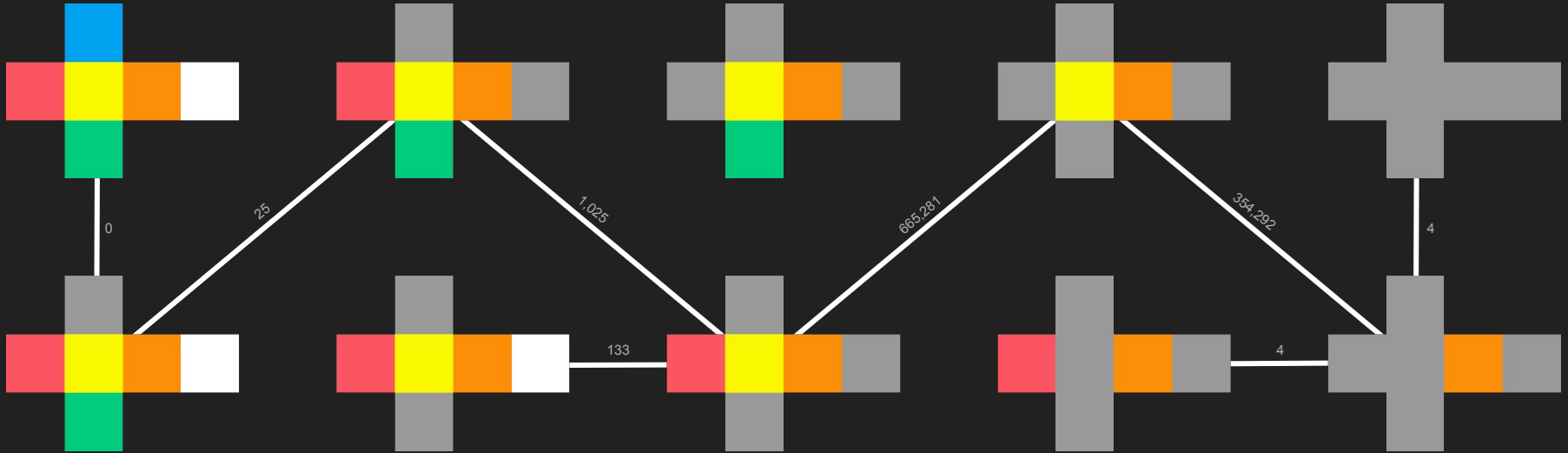
Evaluation

Which Order is the Most Efficient?



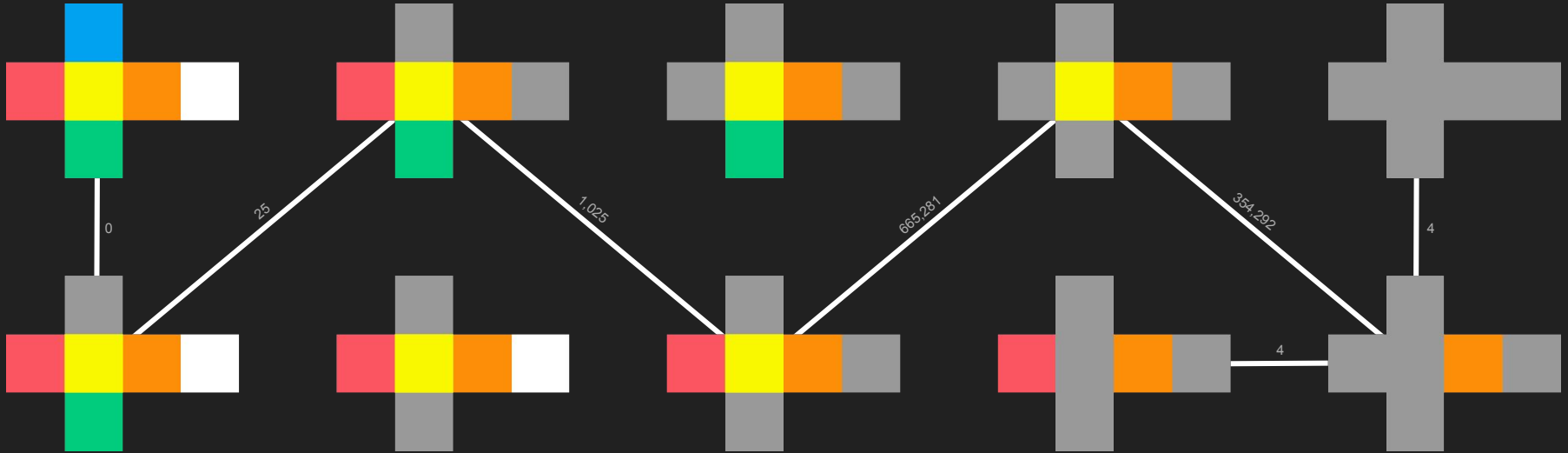
Evaluation

Which Order is the Most Efficient?



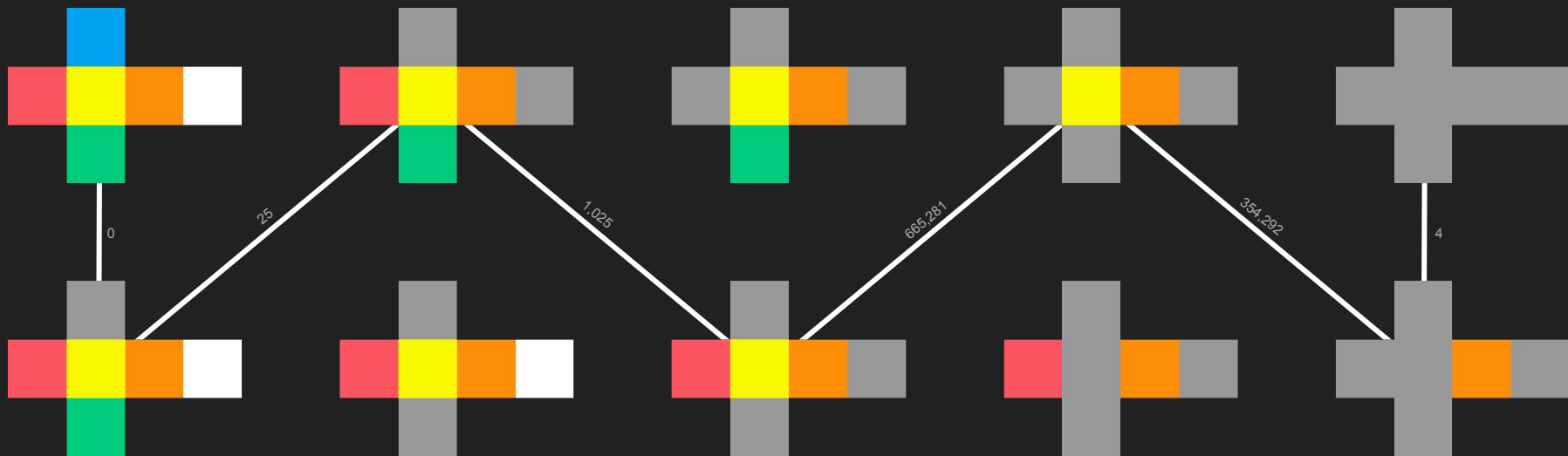
Evaluation

Which Order is the Most Efficient?



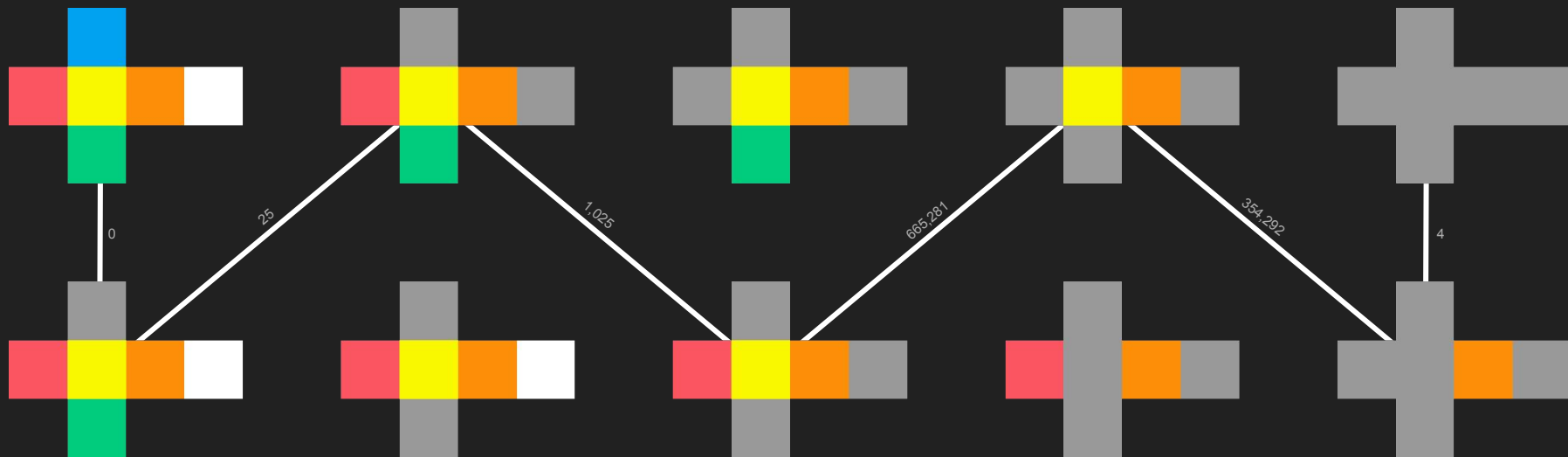
Evaluation

The Most Efficient Order



Evaluation

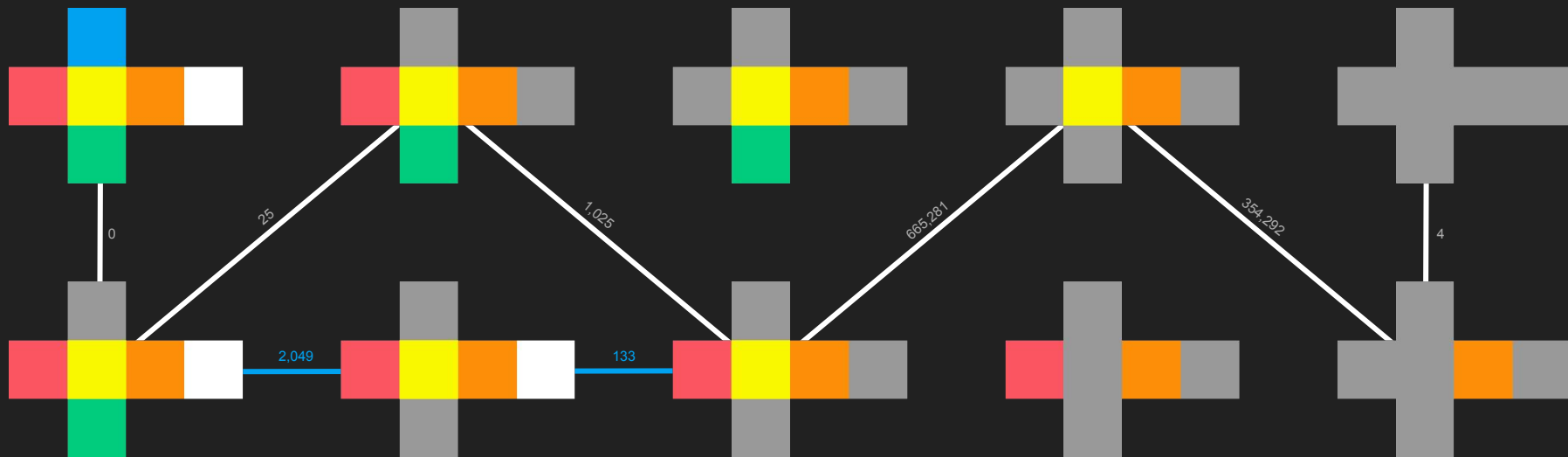
The Most Efficient Order



(1,020,627 Permutations)

Evaluation

The Implemented Order



(1,020,627 Permutations)
(+1132)

Thank You!

Joseph Parker - 2558907p

Supervised by Gethin Norman