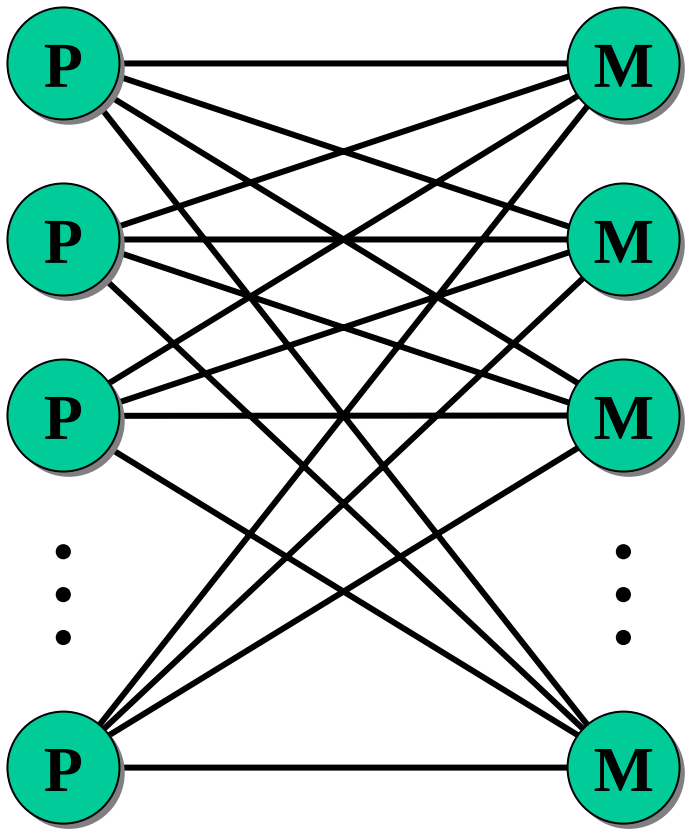
Hypercubic Networks

Charles E. Leiserson

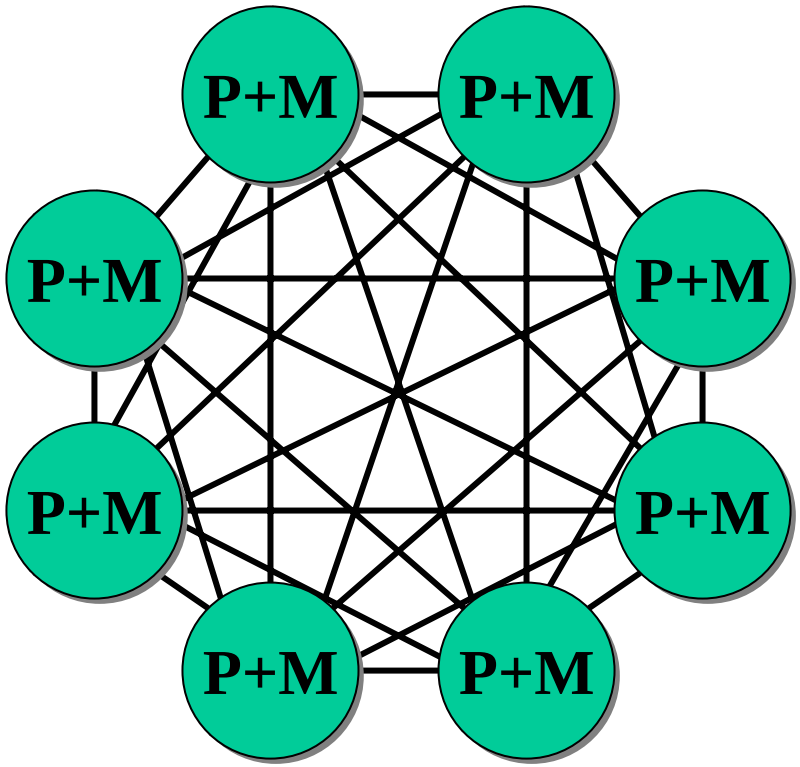
6.895 *Theory of Parallel Systems*

November 12, 2003

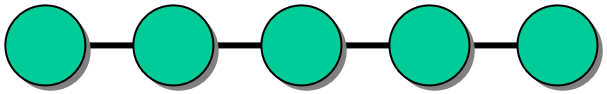
“Ideal” Parallel Computer



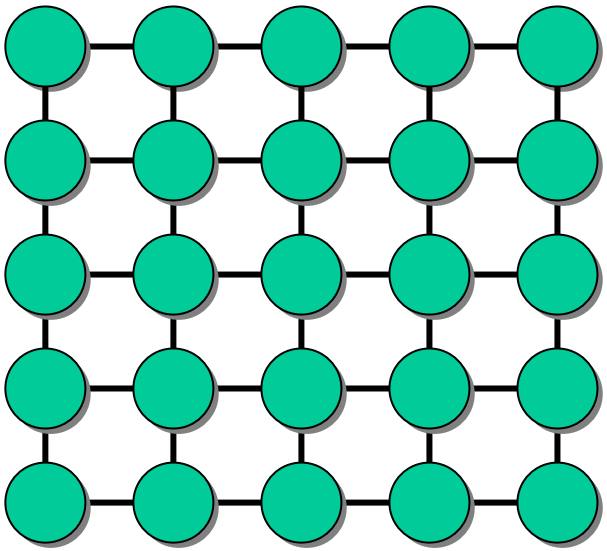
“Ideal” Distributed-Memory Parallel Computer



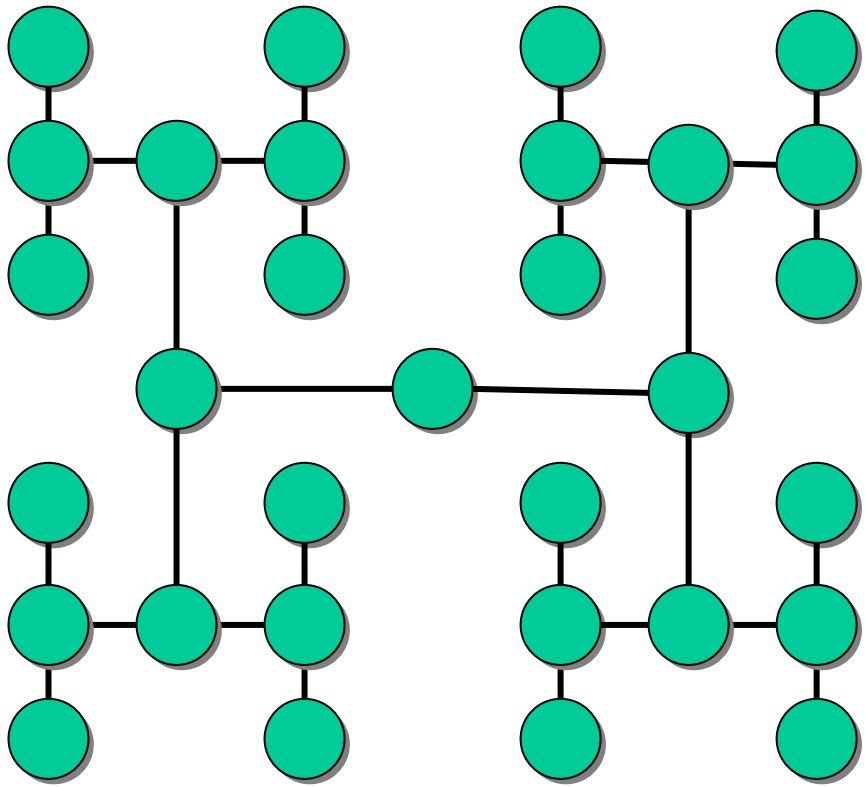
Interconnection Networks



linear array



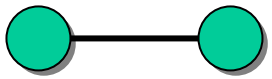
2D mesh



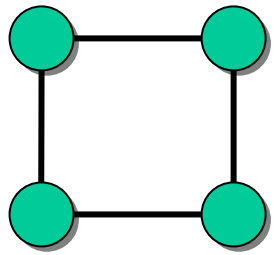
binary tree

Hypercube

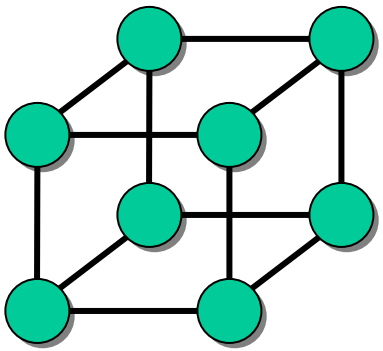
$d = 0$
$N = 1$



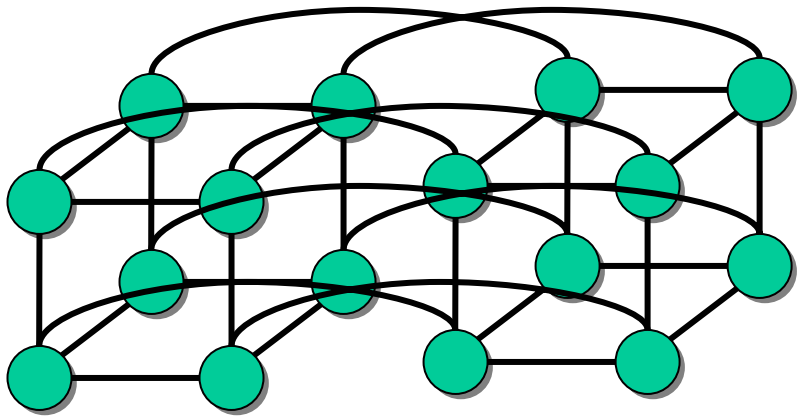
$d = 1$
$N = 2$



$d = 2$
$N = 4$

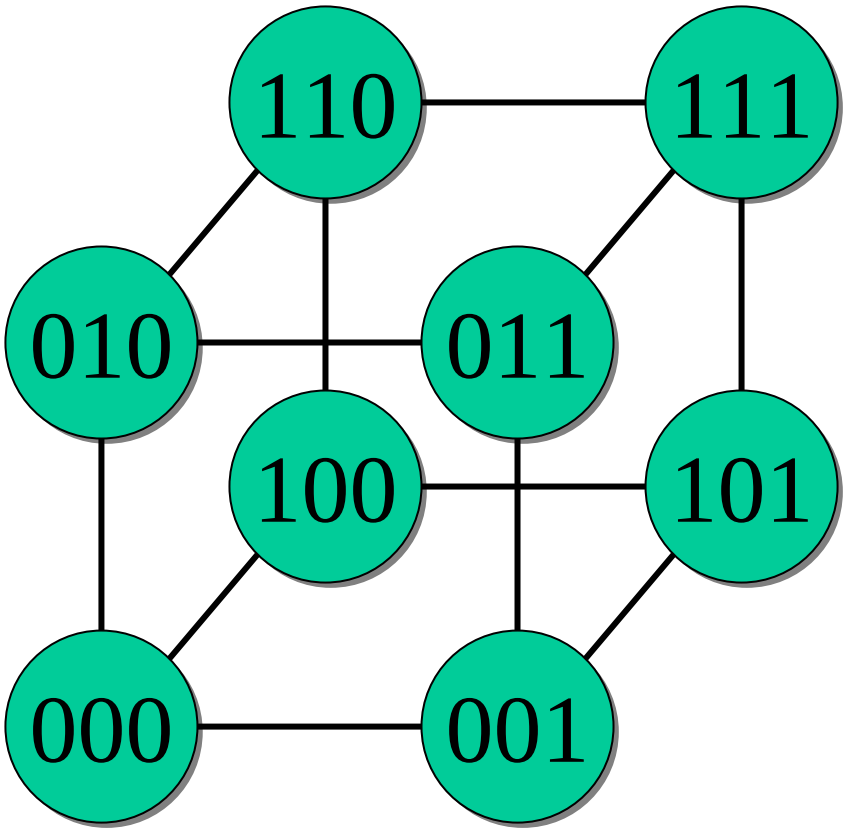


$d = 3$
$N = 8$

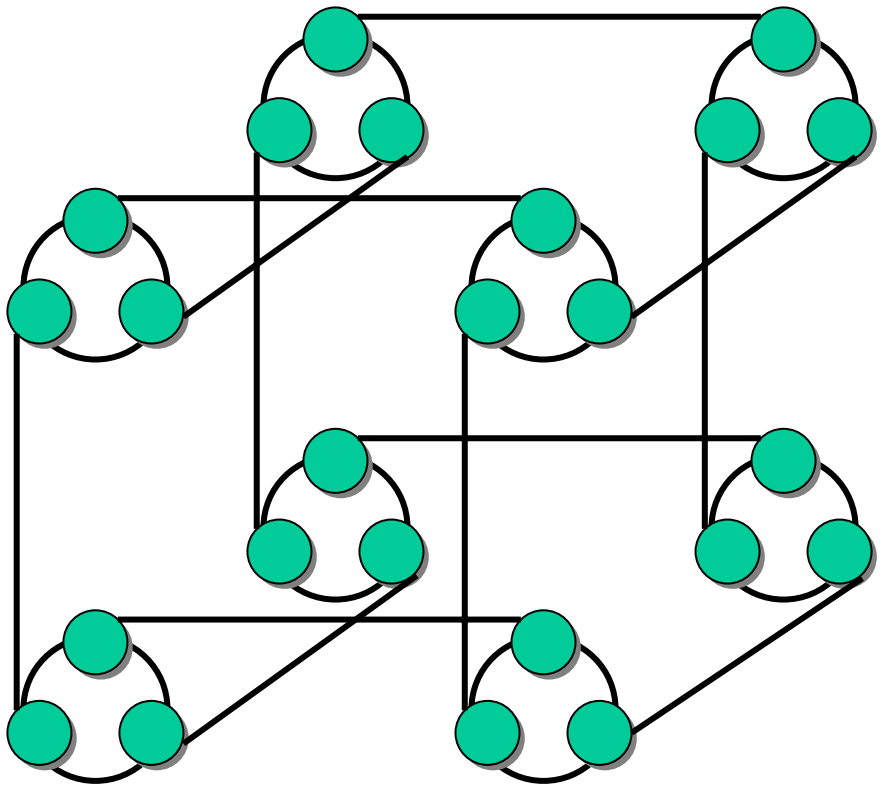


$d = 4$
$N = 16$

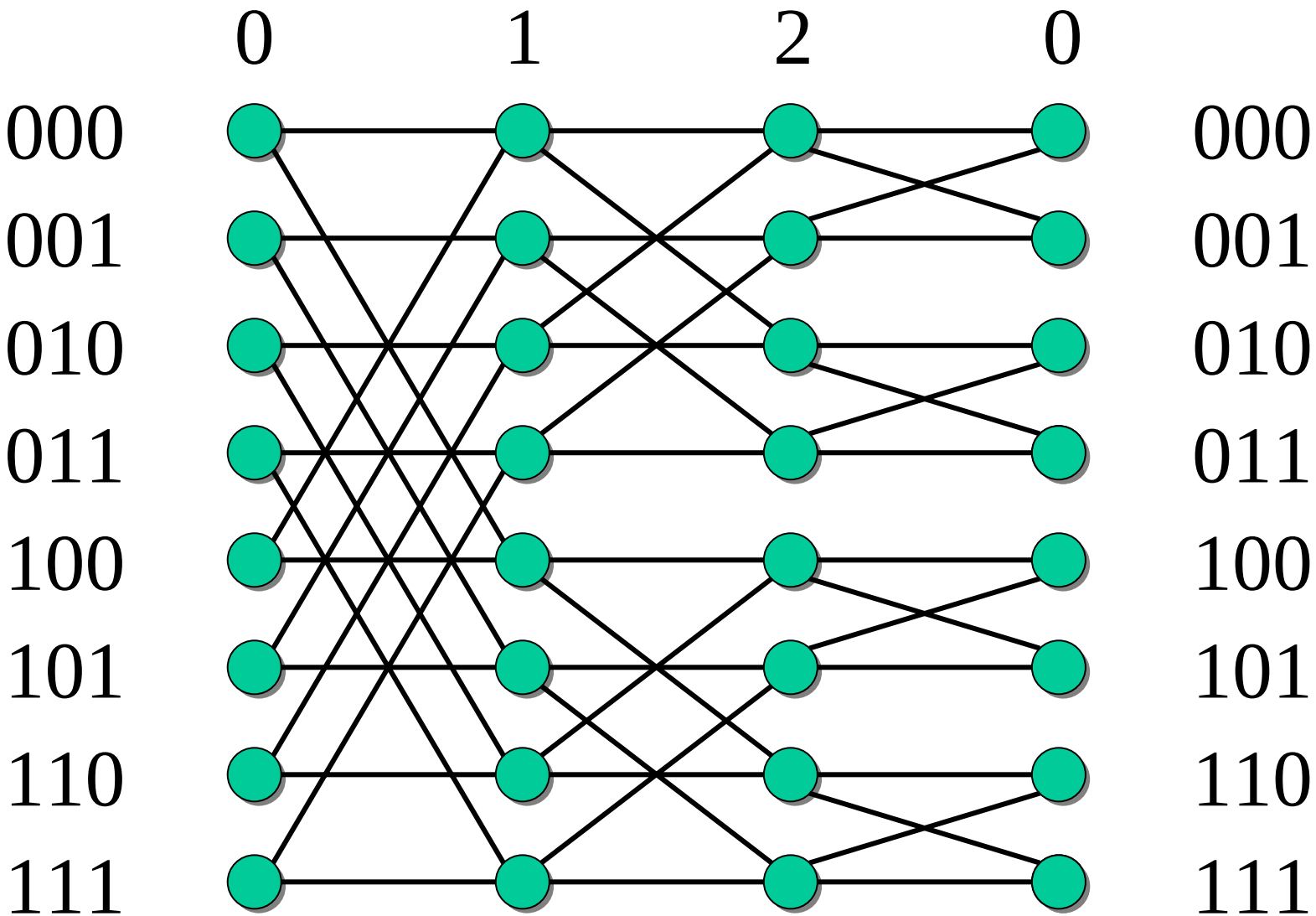
Hypercube



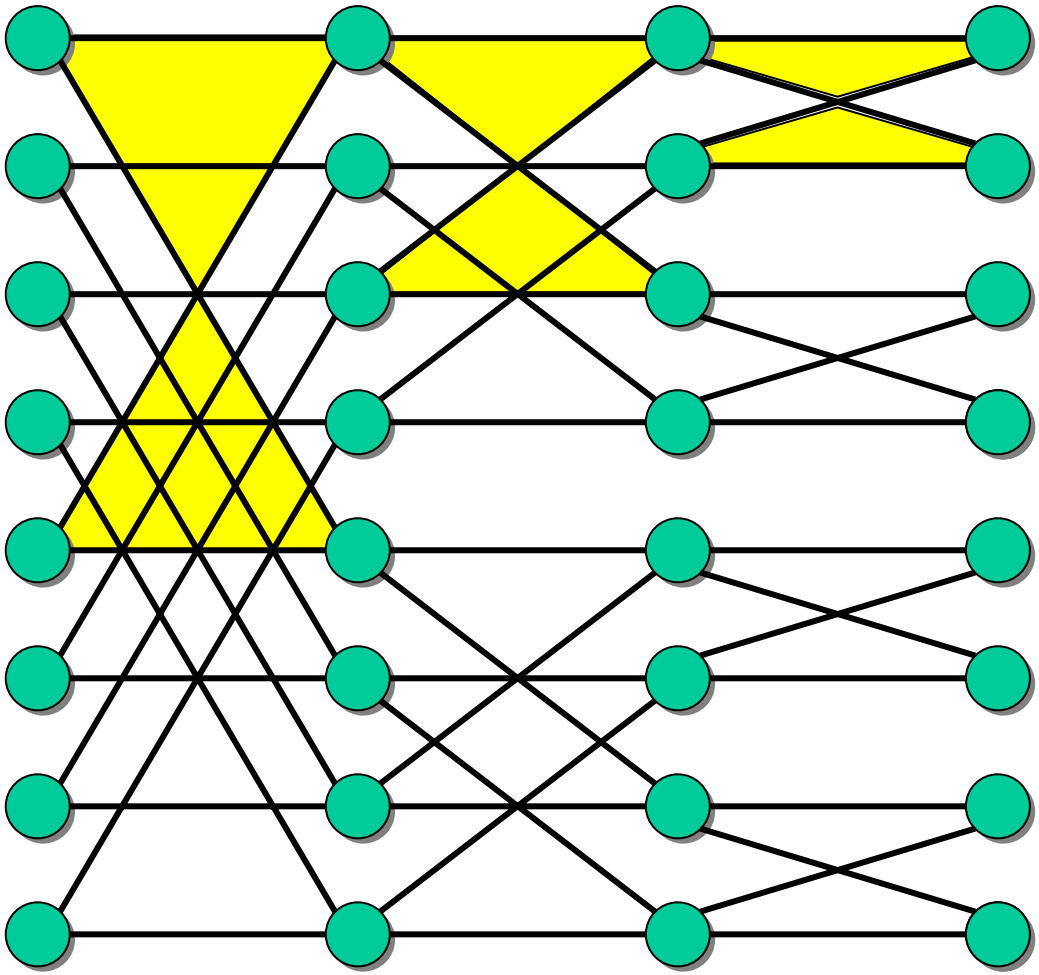
Cube-Connected Cycles



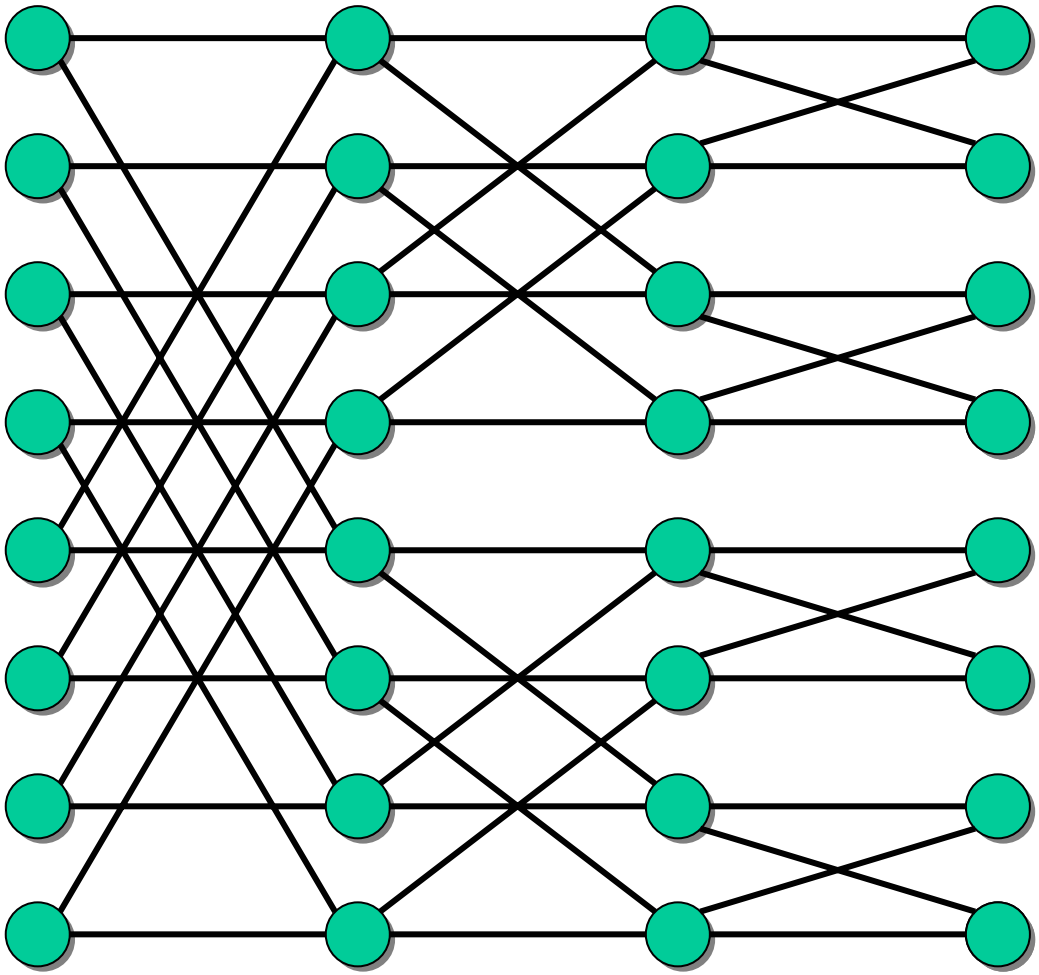
Butterfly (FFT) Network



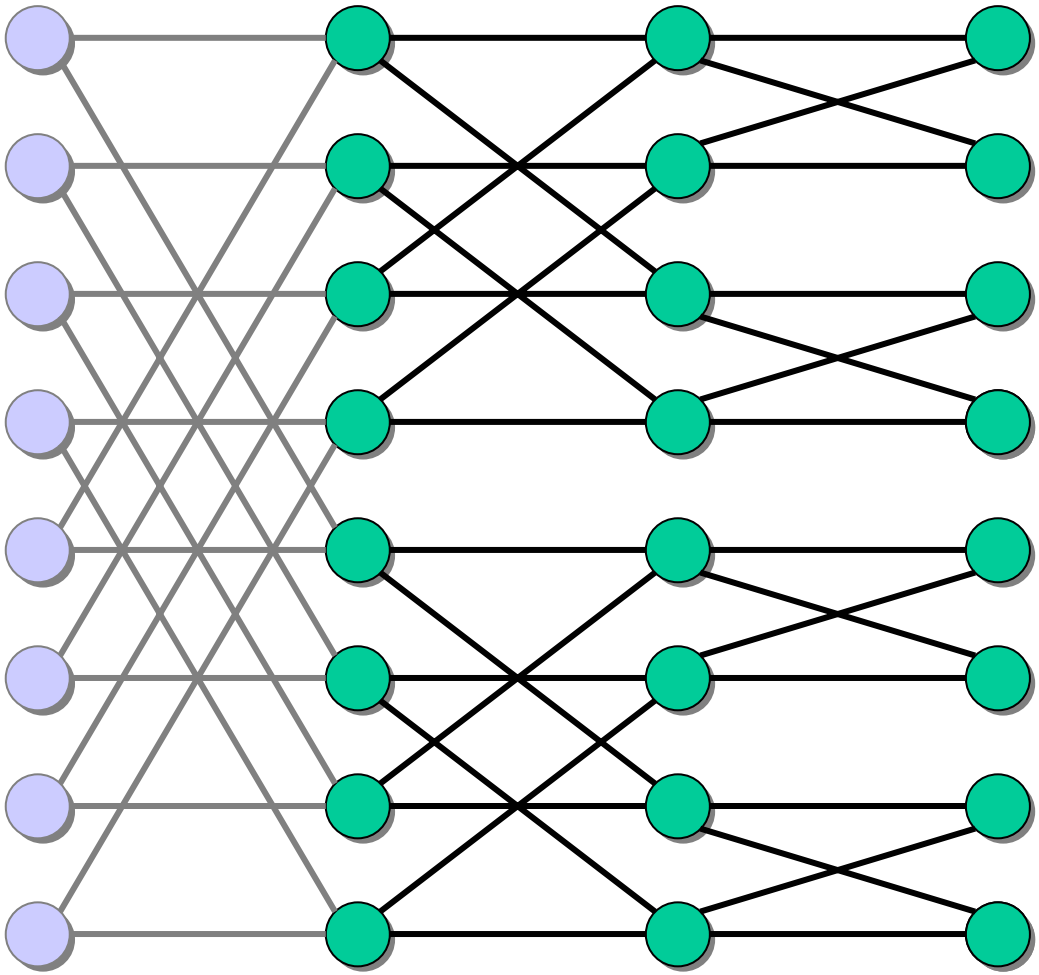
Butterflies



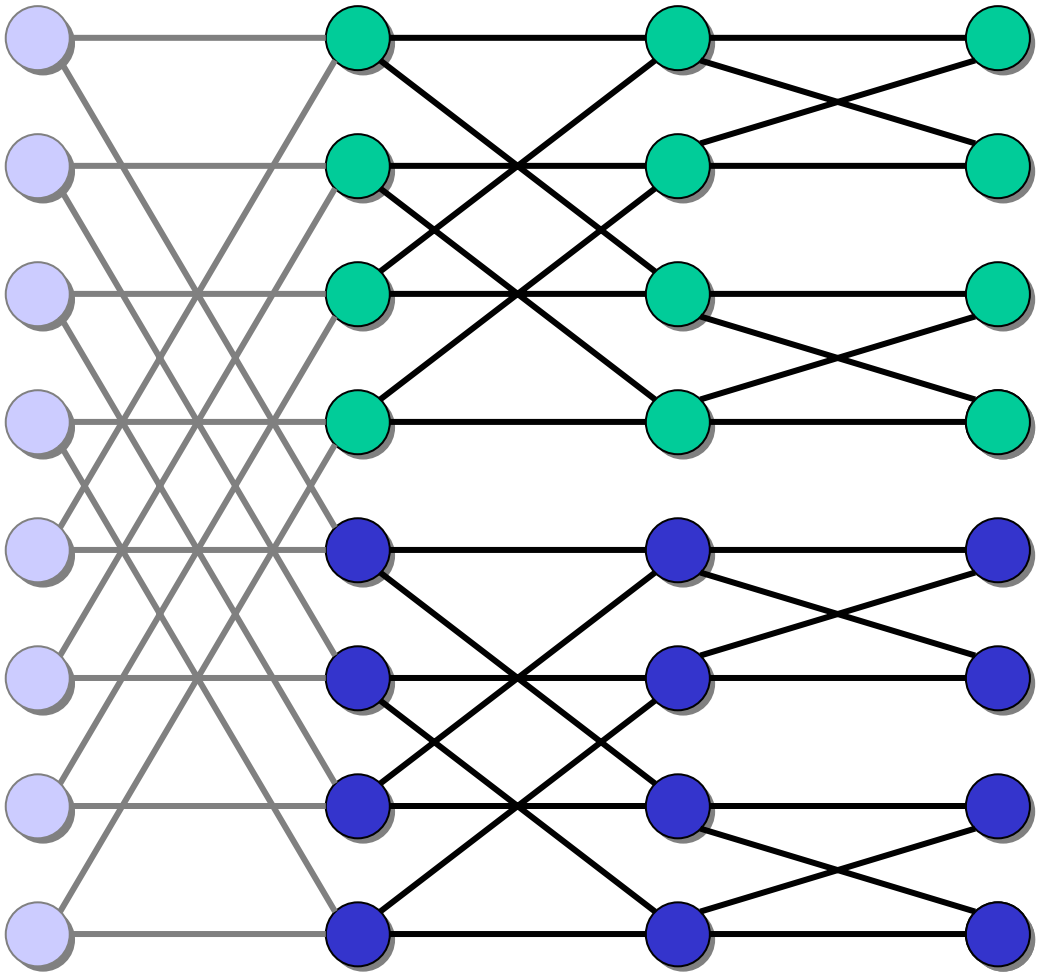
Decomposing a Butterfly



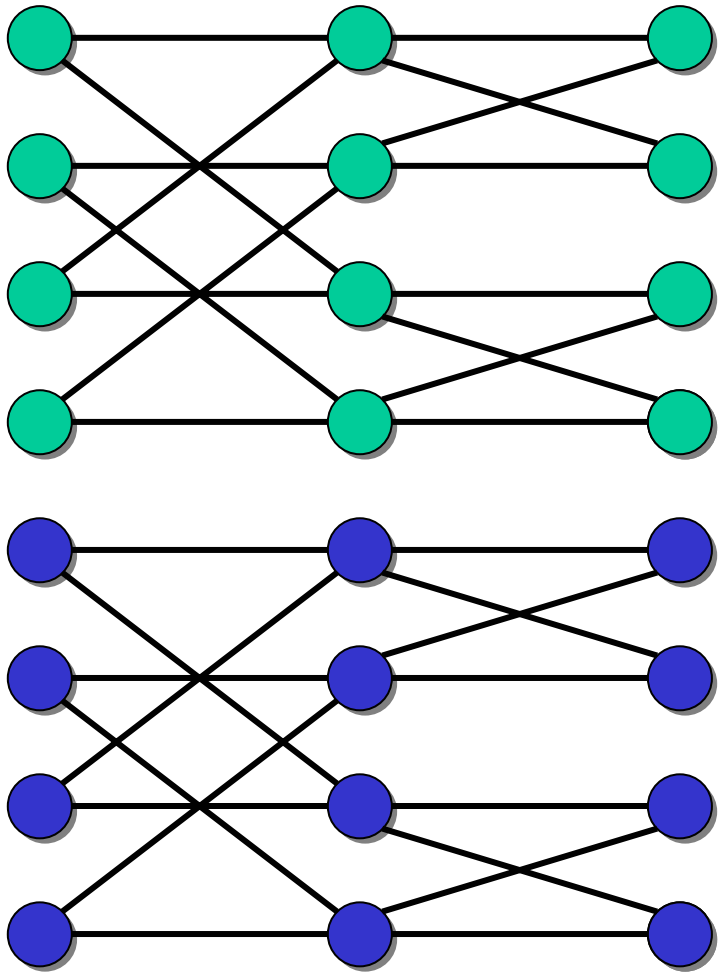
Decomposing a Butterfly



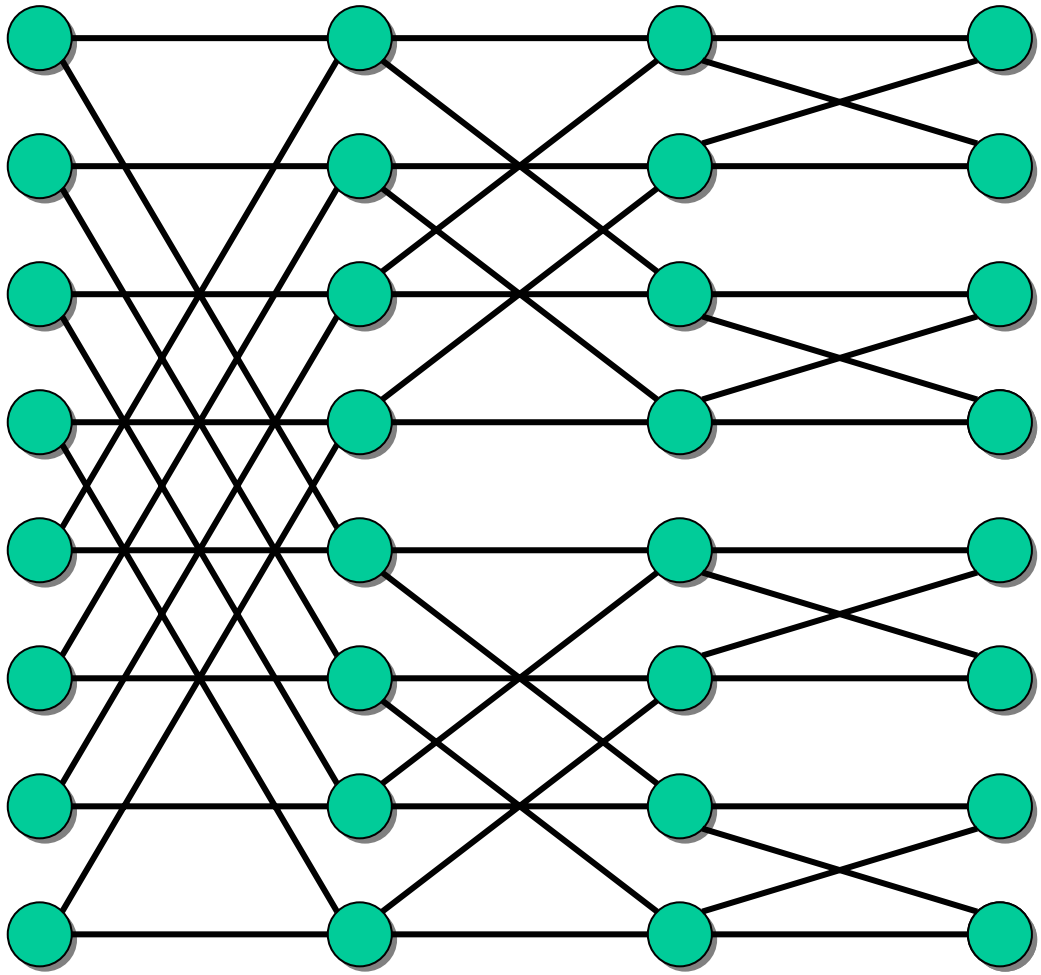
Decomposing a Butterfly



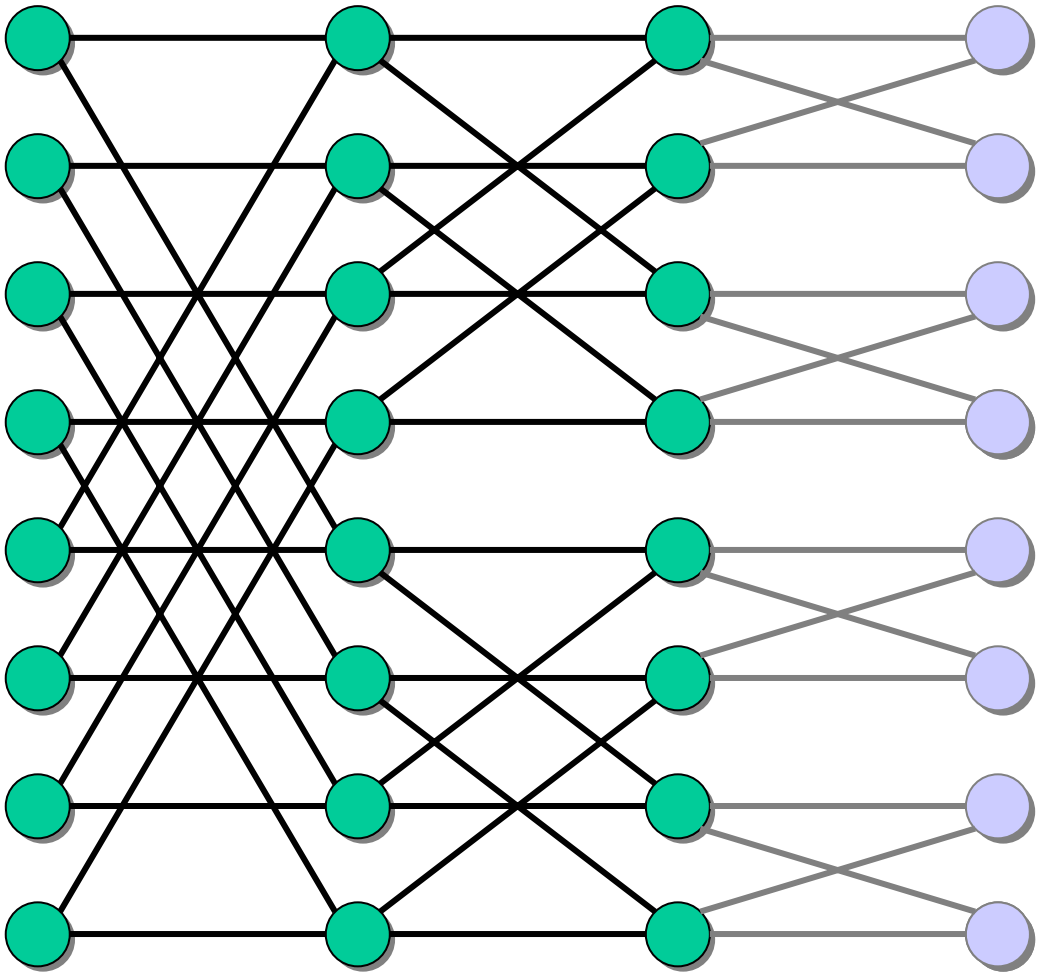
Decomposing a Butterfly



Decomposing a Butterfly II



Decomposing a Butterfly II



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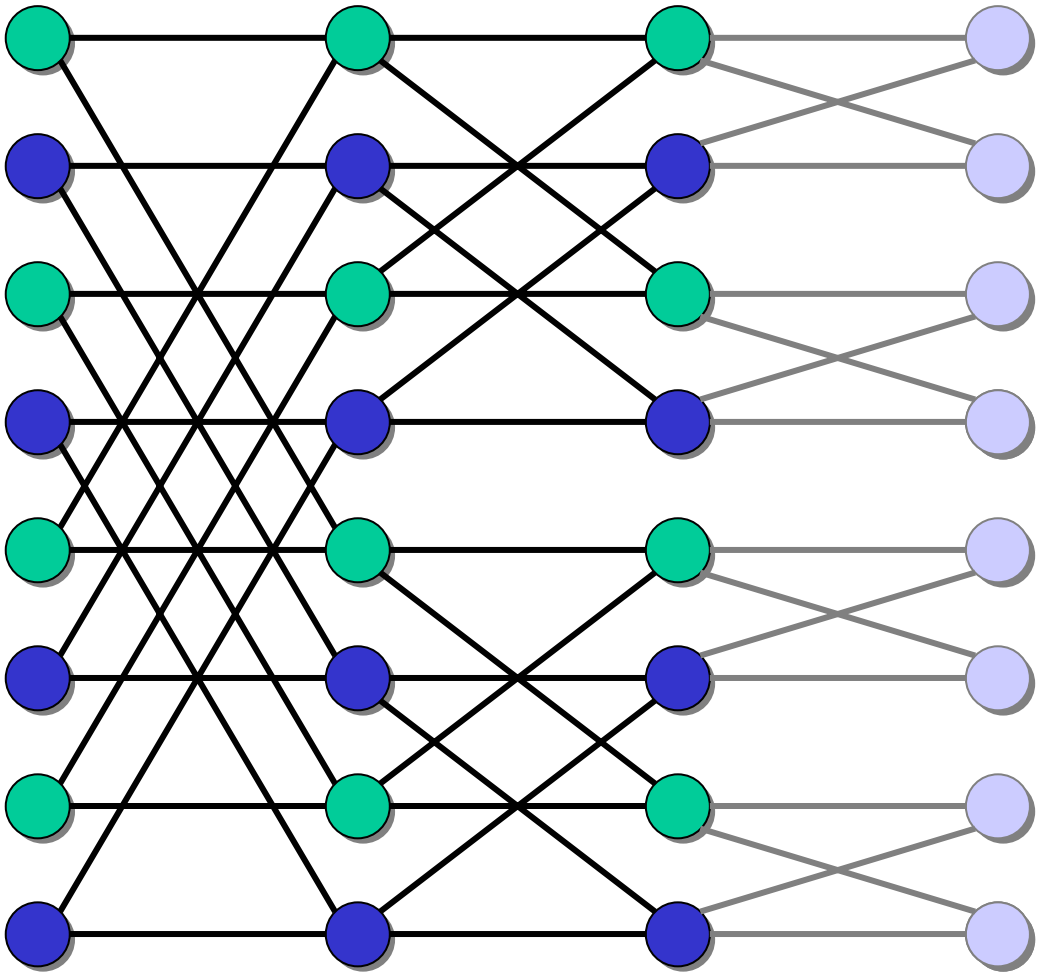
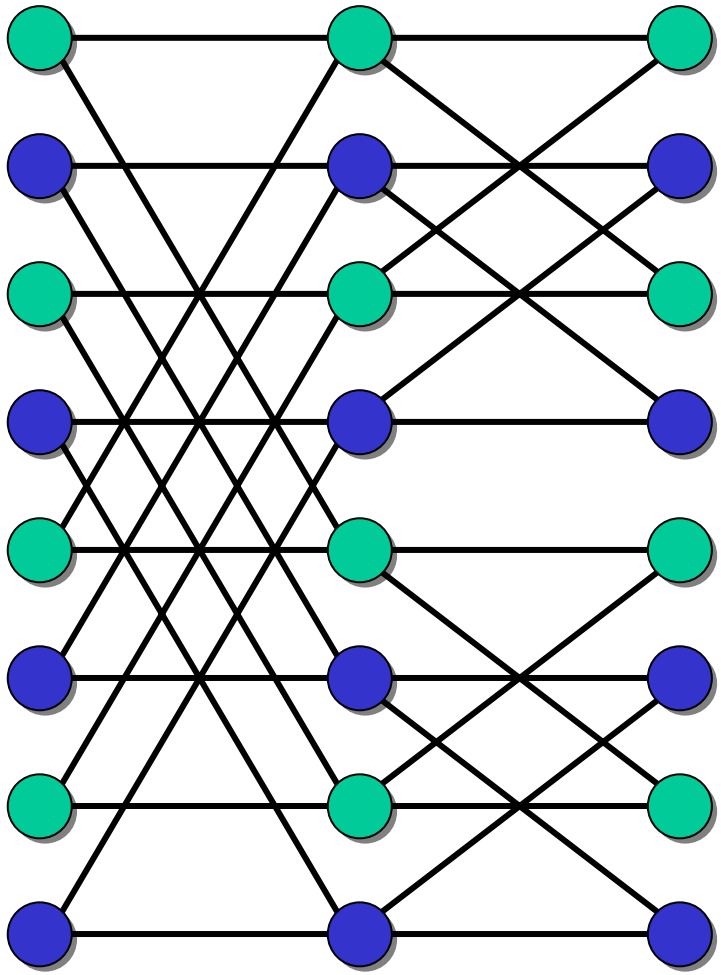


Decomposing a Butterfly II



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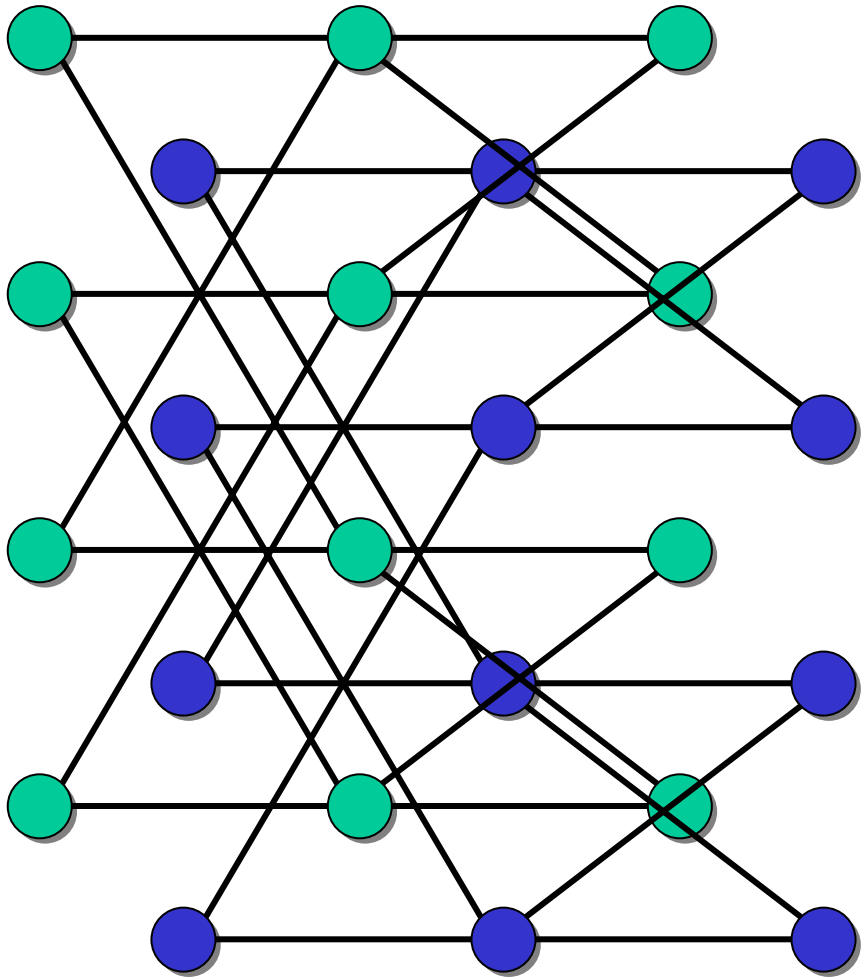

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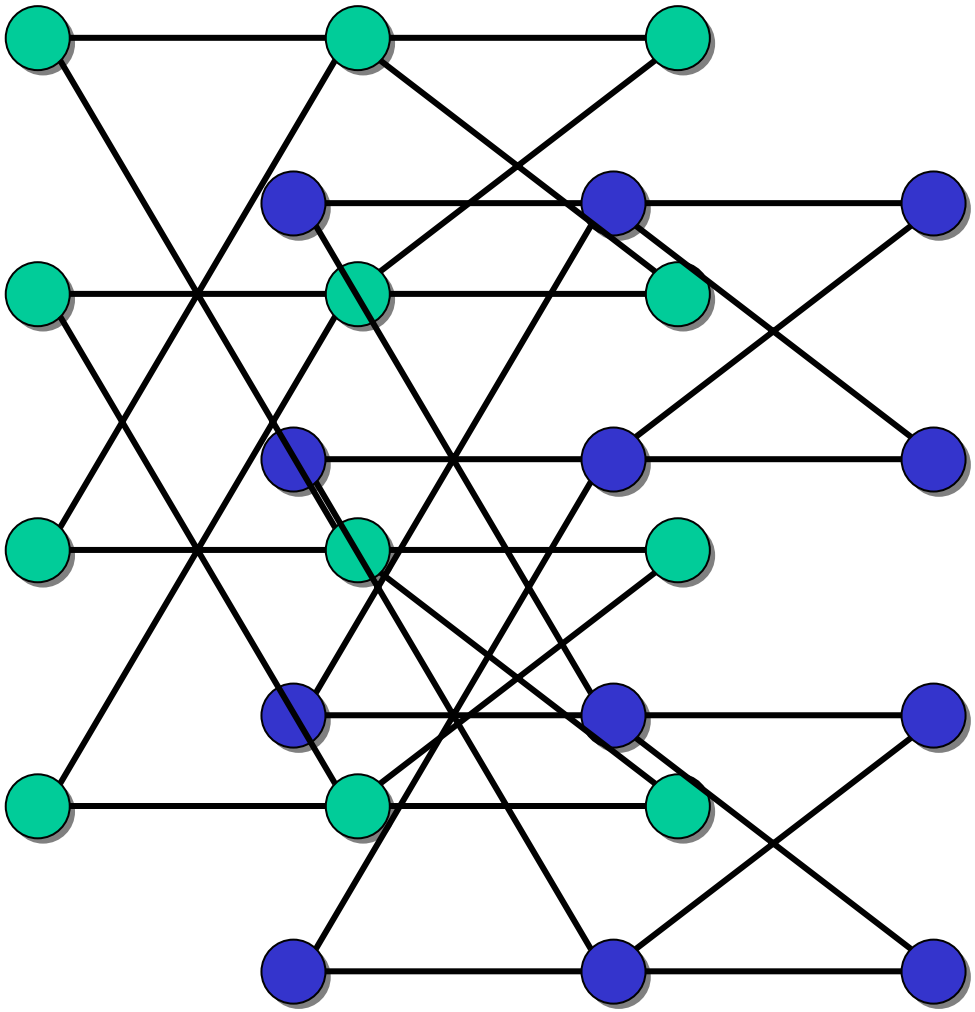

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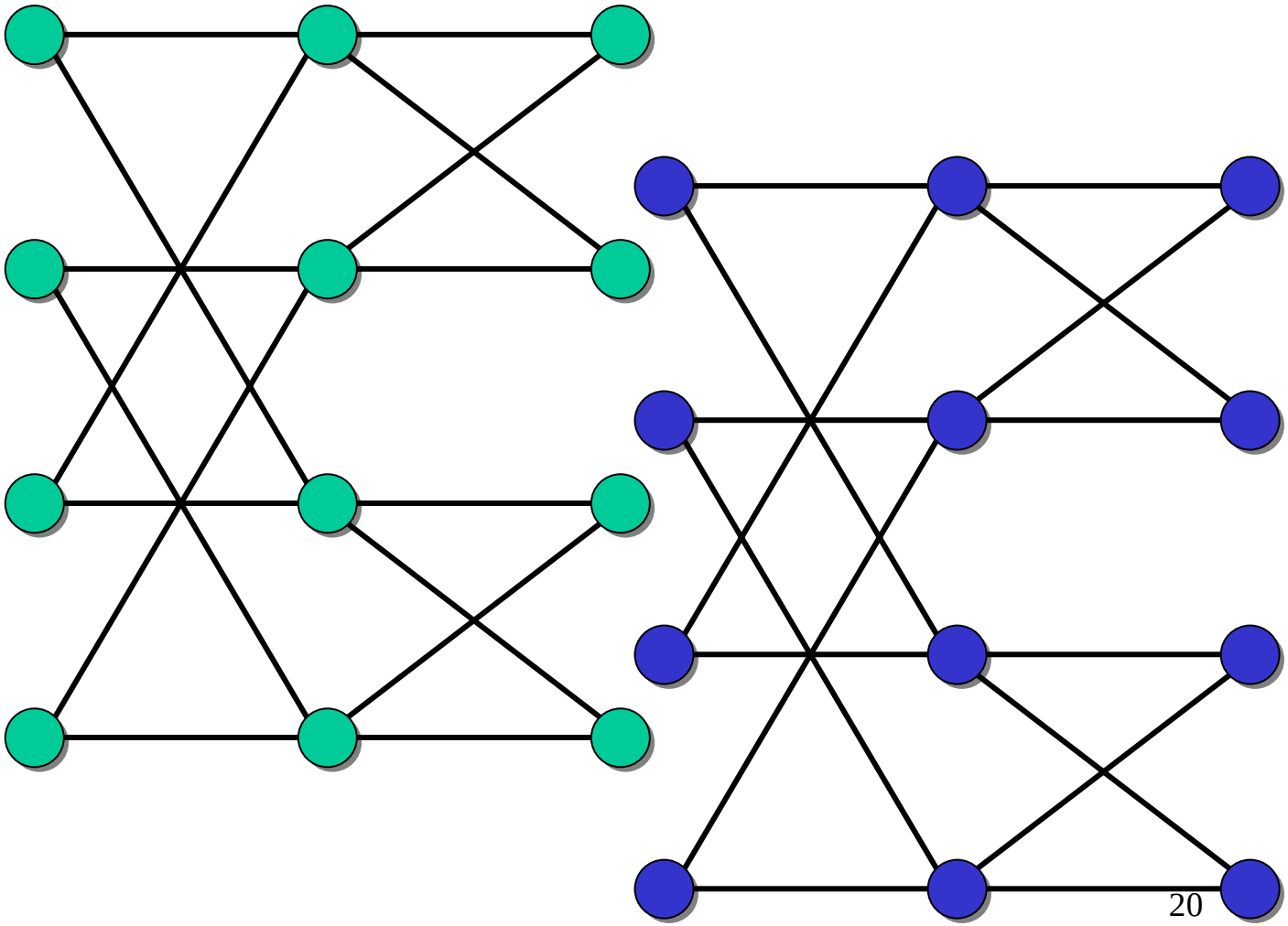
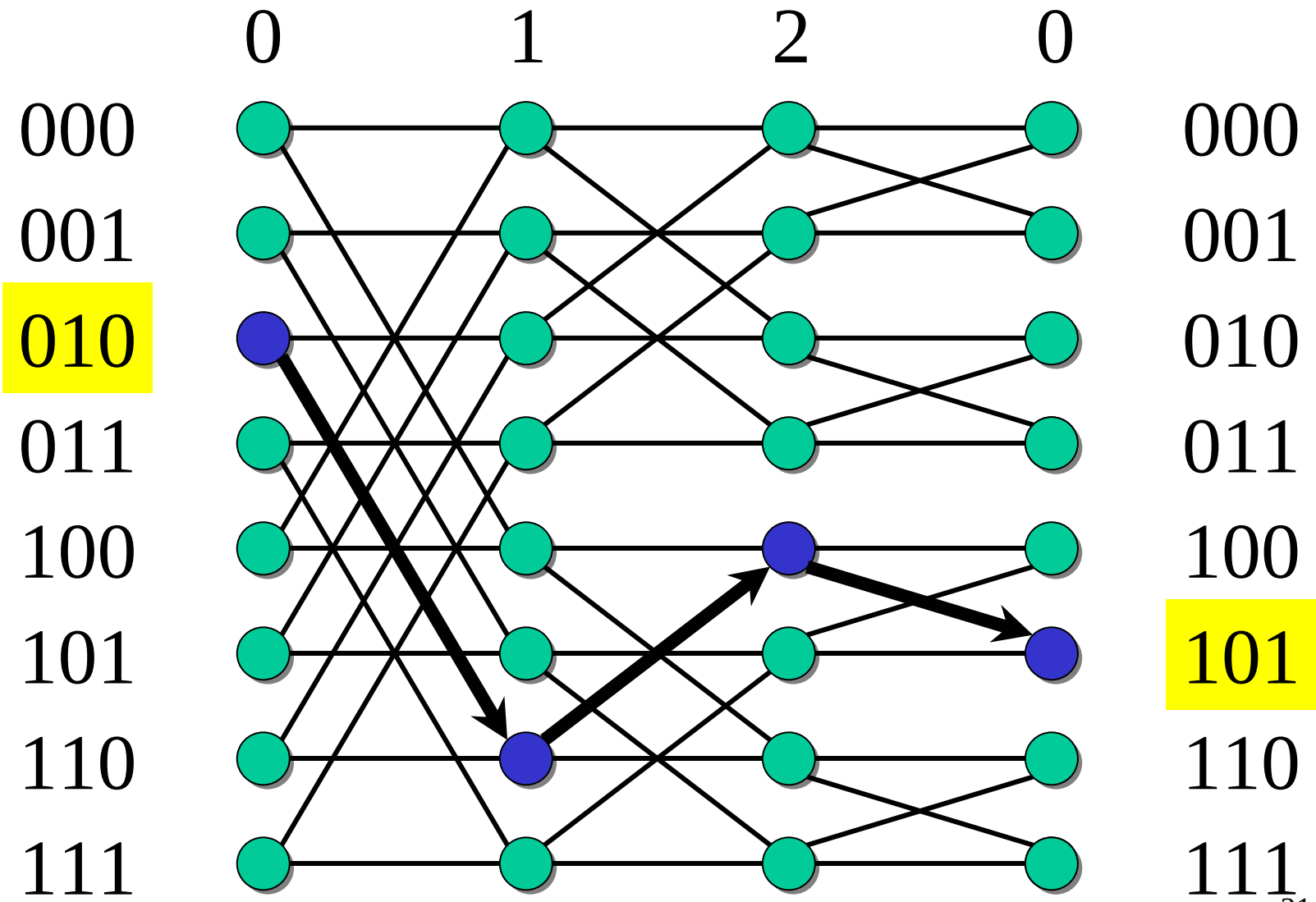
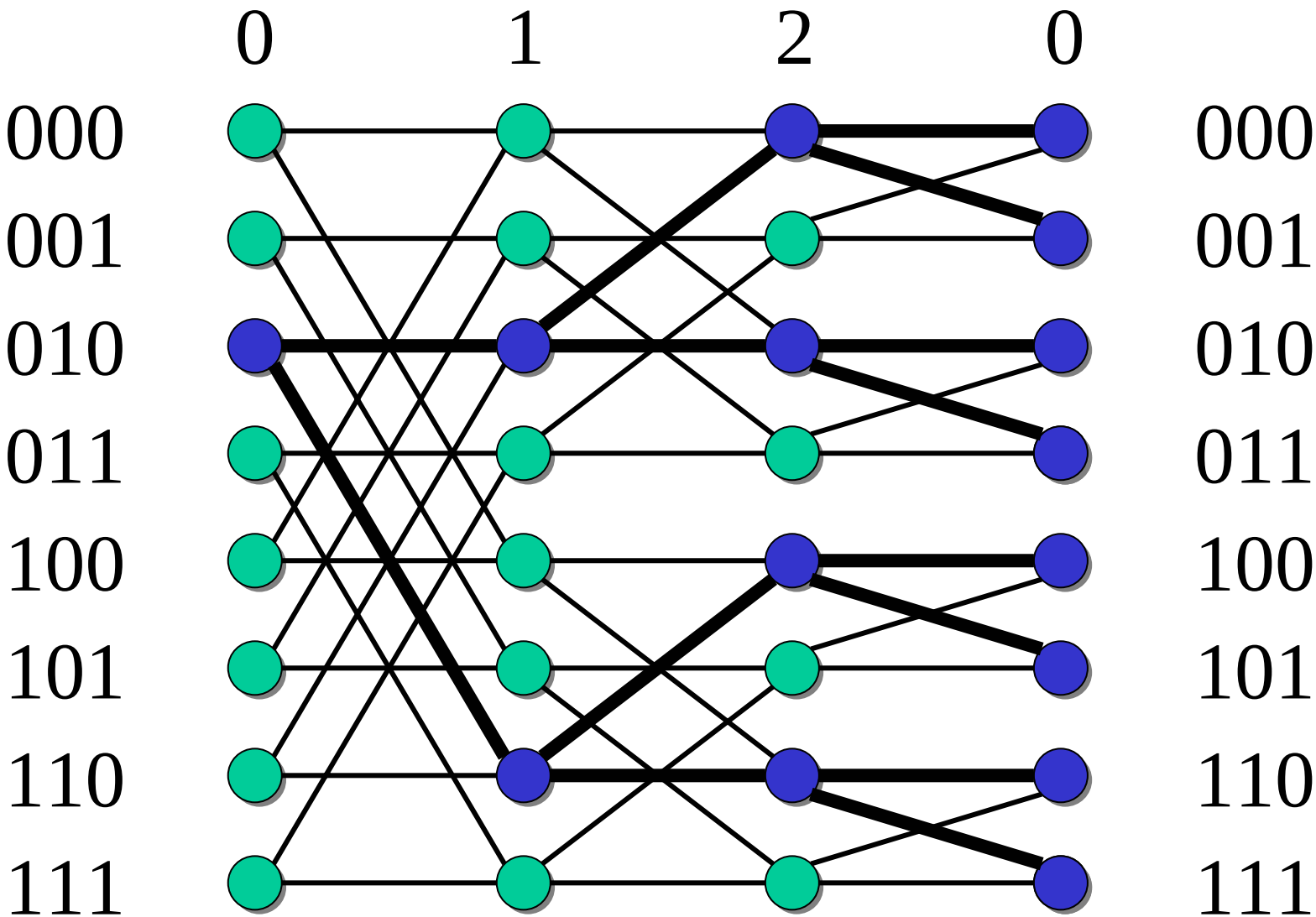


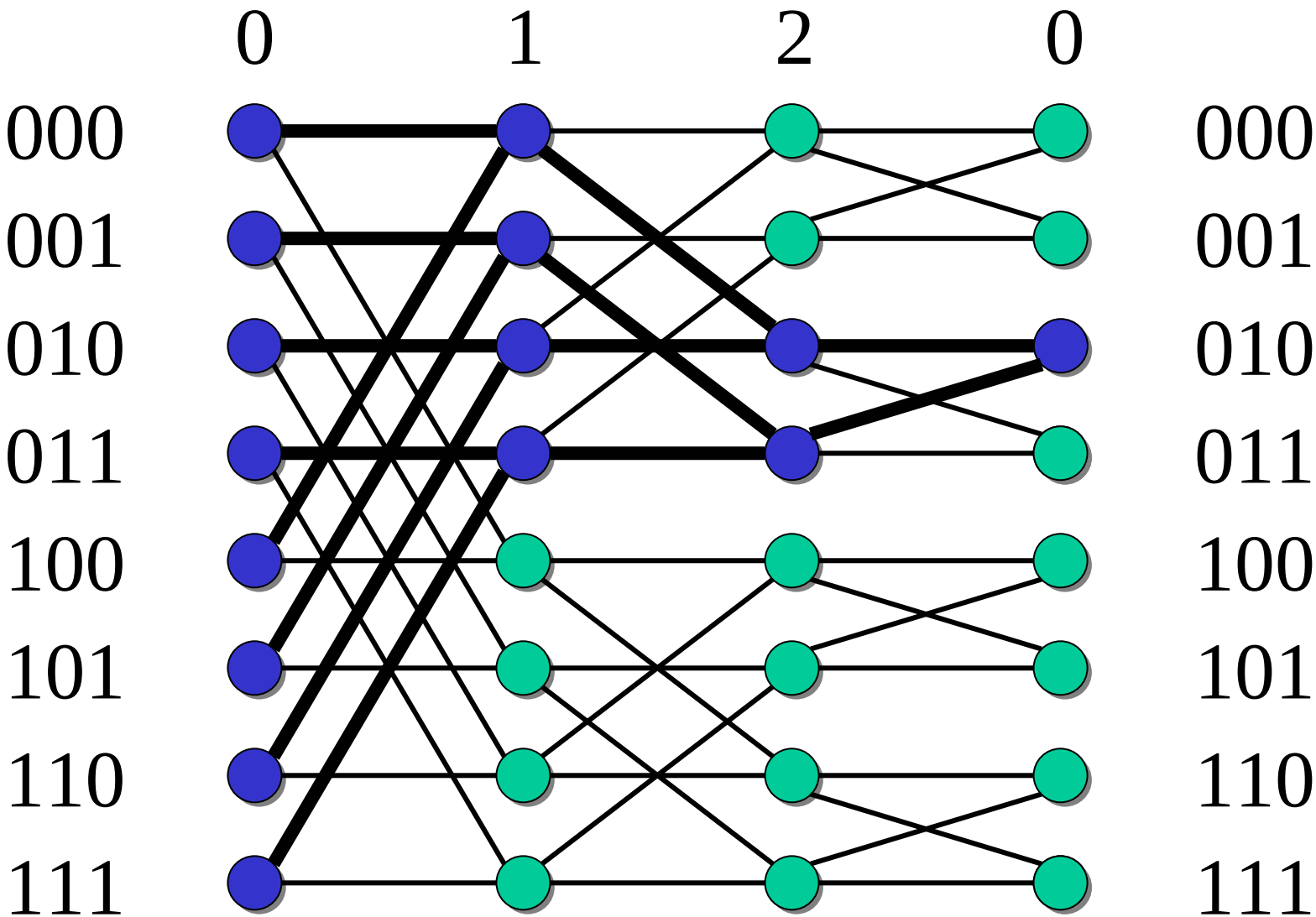
Routing on a Butterfly



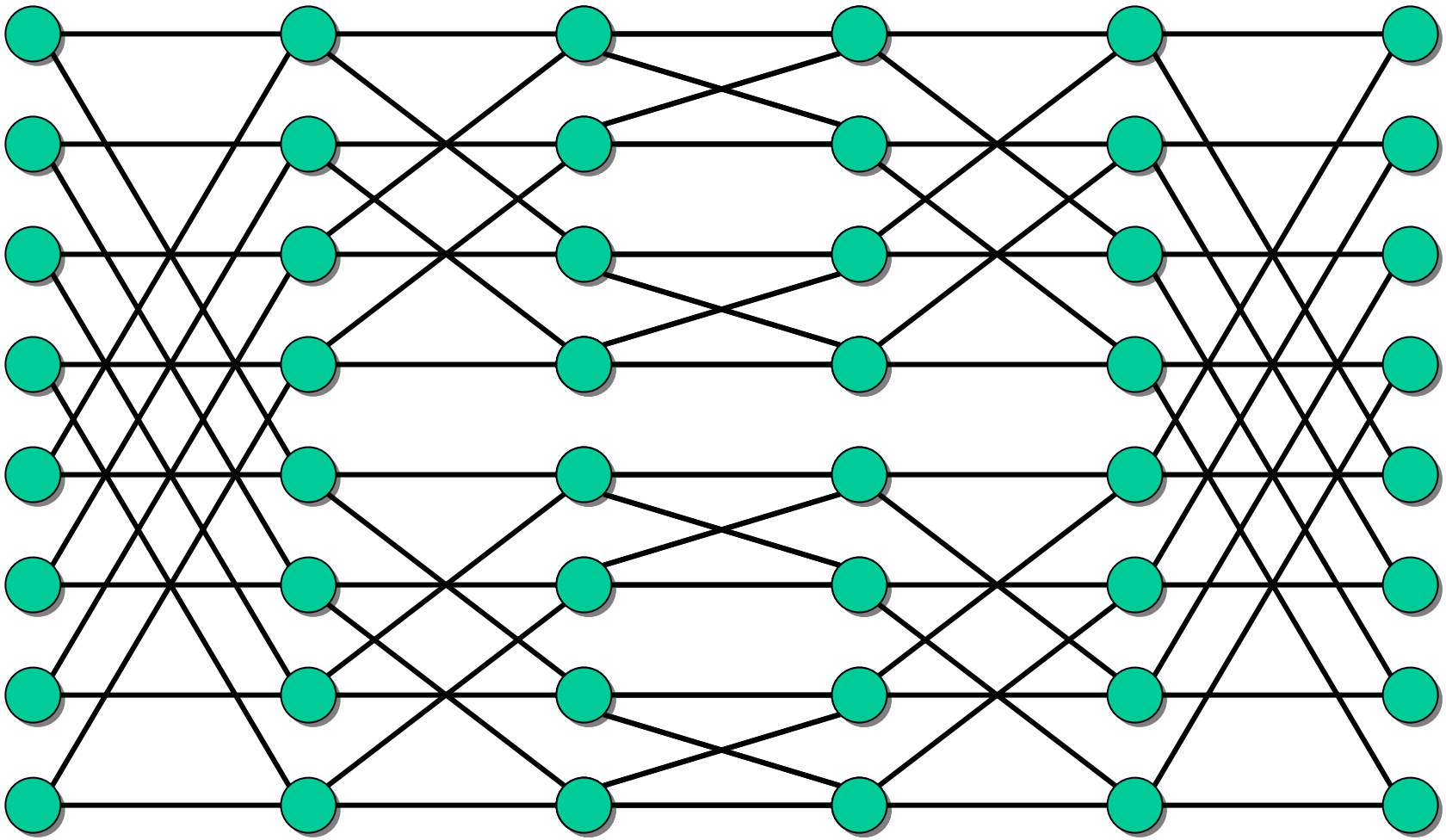
Tree in Butterfly



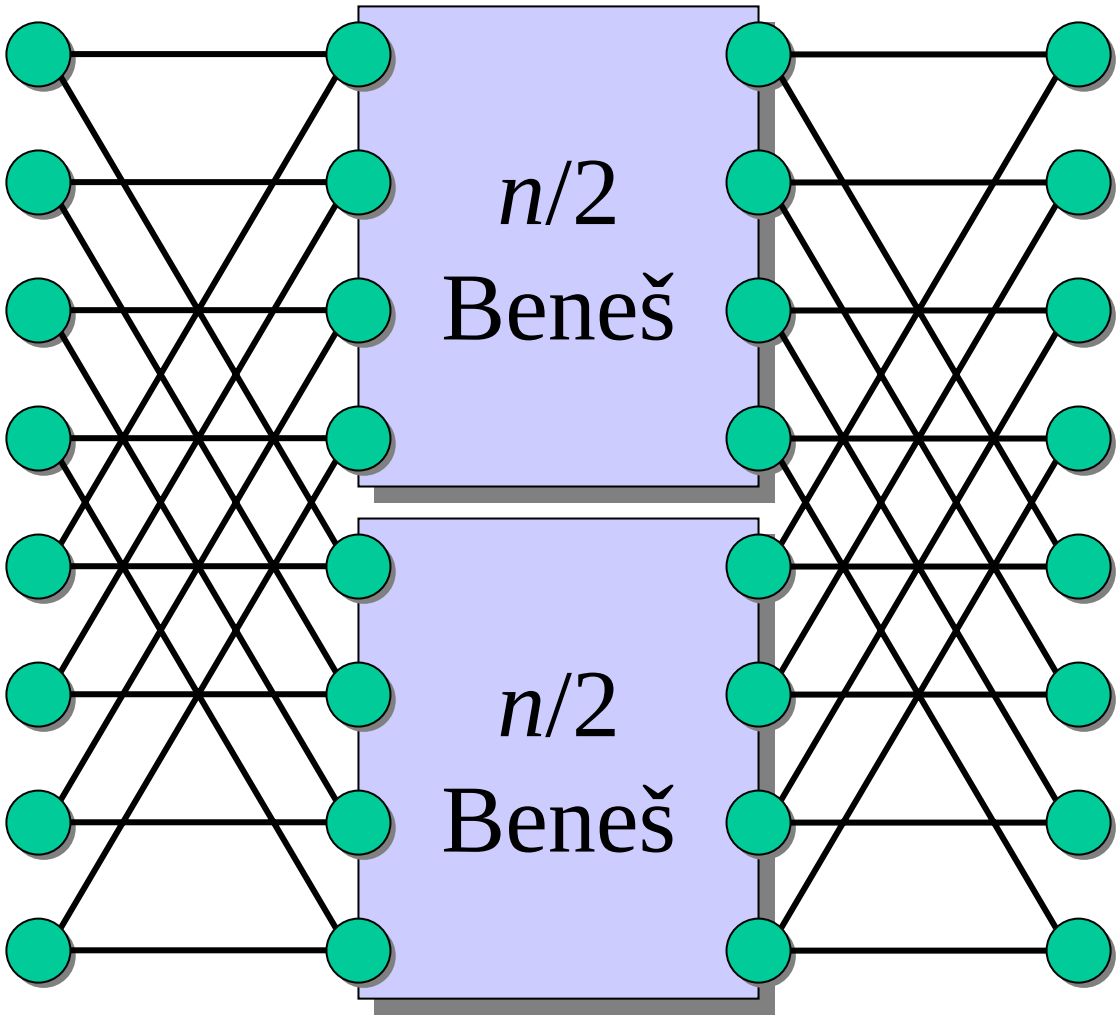
Tree in Butterfly



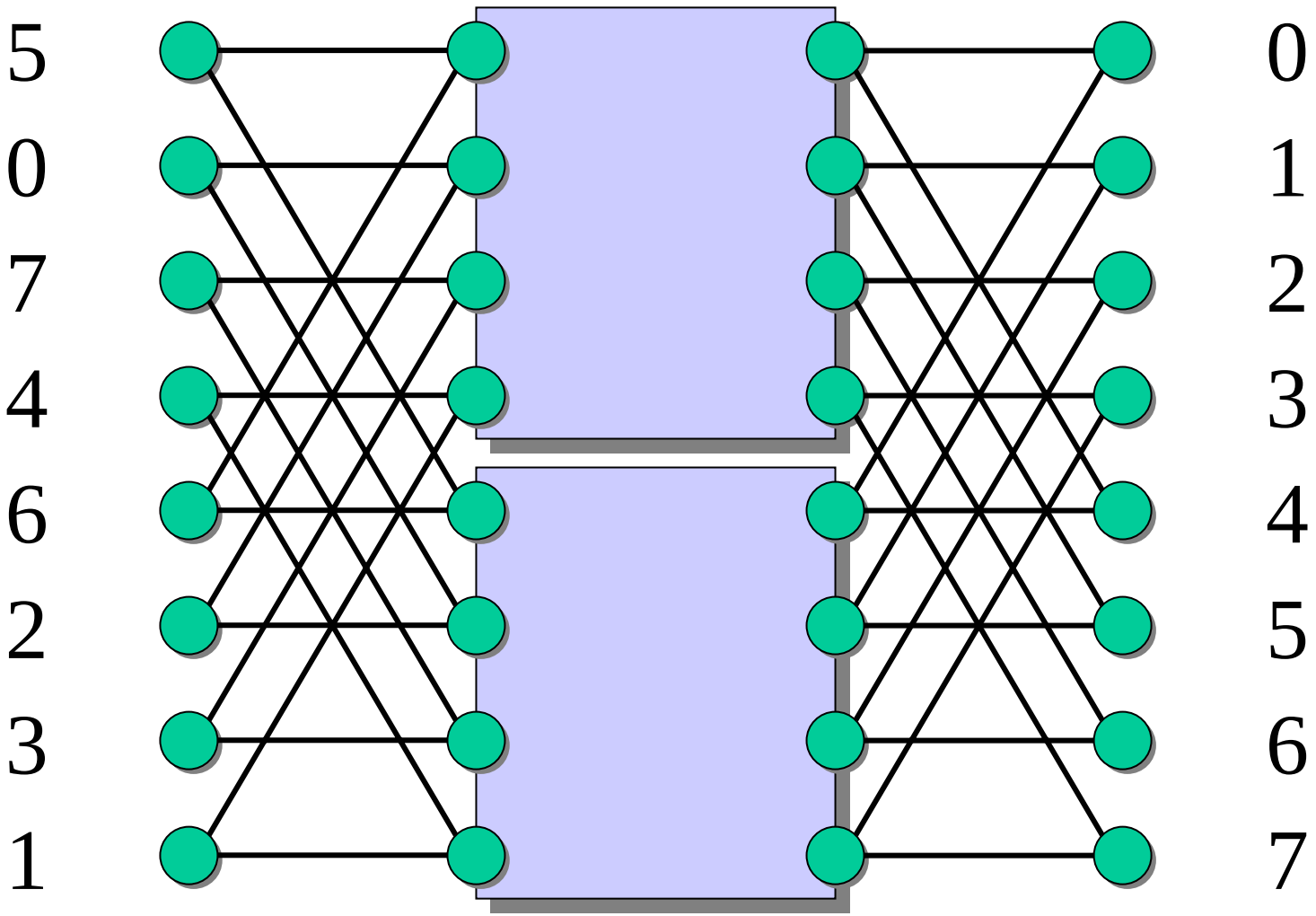
Beneš Network



Decomposing a Beneš Network



Routing on a Beneš Network



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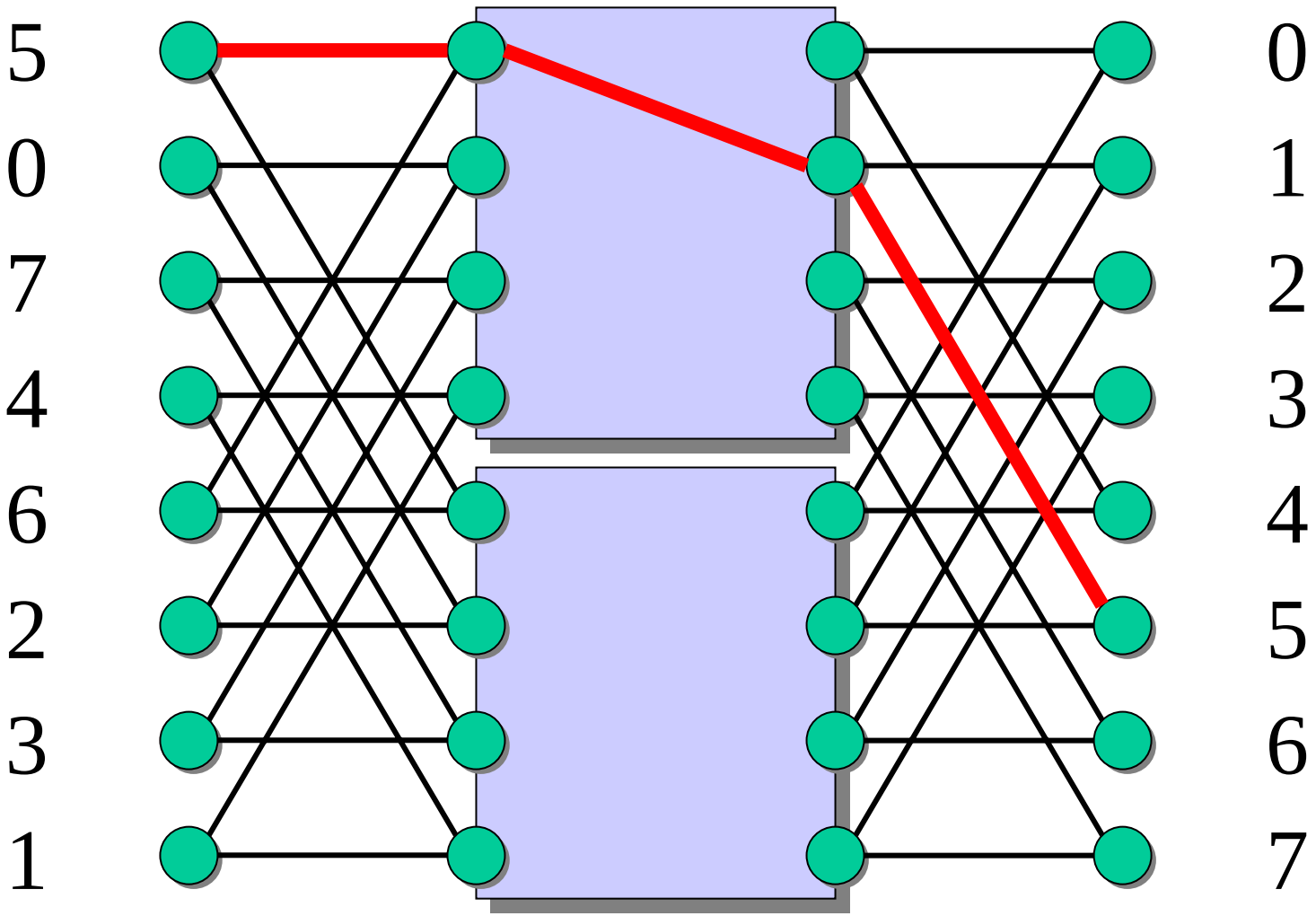

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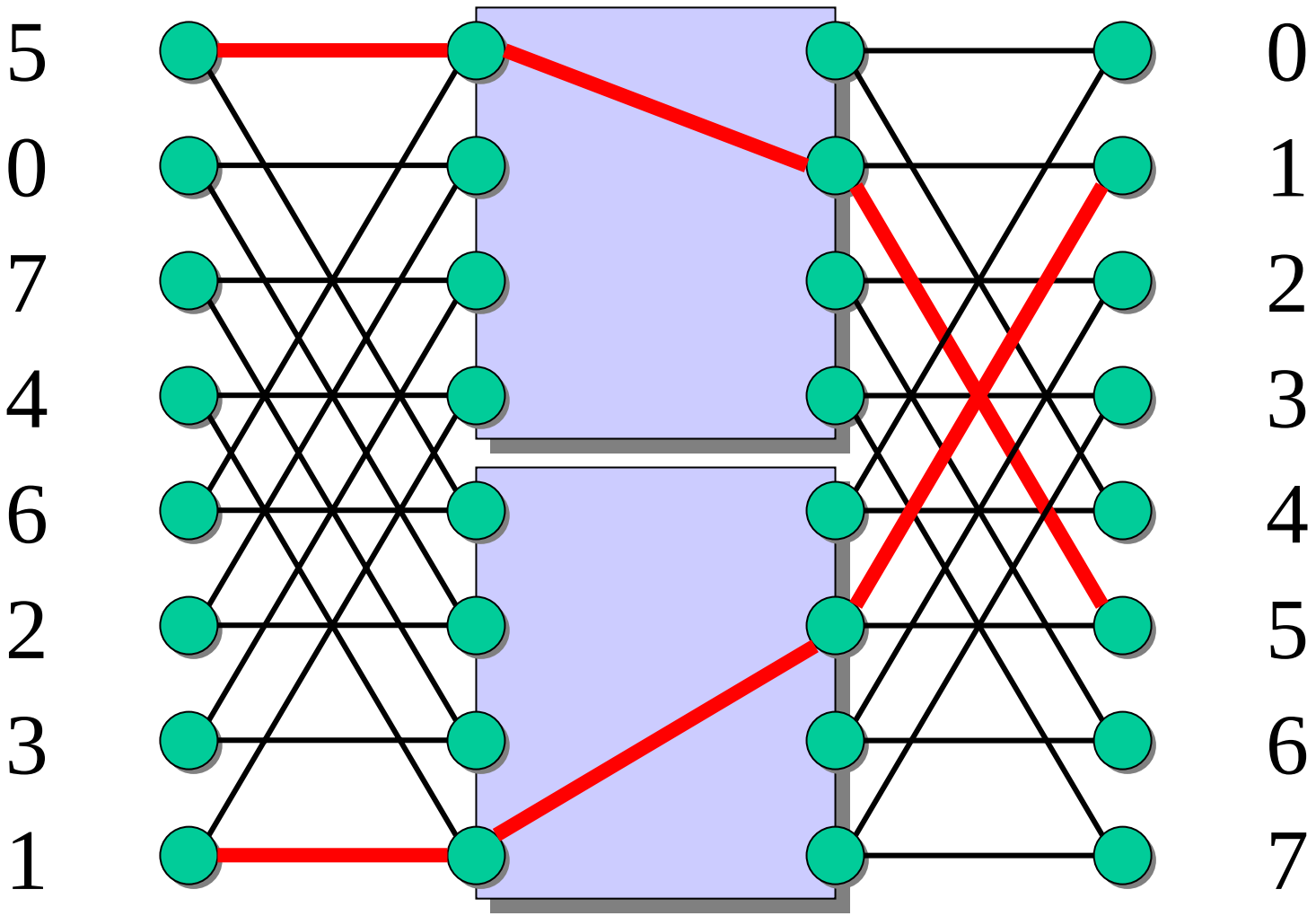

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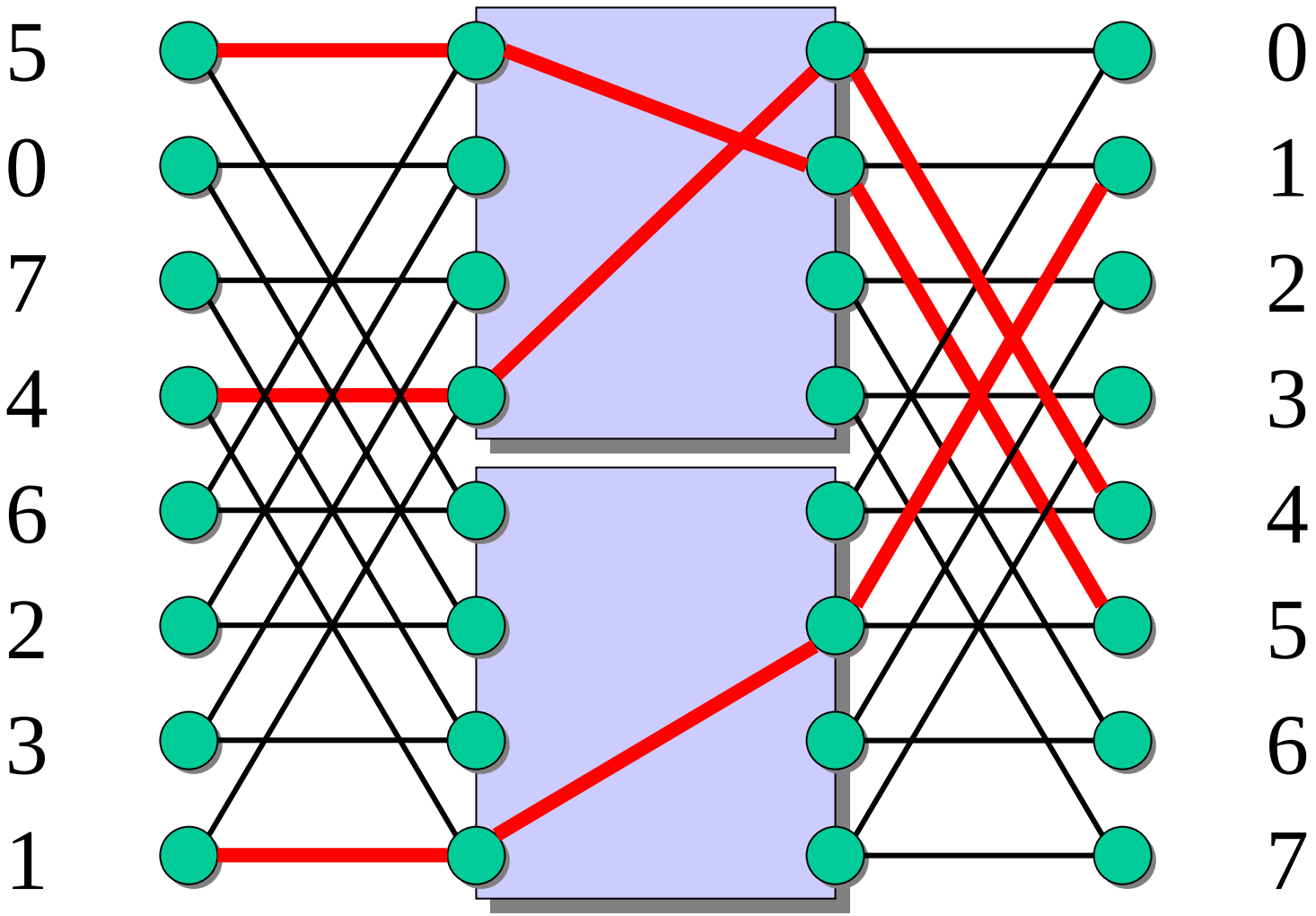

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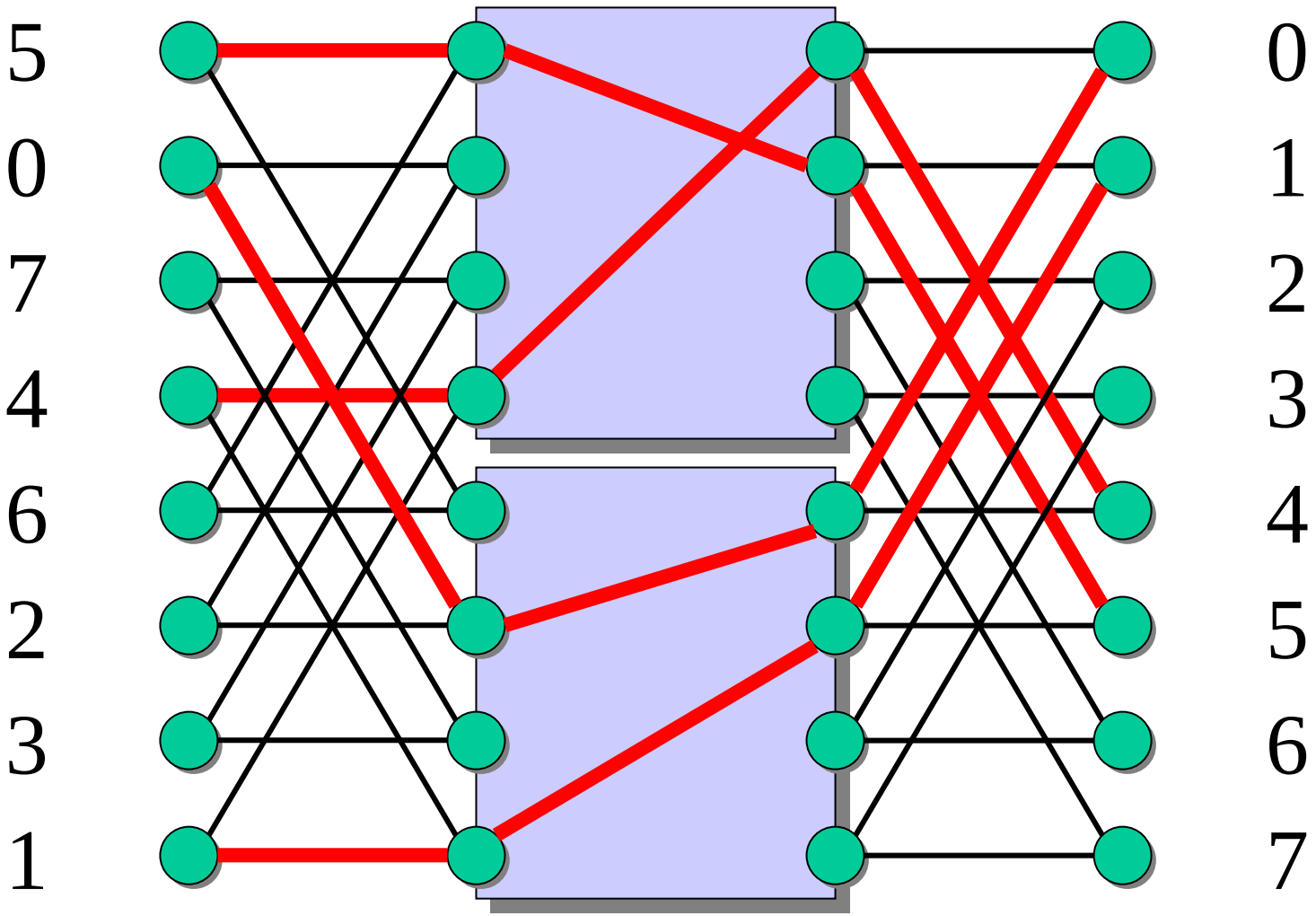

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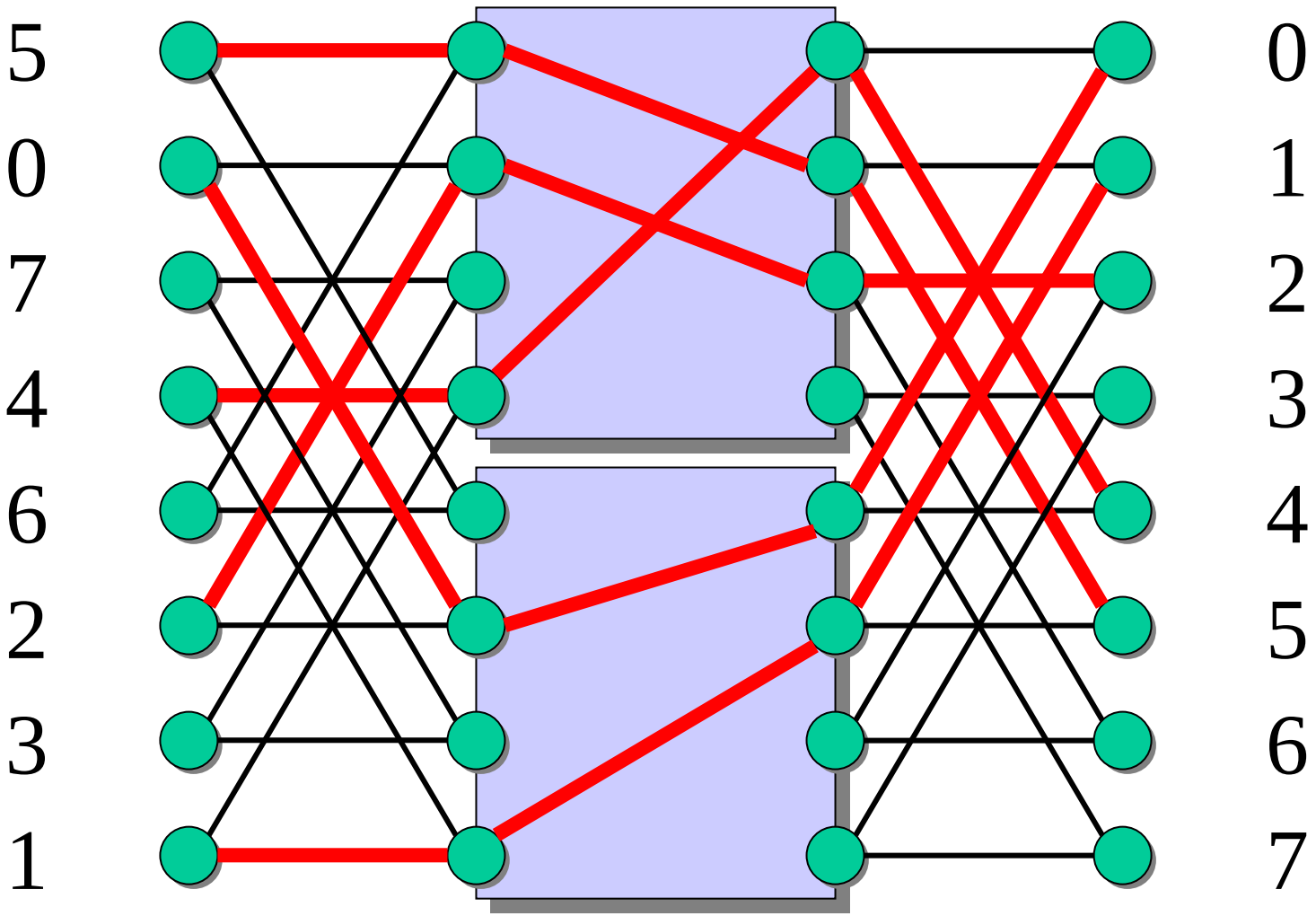

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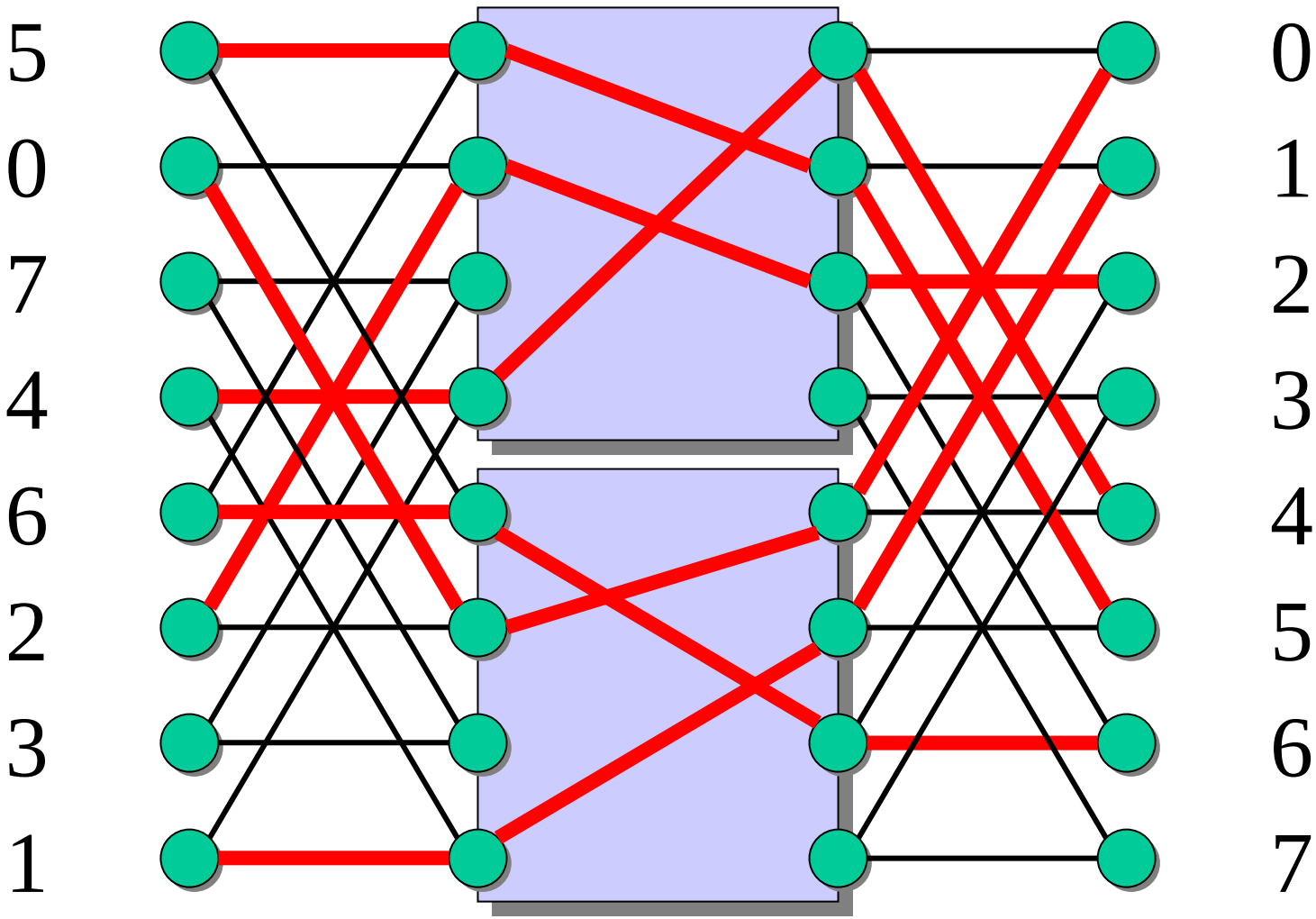

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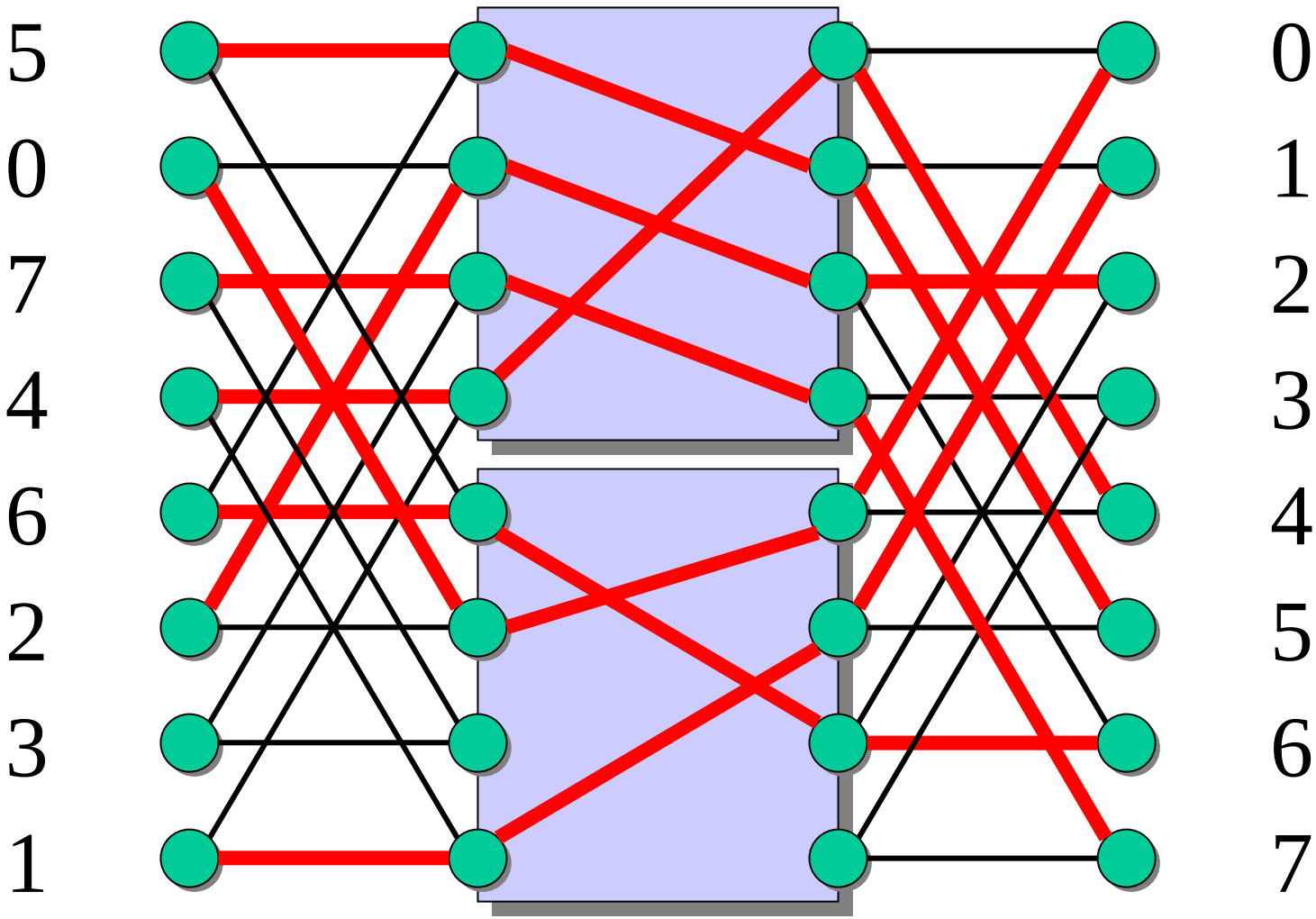
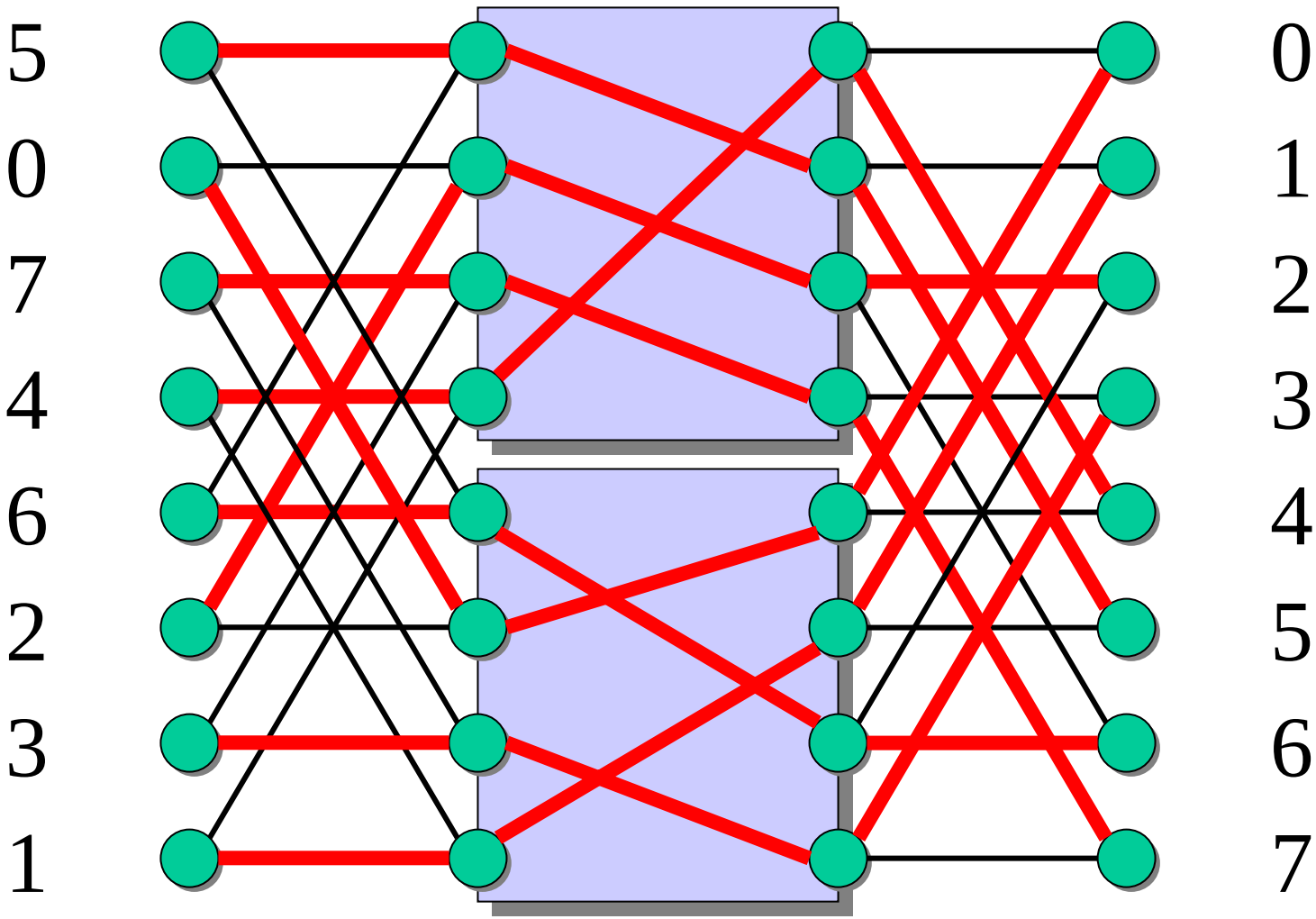
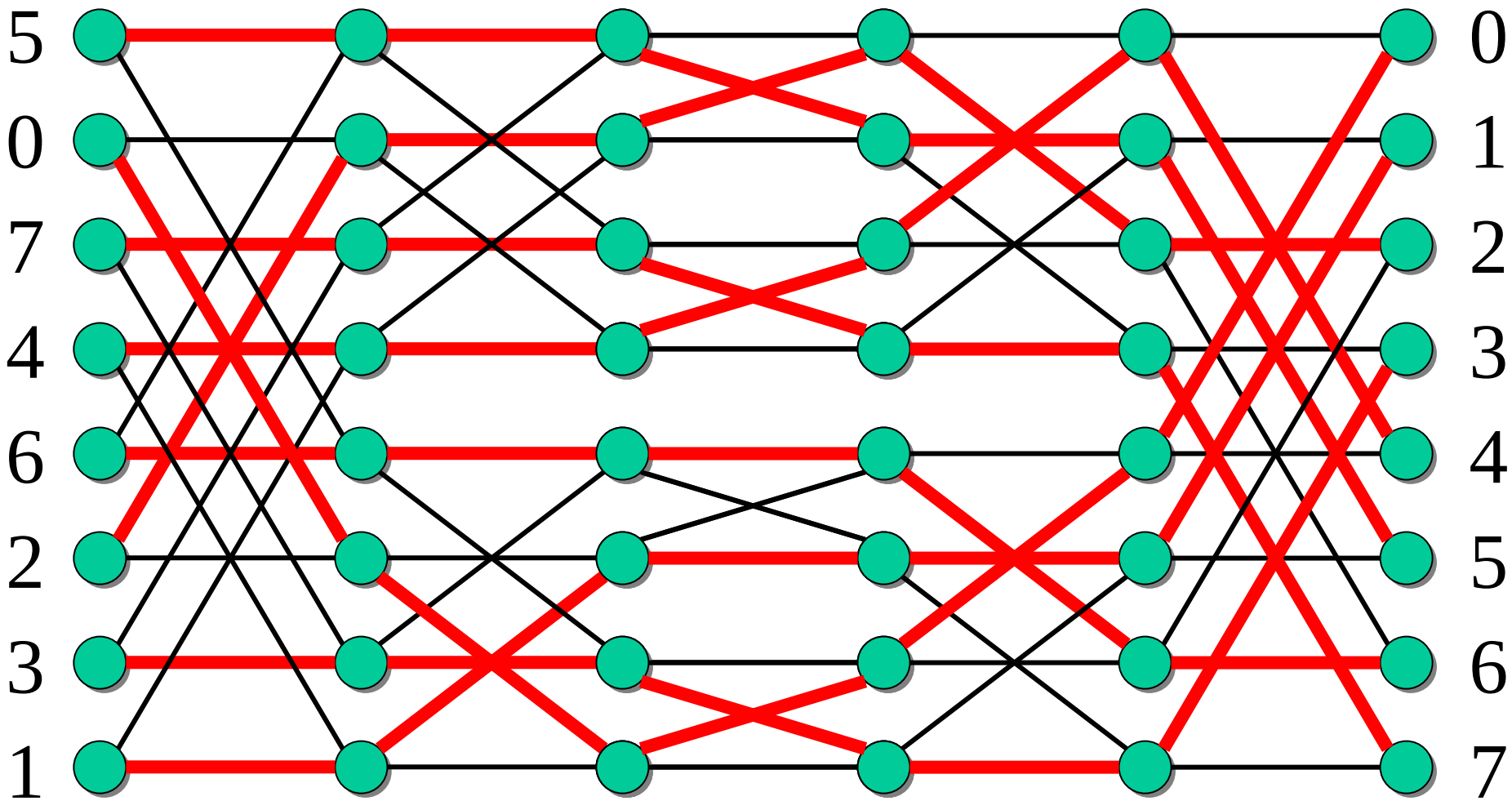


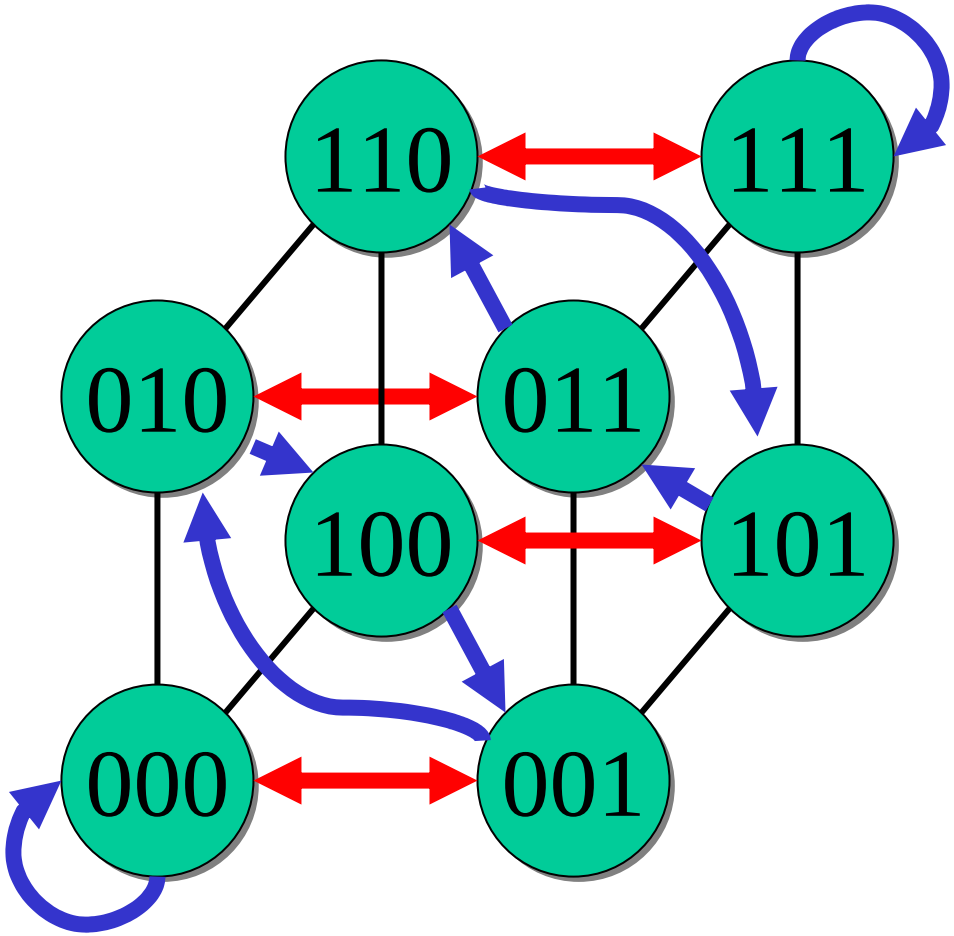
Routing on a Beneš Network



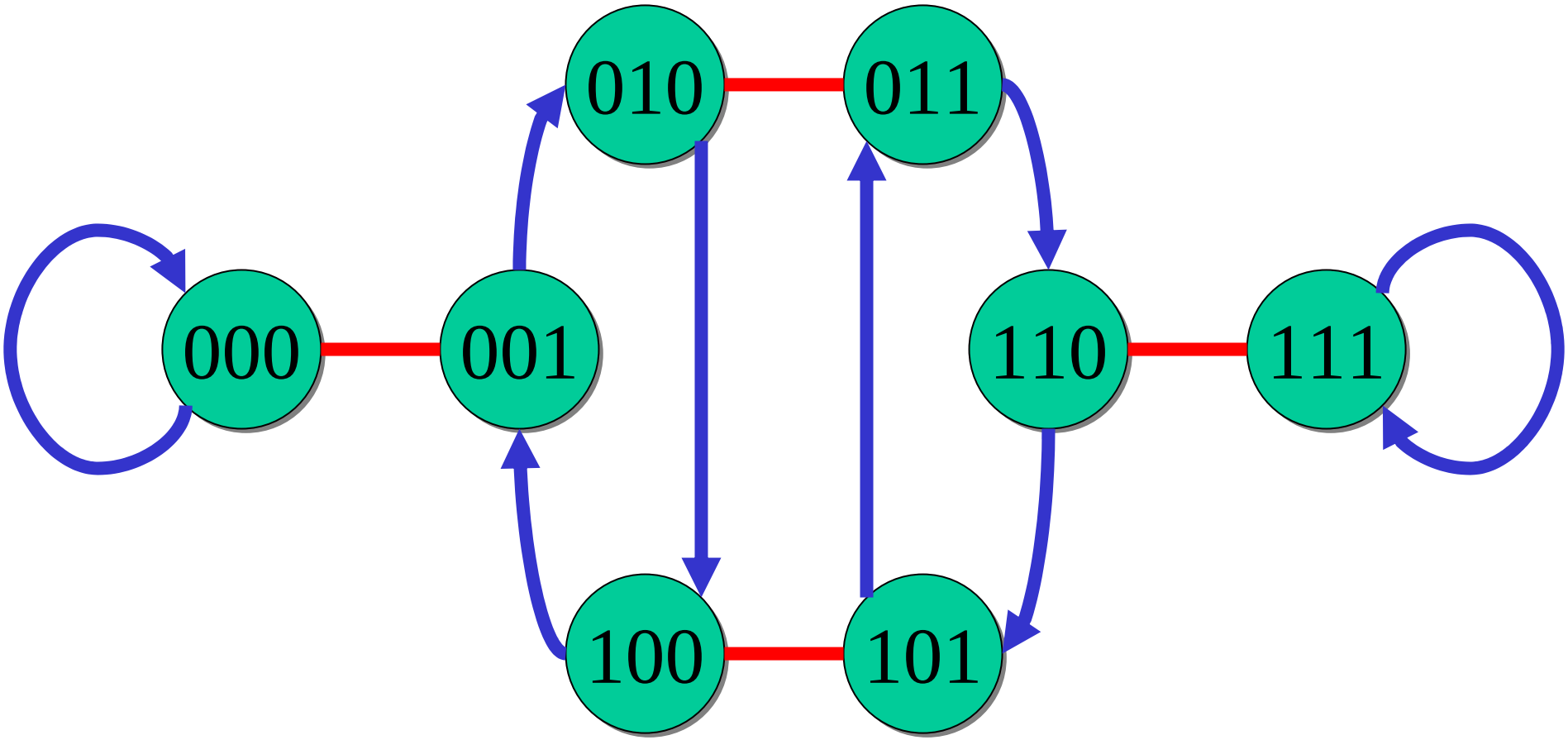
Routing on a Beneš Network



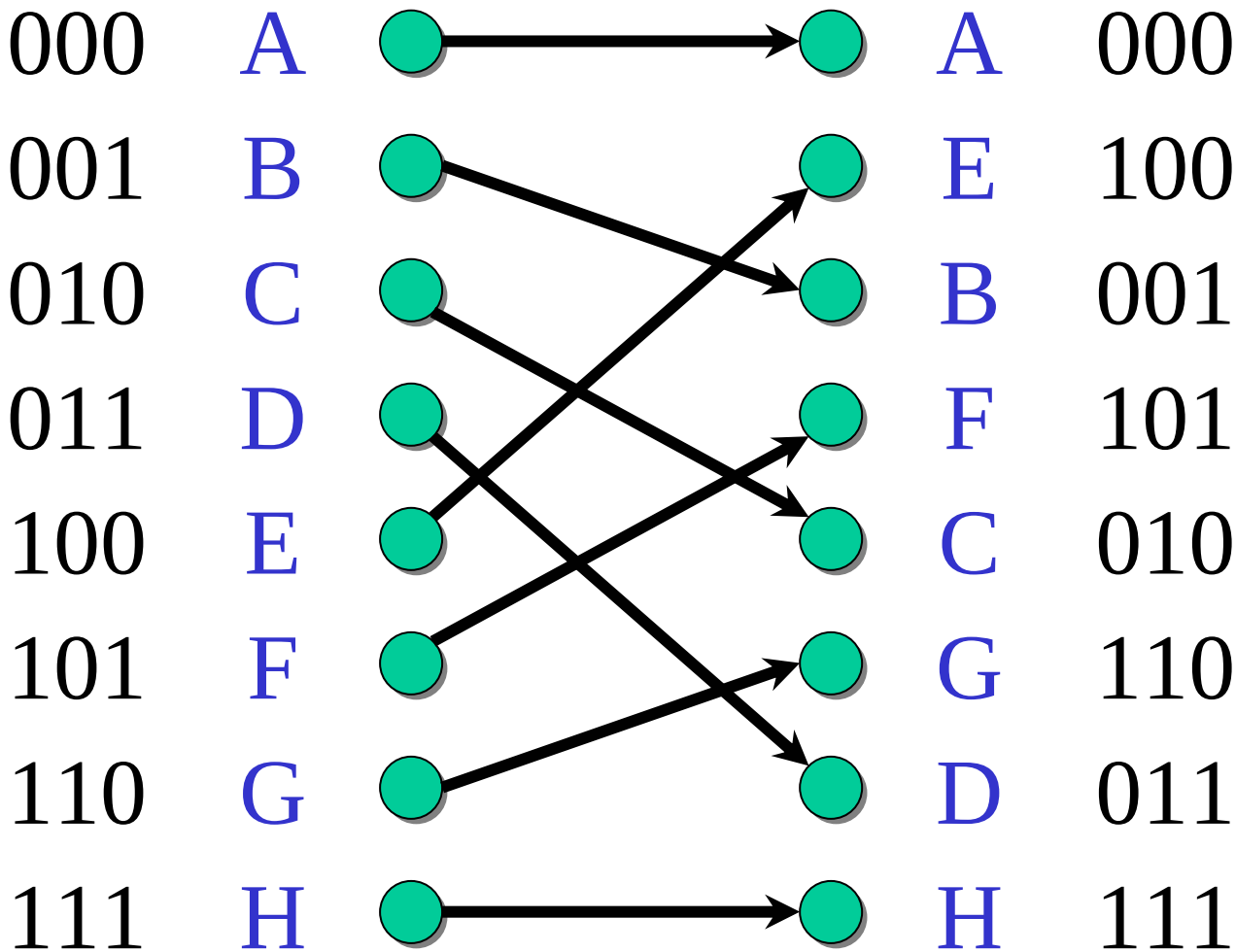
Shuffle-Exchange Network



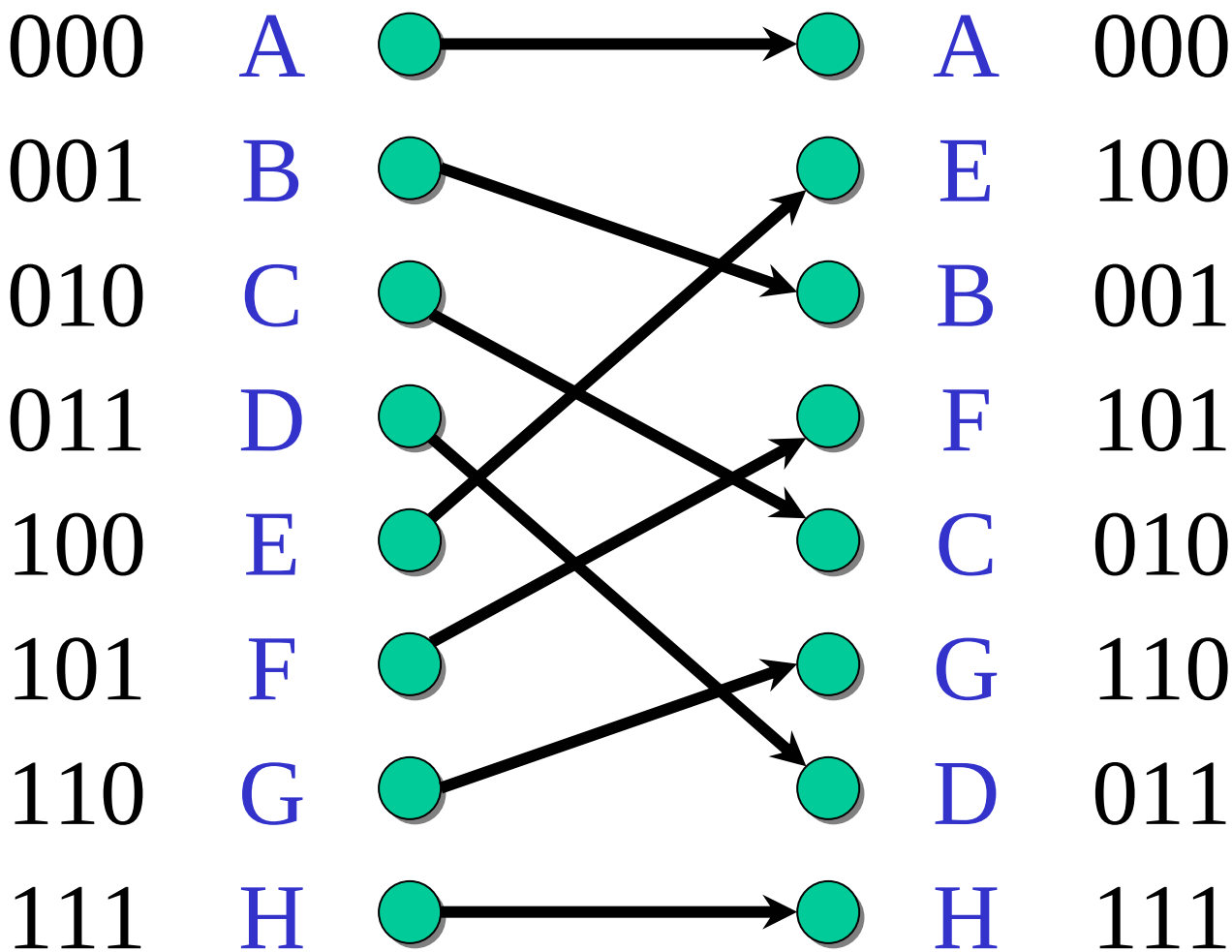
Shuffle-Exchange Network



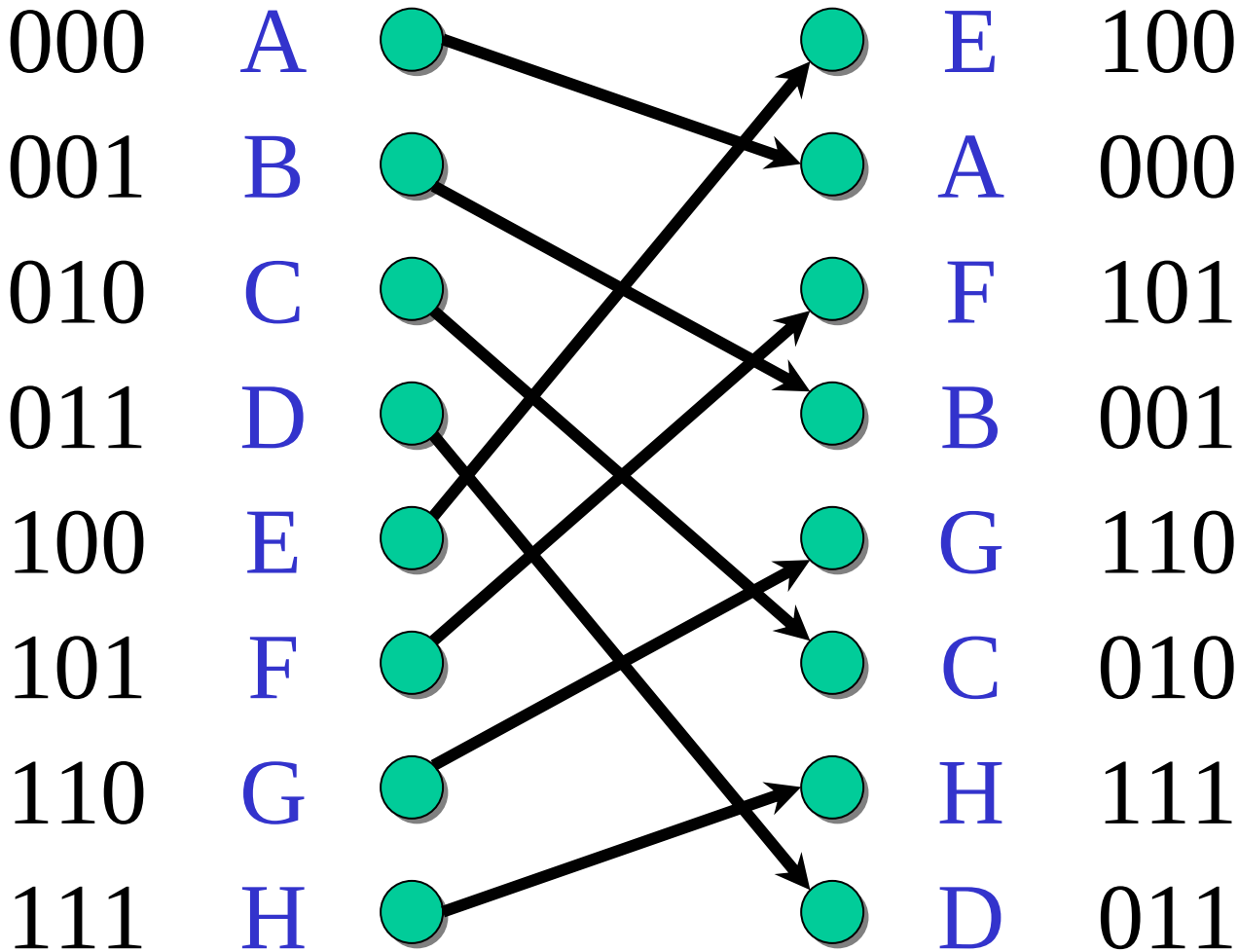
Perfect Shuffle



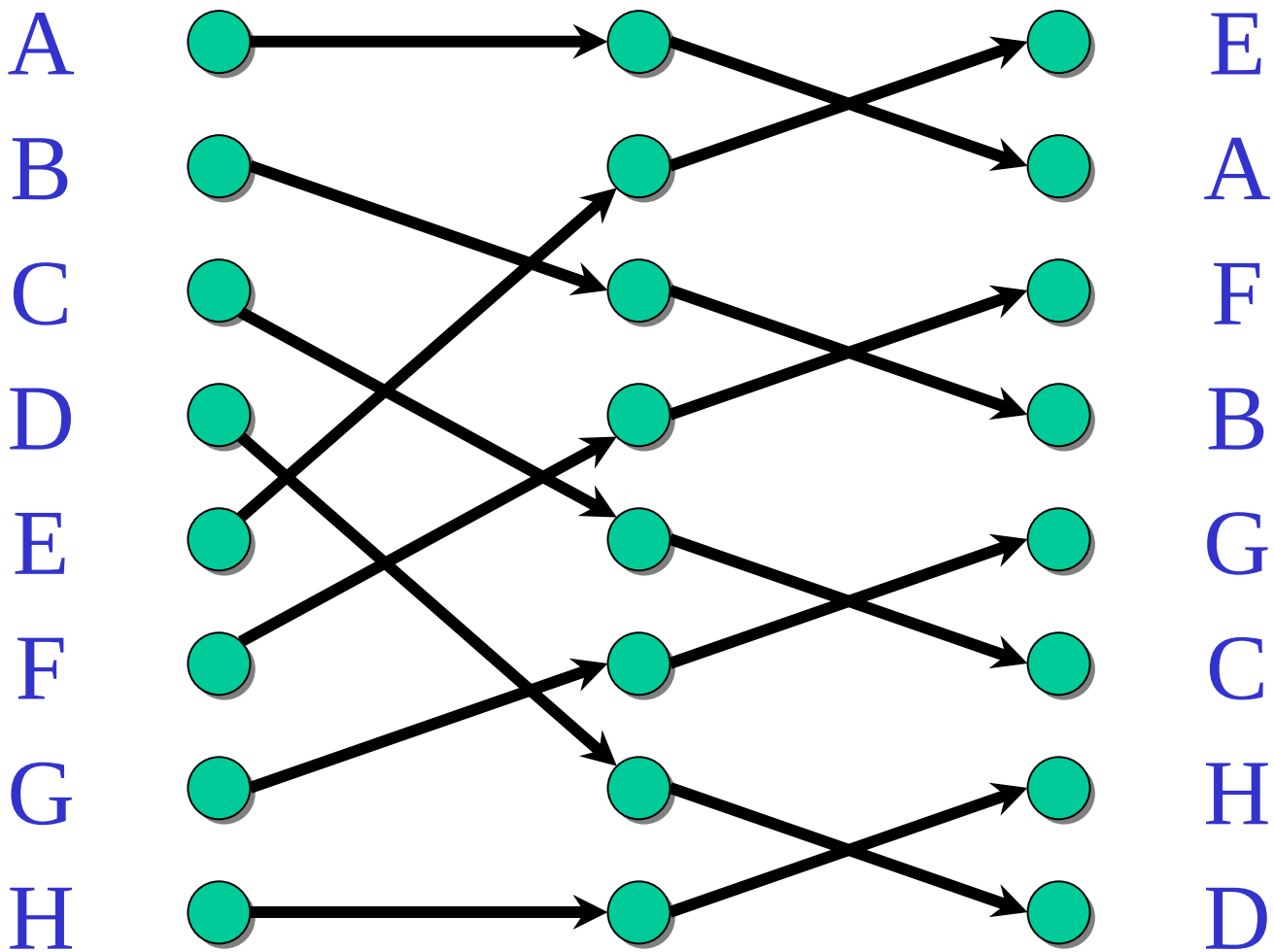
Perfect Out-Shuffle



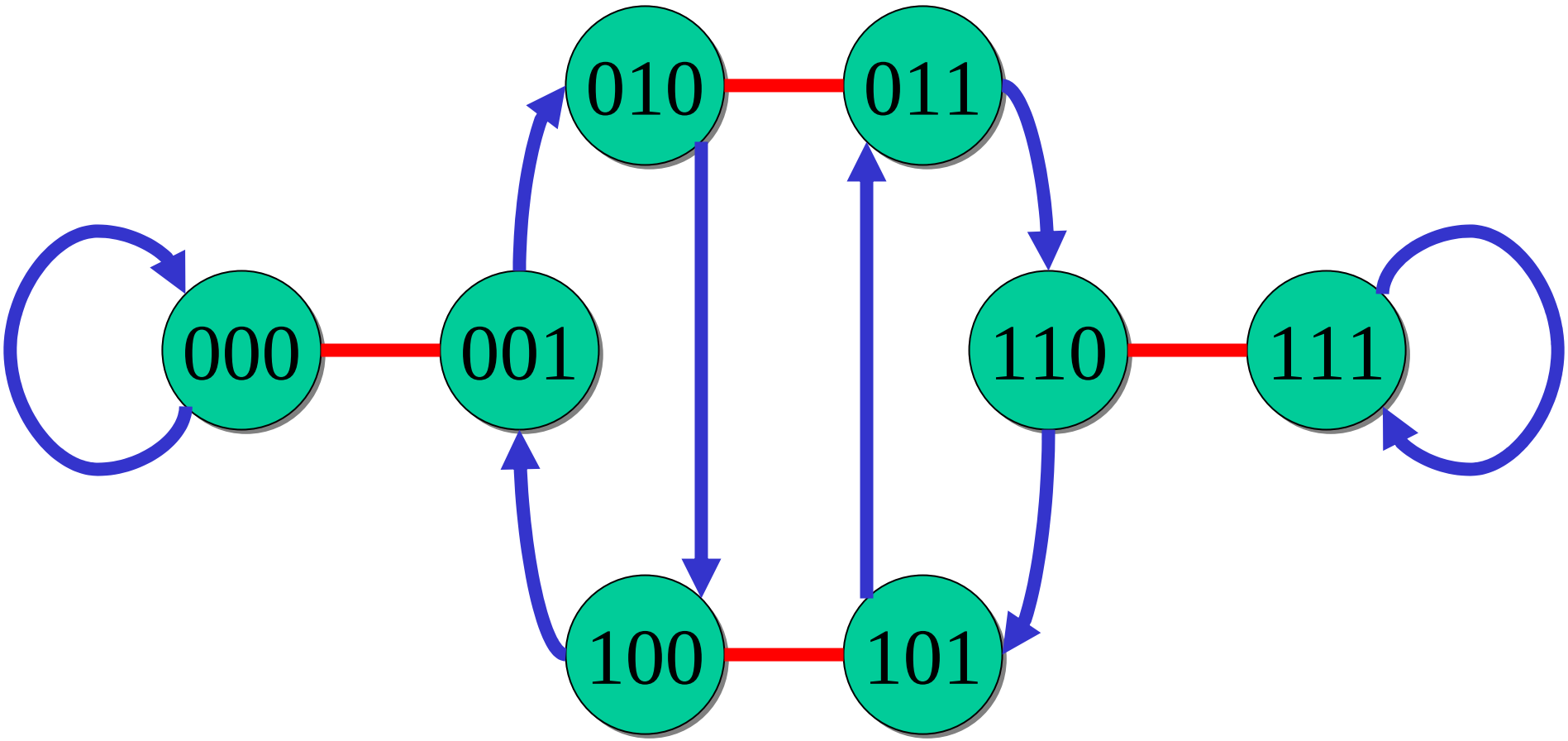
Perfect In-Shuffle



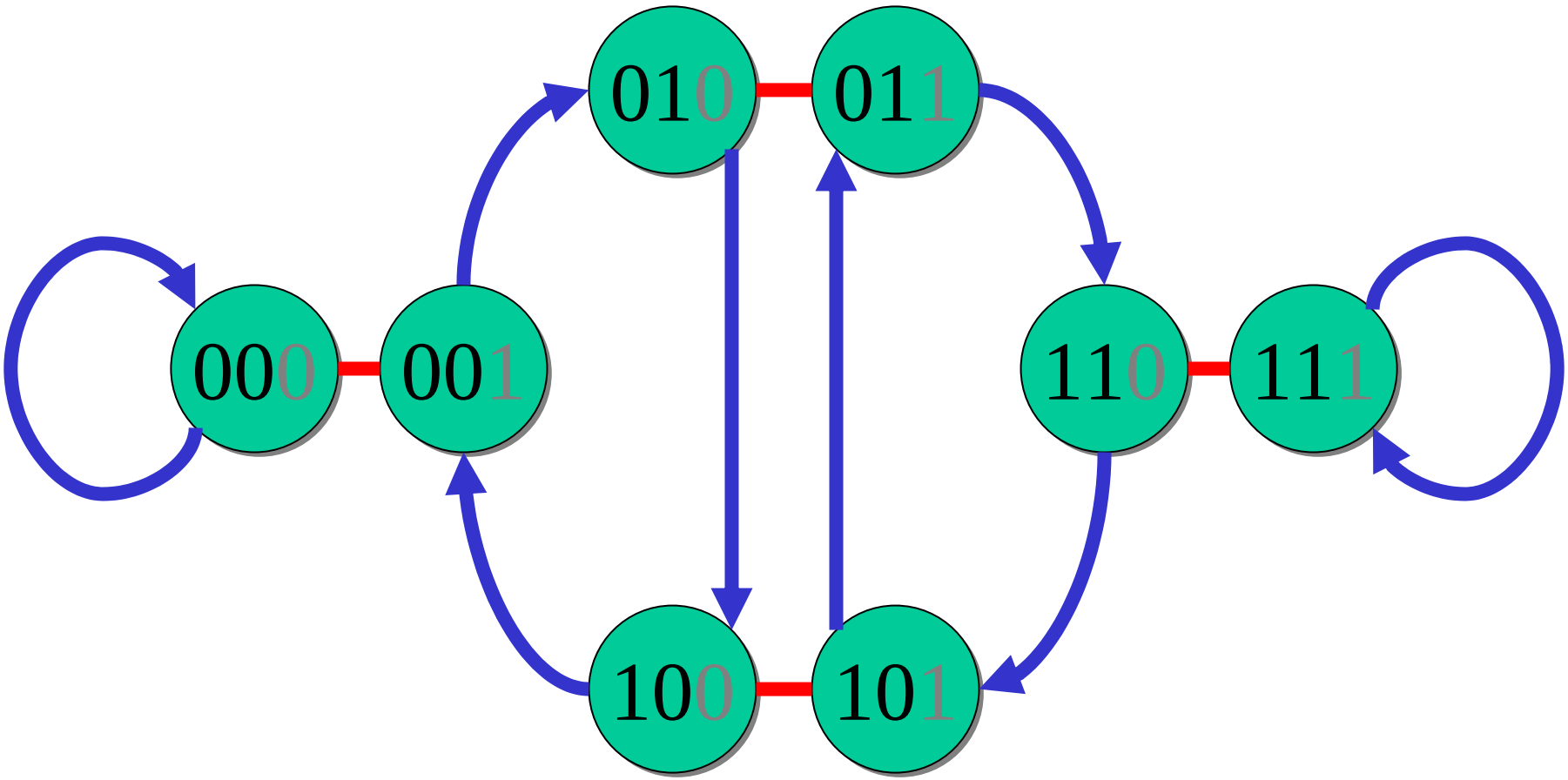
In-Shuffle = Out-Shuffle + Exchange



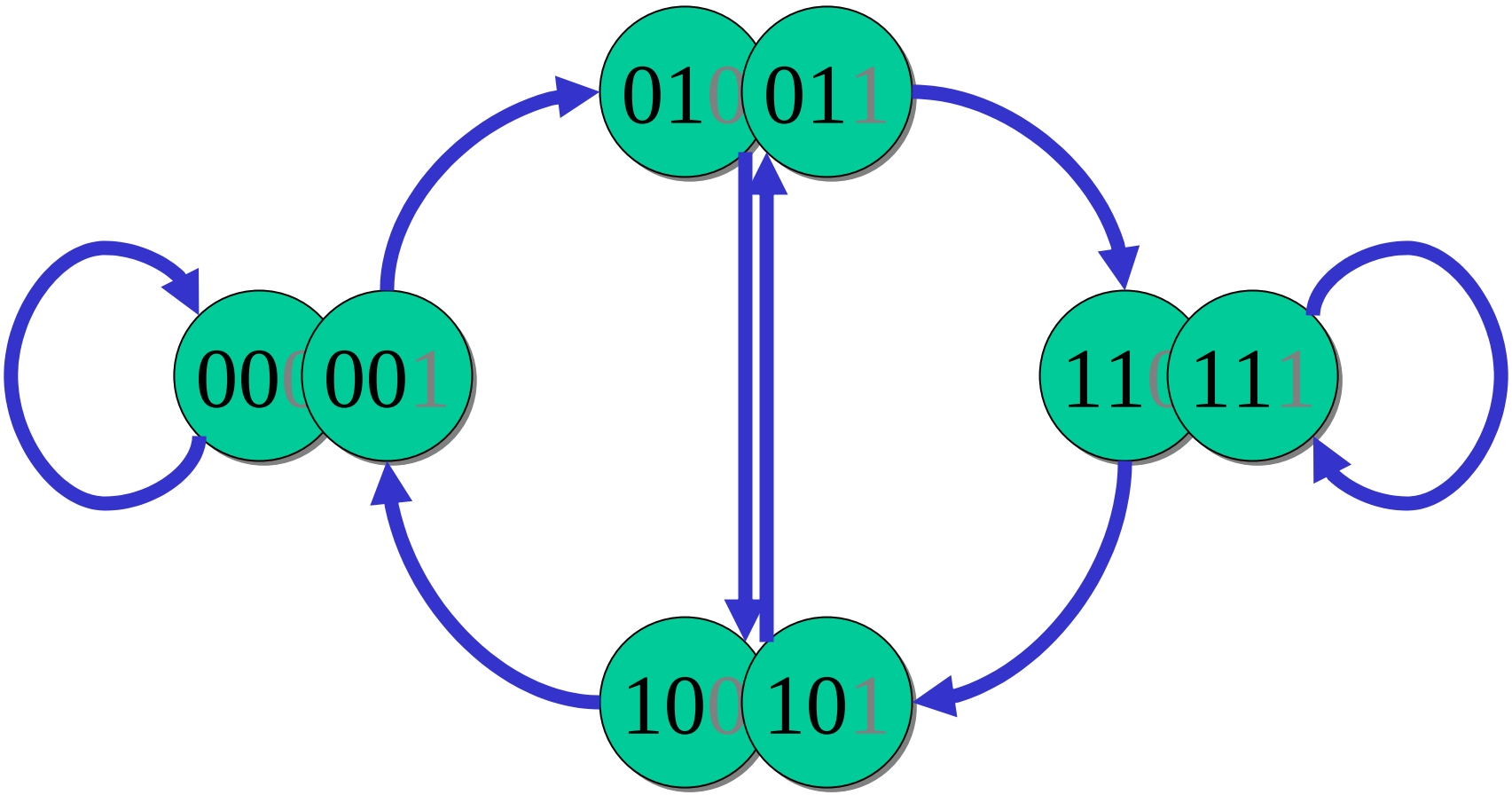
SE → DeBruijn



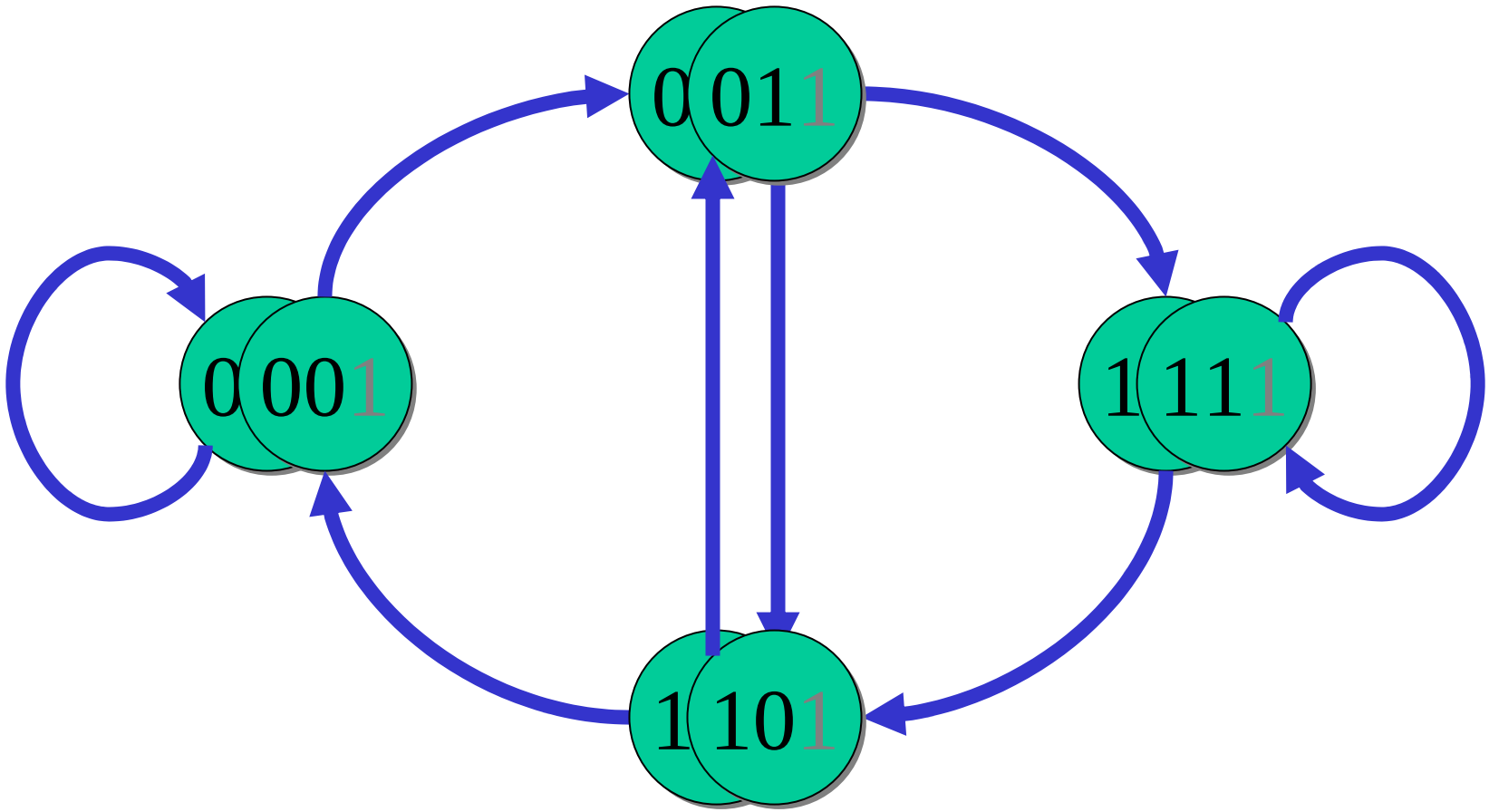
SE → DeBruijn



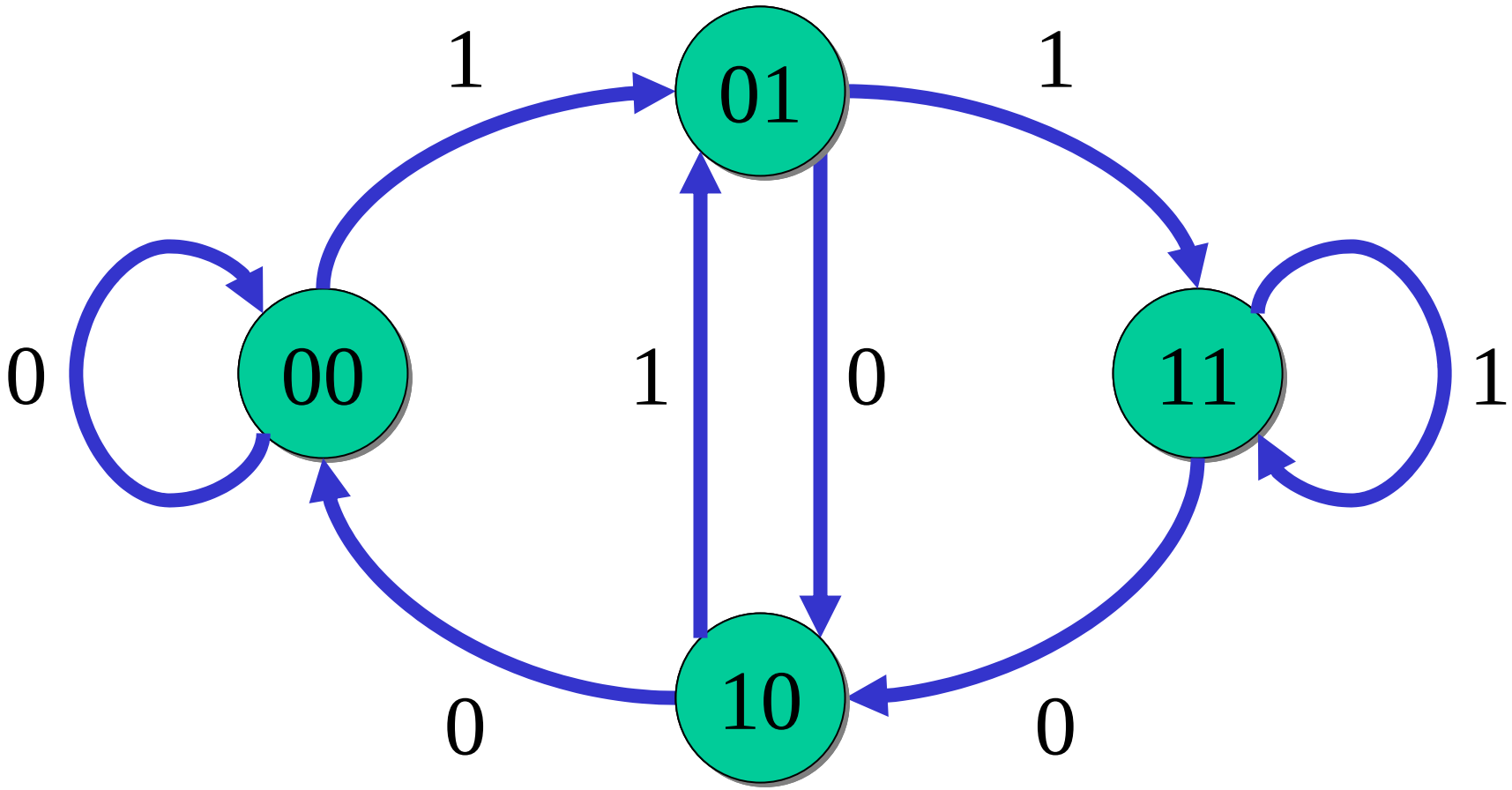
SE → DeBruijn



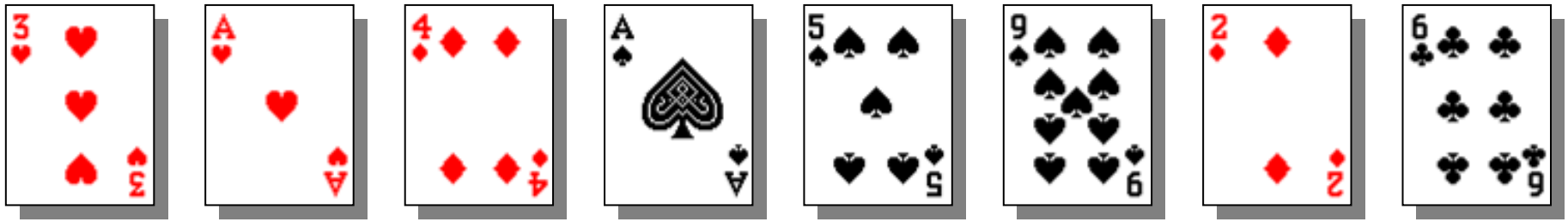
SE → DeBruijn



DeBruijn Network



DeBruijn Sequence



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Complex Plane Diagram of SE