

Equilibrium rules

204	108 (201)	105	54 (147)	51
	156 (198)	150 60 (102, 153, 195)	57 (99)	

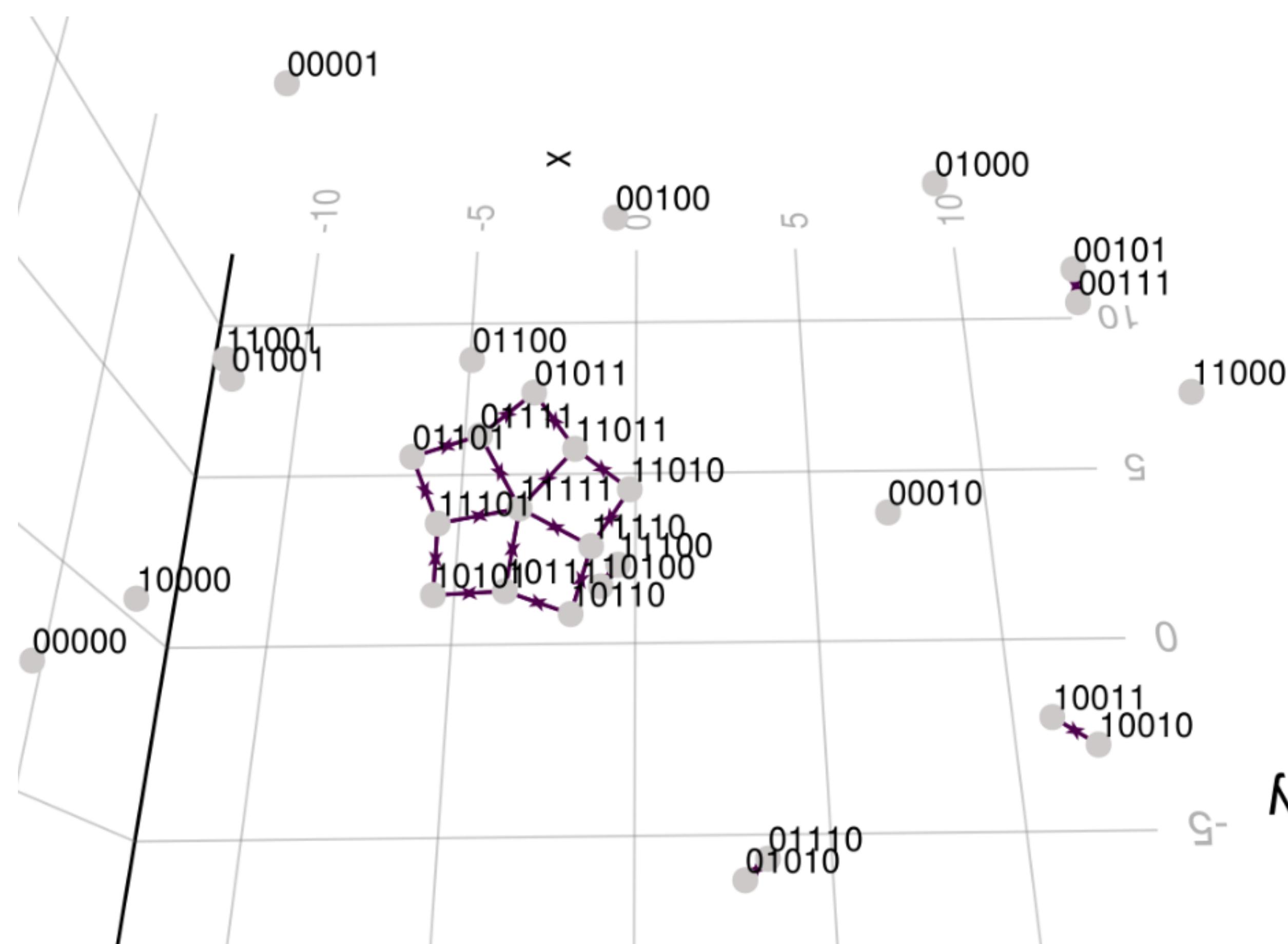
Rules 204, 51 are obvious and boring

E_9 rule 108

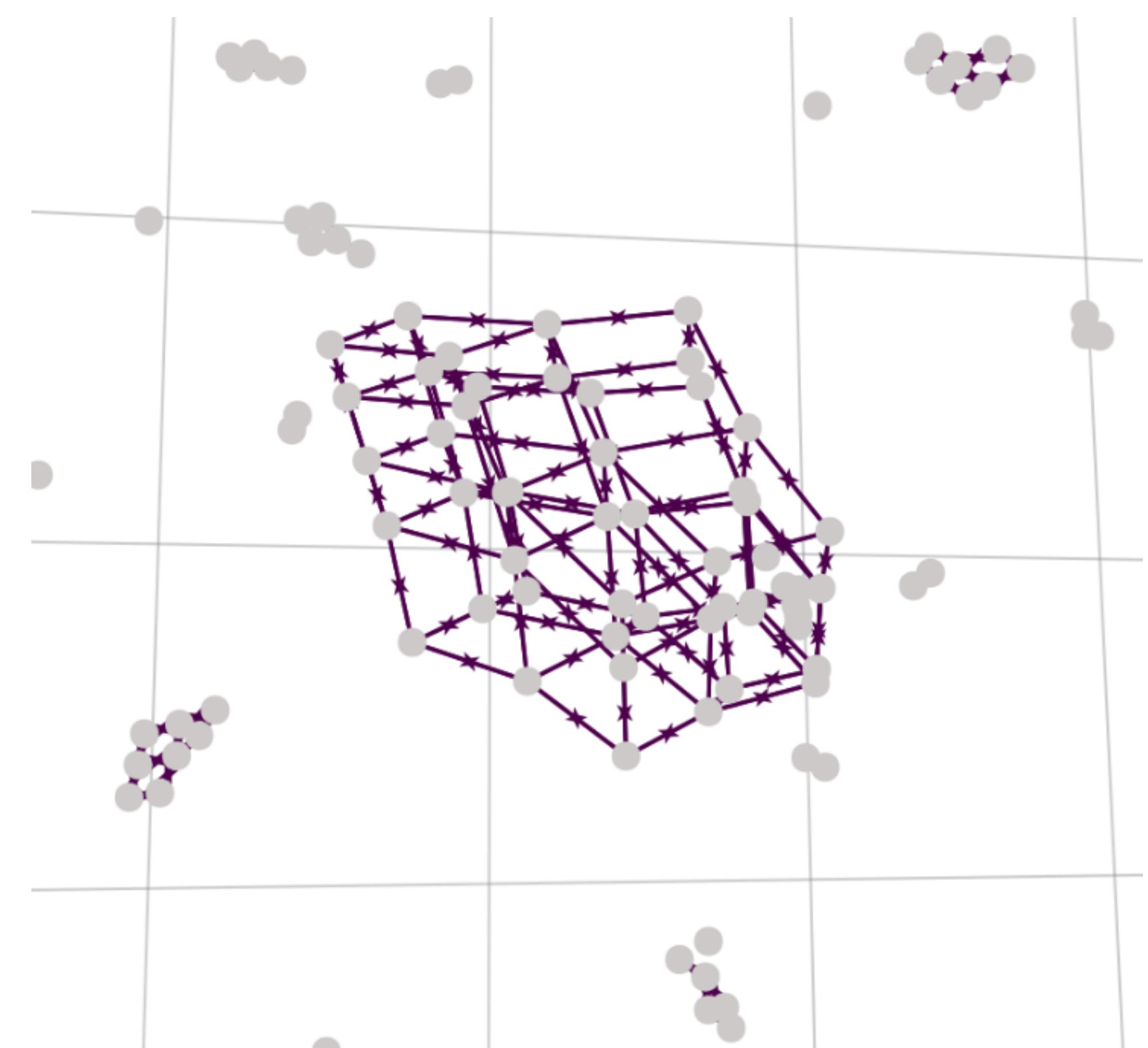
00 00
01 01

Creates complex structures around states with domains of 1s, in particular the all 1s state
otherwise all isolated states

$N=5$



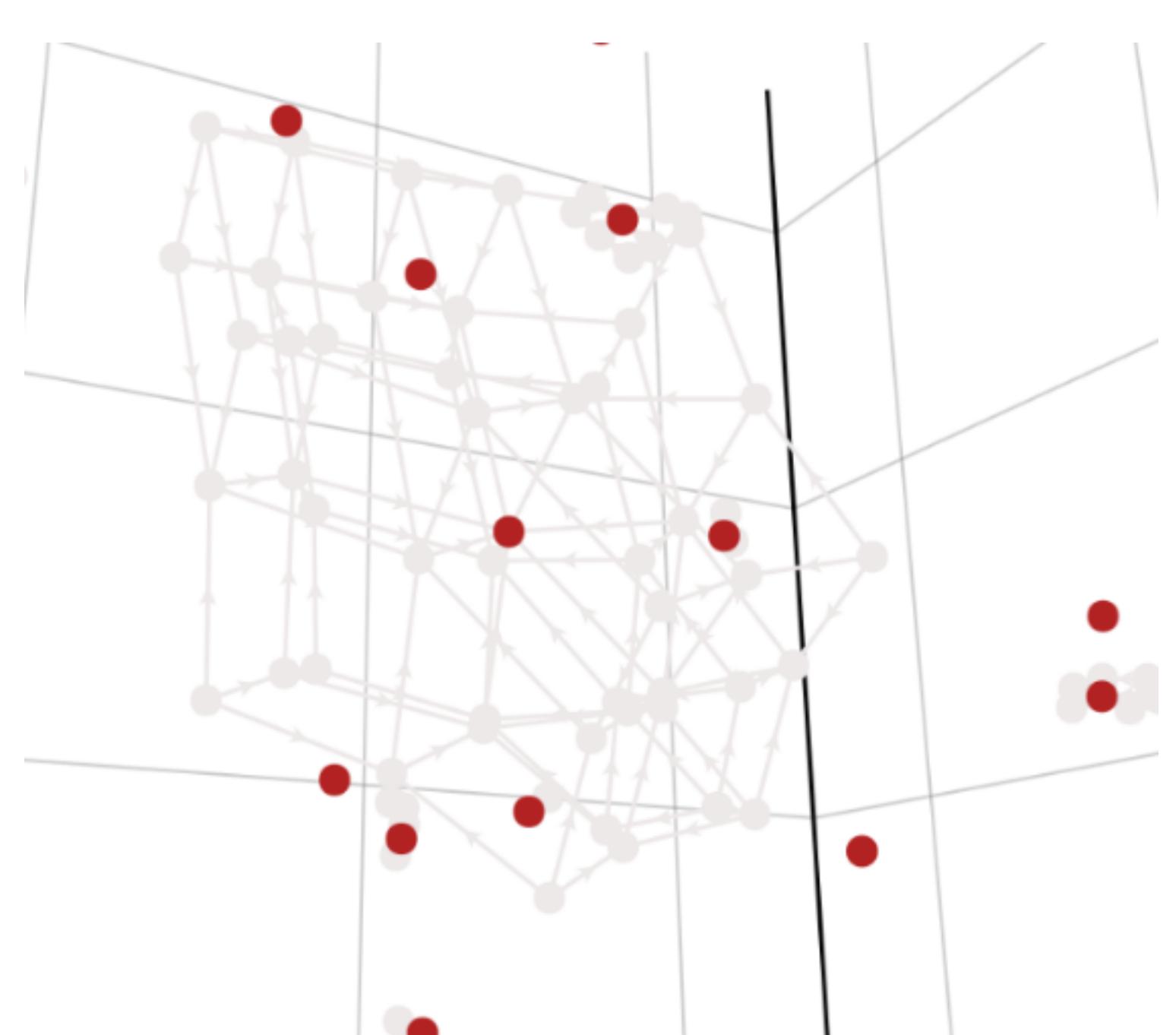
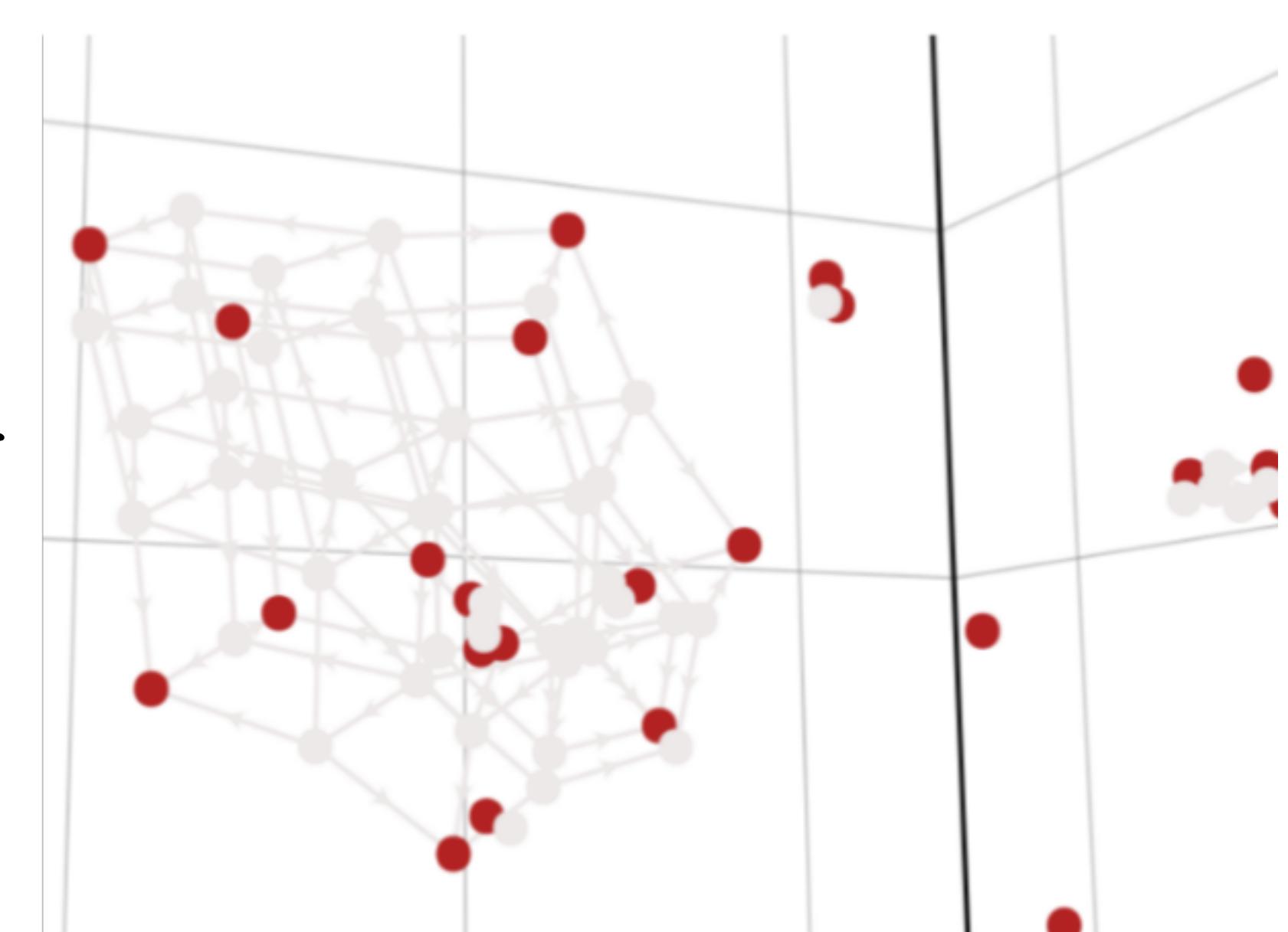
$N=8$



Non eq substrates

76 - domains of 1s can be irreversibly broken,
only single ACS, there are multiple
ACS around the edges of the structures

236 - domains can be completed but not
broken - every structure has 1
single ACS



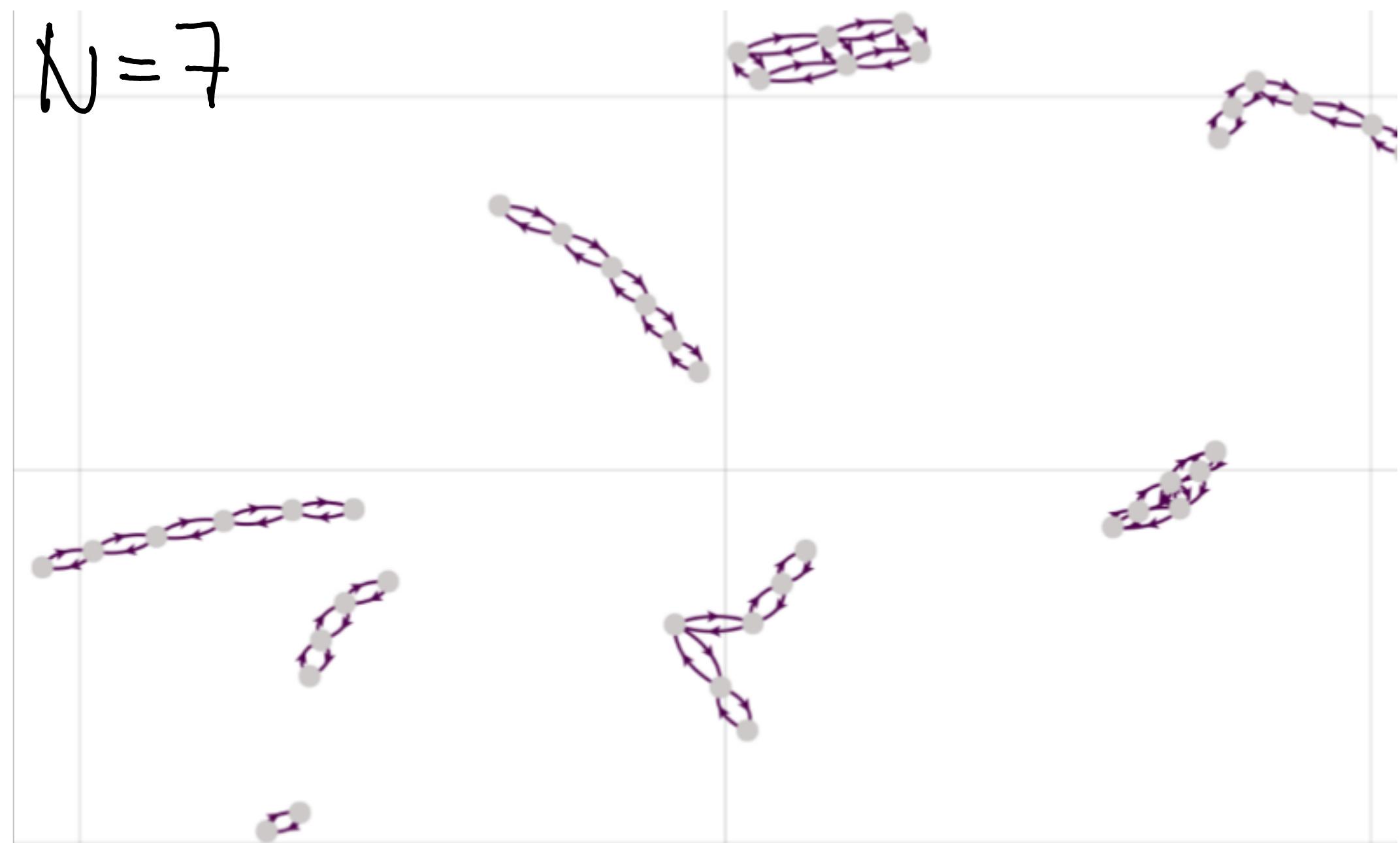
E₉ rule 156

00 00
10 10

Boundaries can grow/shrink on one side but not propagate?

We see many single state lines of states and at higher N
also their "cartesian products"

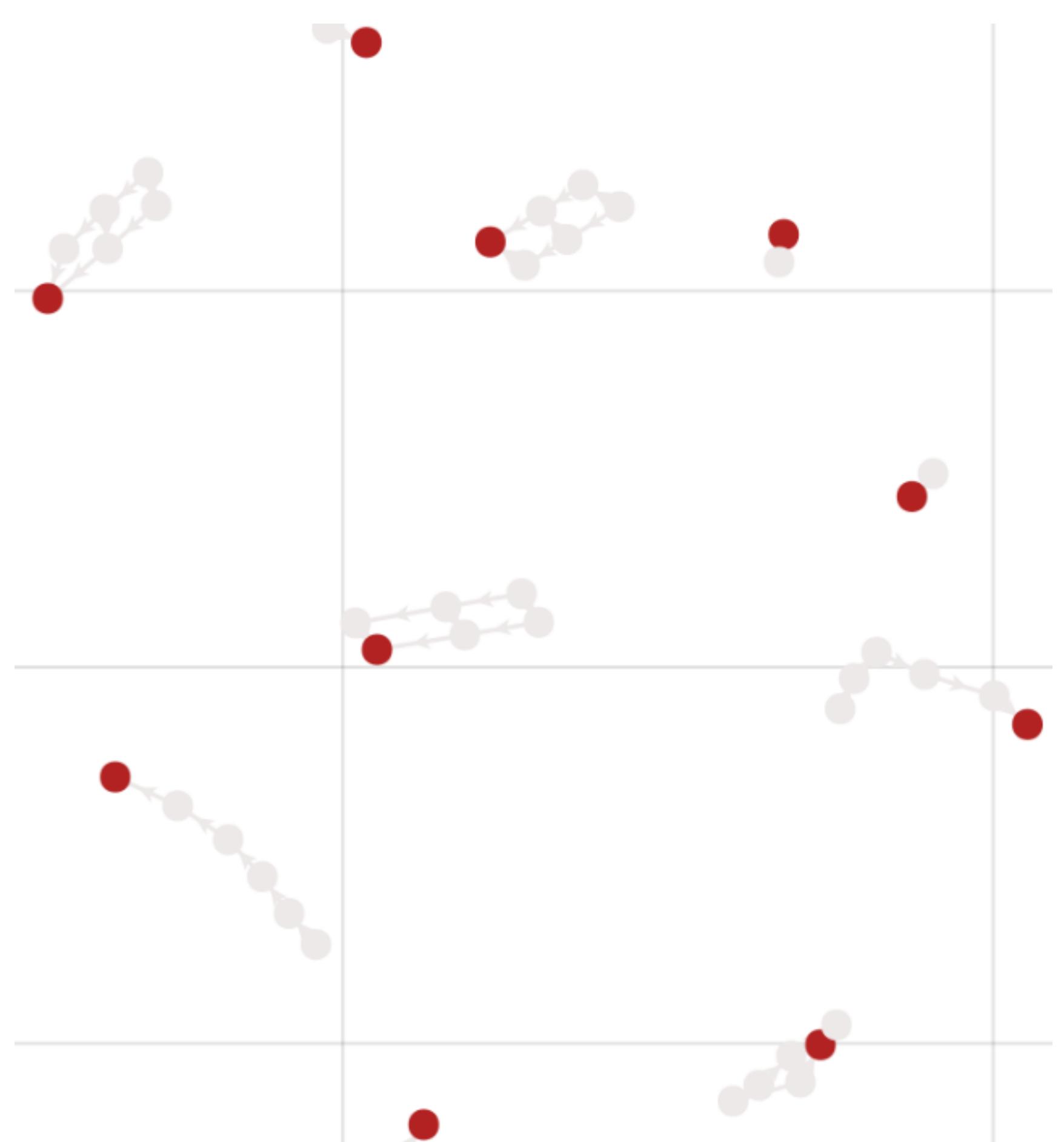
N=7



Only 1 substrate

140 - Biased towards one side, naturally

00 00
00 10
results in 1 single ac at the end
or side of each group



E_g rule 105

10 10
01 01

All domains can be seeded and completed and while they cannot move directly, we get a 2 step move by \vec{P}

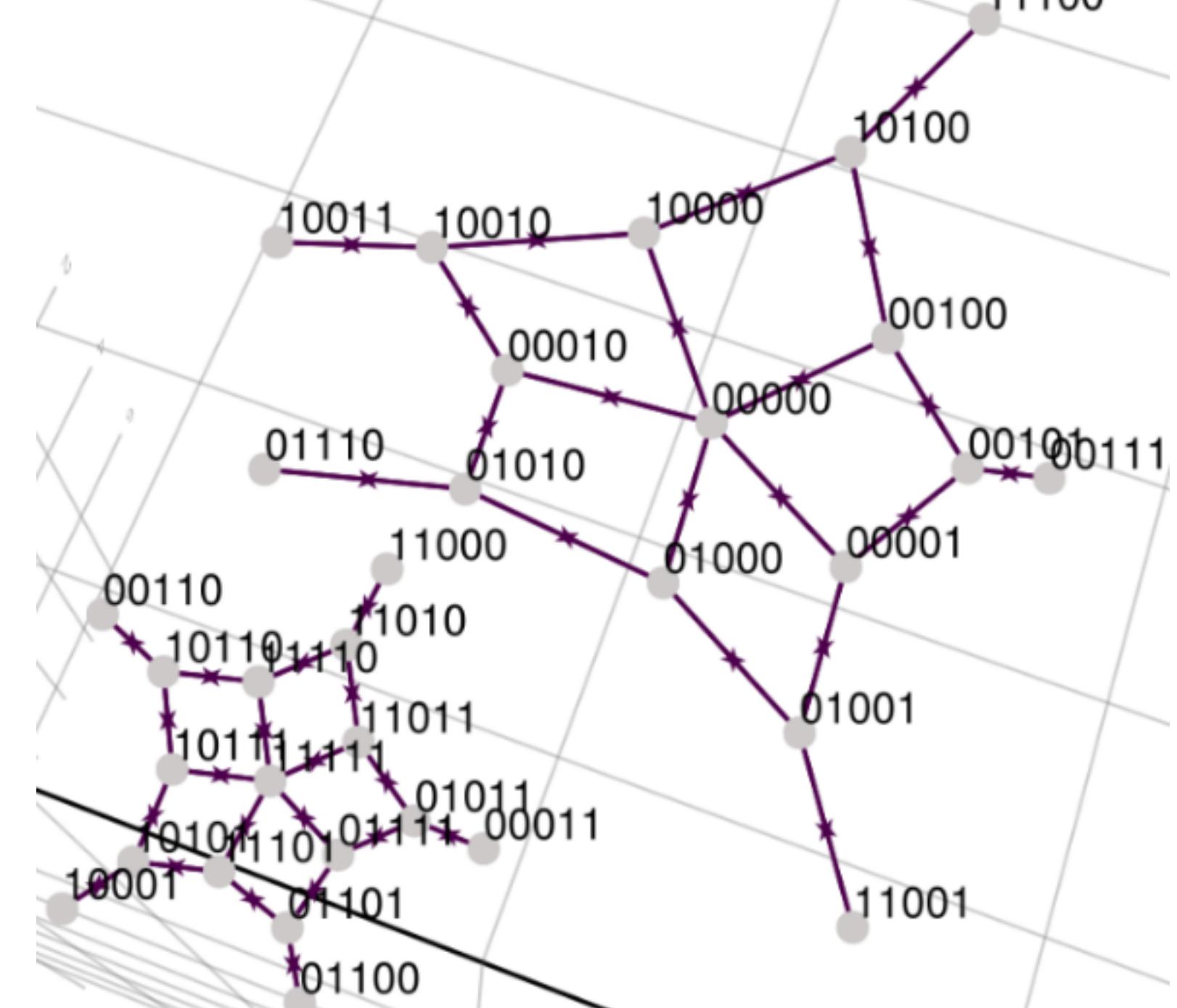
... 00011 ... \rightarrow ... 01011 ... \rightarrow ... 01111 ...

\vec{P}
0

Hence we get much more connections

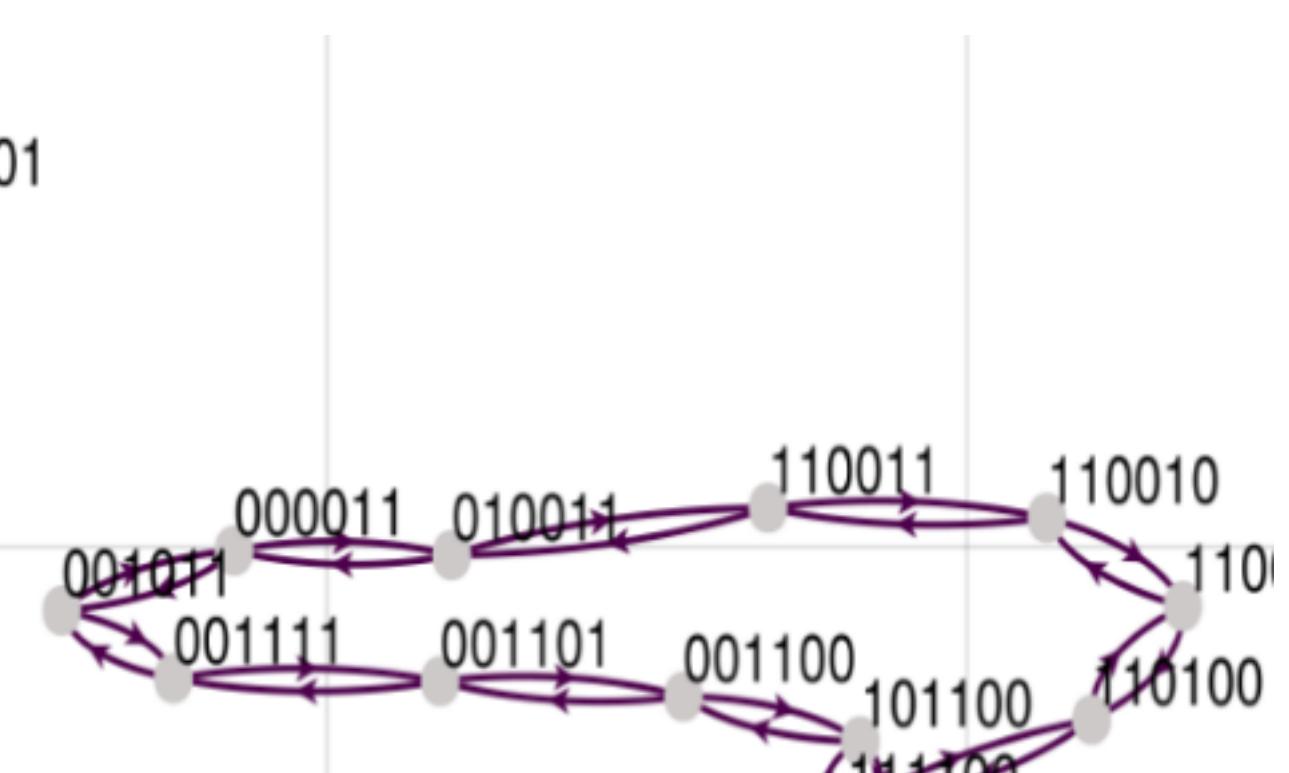
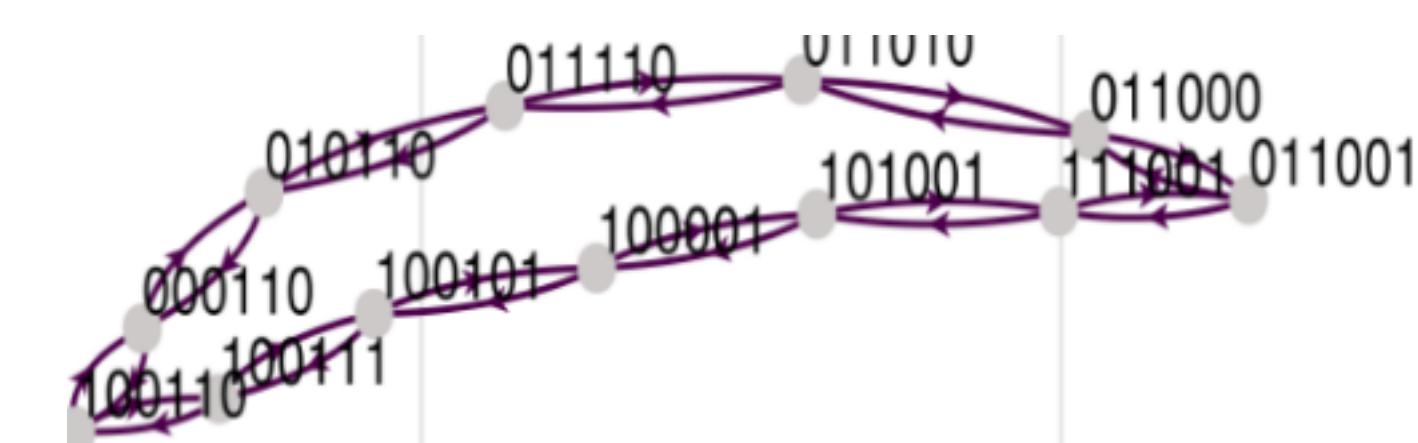
- $\boxed{0 \downarrow \downarrow N}$ we get 2 components one around all 0s and one around all 1s

(they are roughly plane-like)



- $\boxed{\text{Even } N}$ We get loops, all states are in loops besides $\overline{0011}$ which only happen in N divisible by 4

There is always one loop containing both all 0s and all 1s

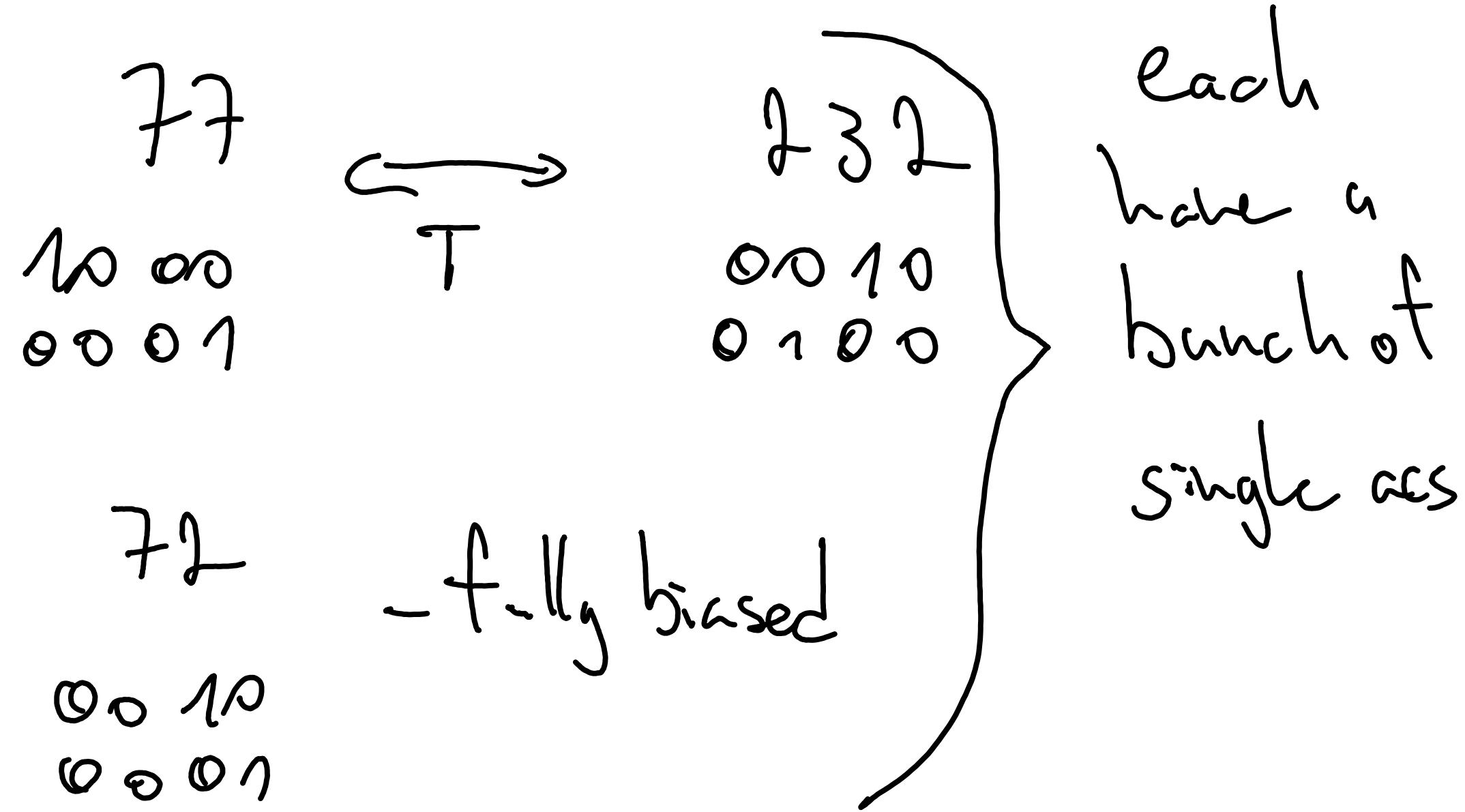


The rest seem to mostly rely on the 2 step propagation mechanism described above



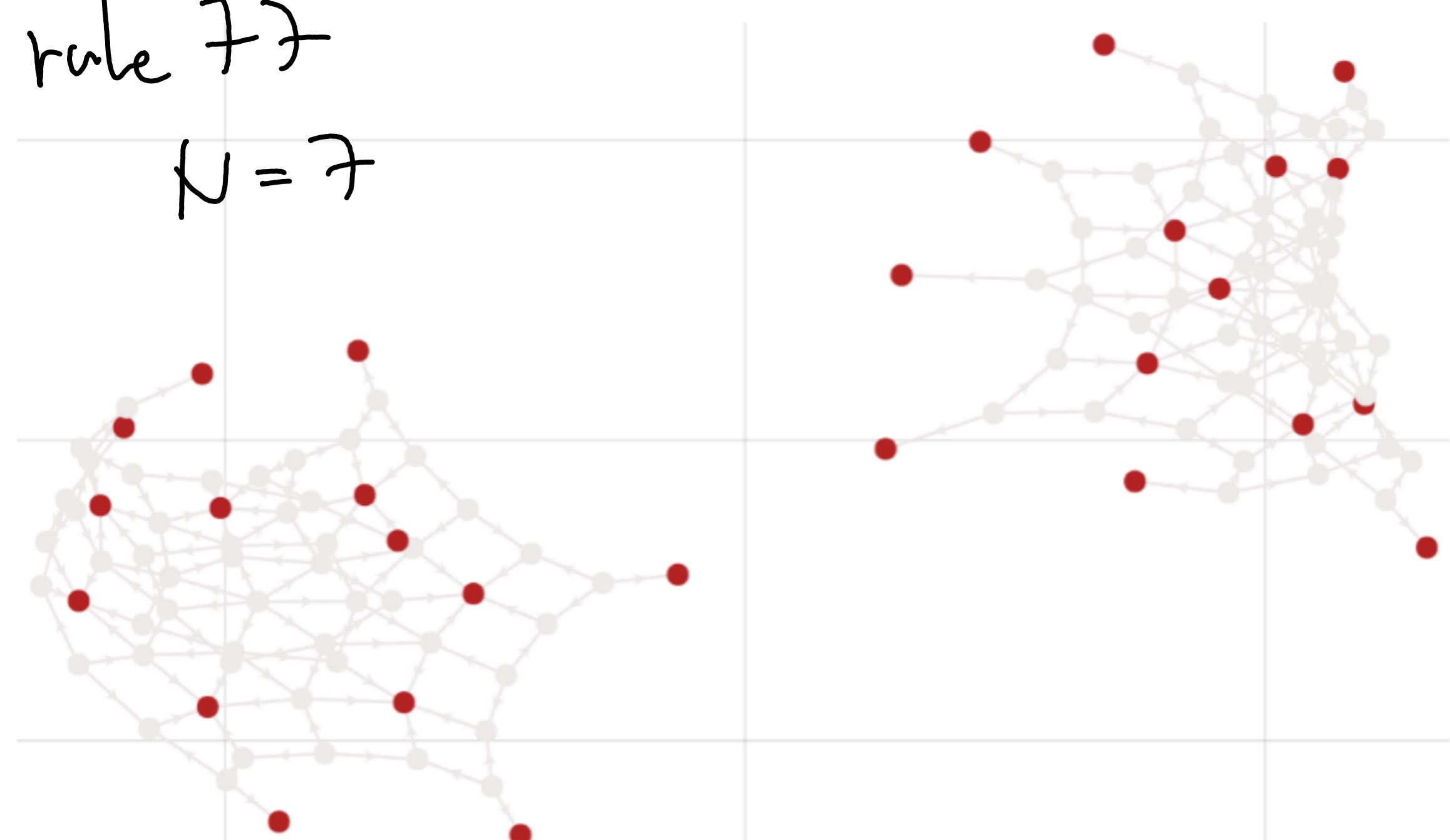
$N=6$
more complex but still [loop] begin

2 enzyme subunits

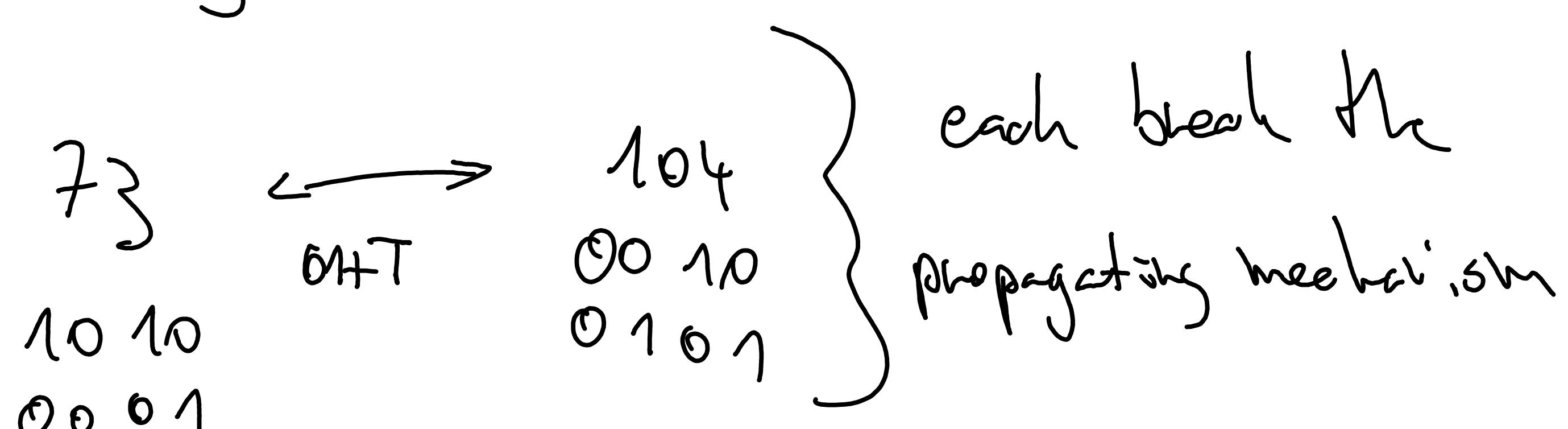


rule 77

$N = 7$

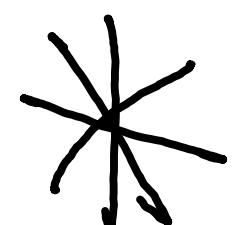


3 enzyme subunits

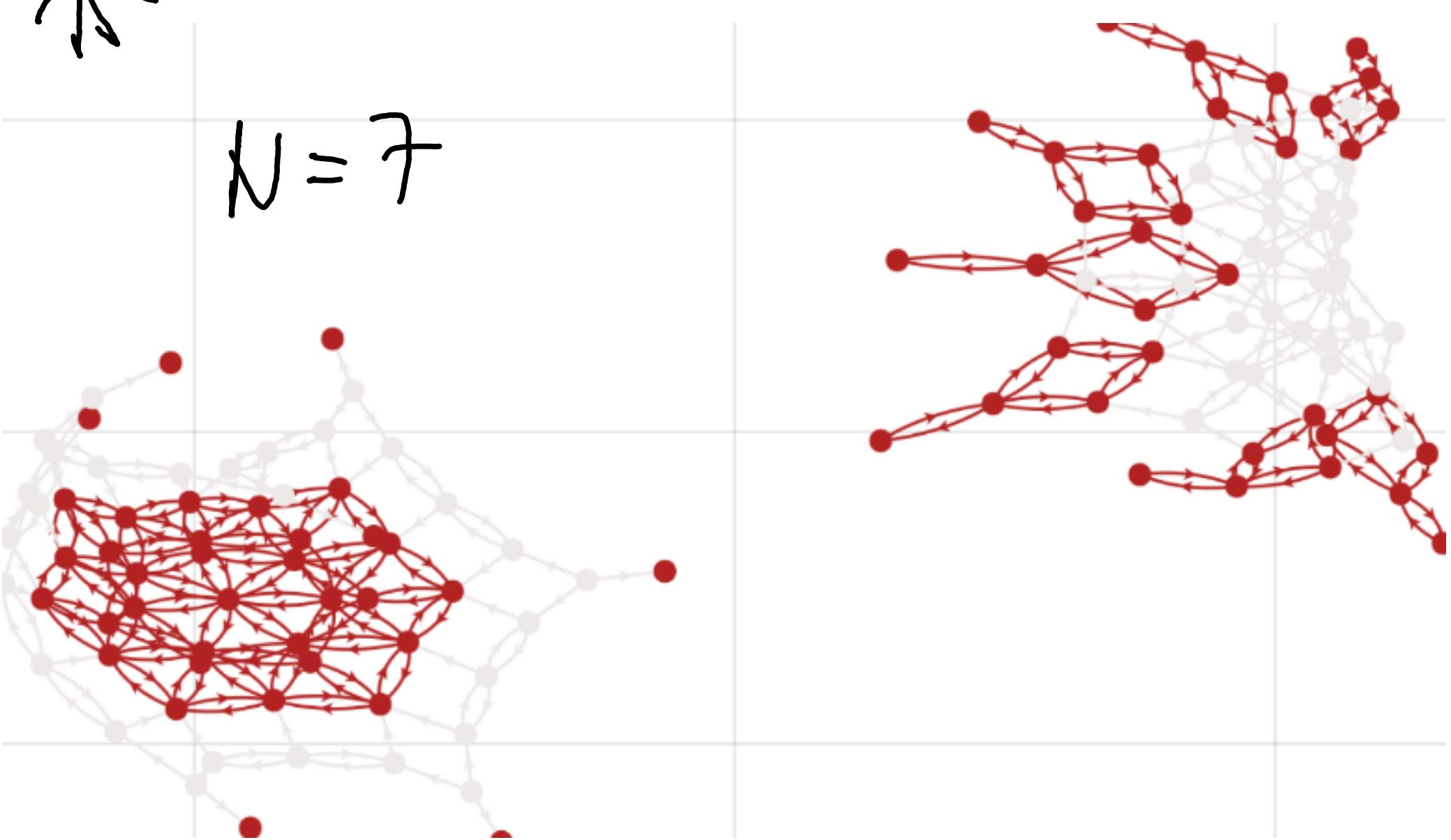


$\begin{matrix} 104 \\ 00\ 10 \\ 01\ 01 \end{matrix}$ - cannot seed 1s and hence gets stuck at either all 0s or products of ...0110...

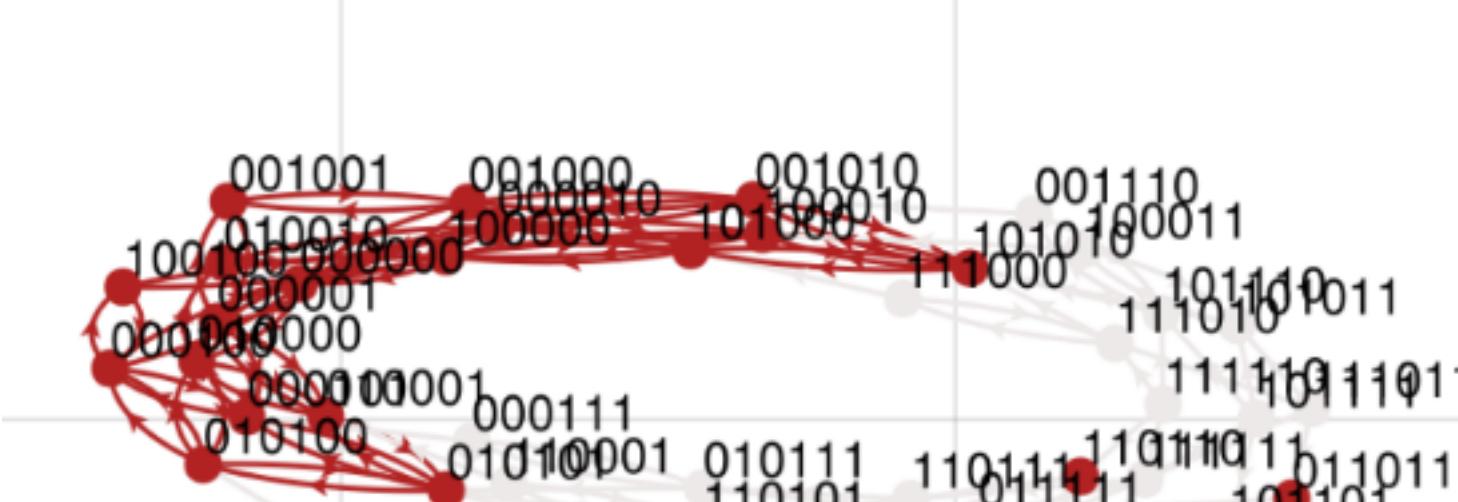
$\begin{matrix} 73 \\ 10\ 10 \\ 00\ 01 \end{matrix}$ - cannot complete 1s but has non-single diffusive ACS!



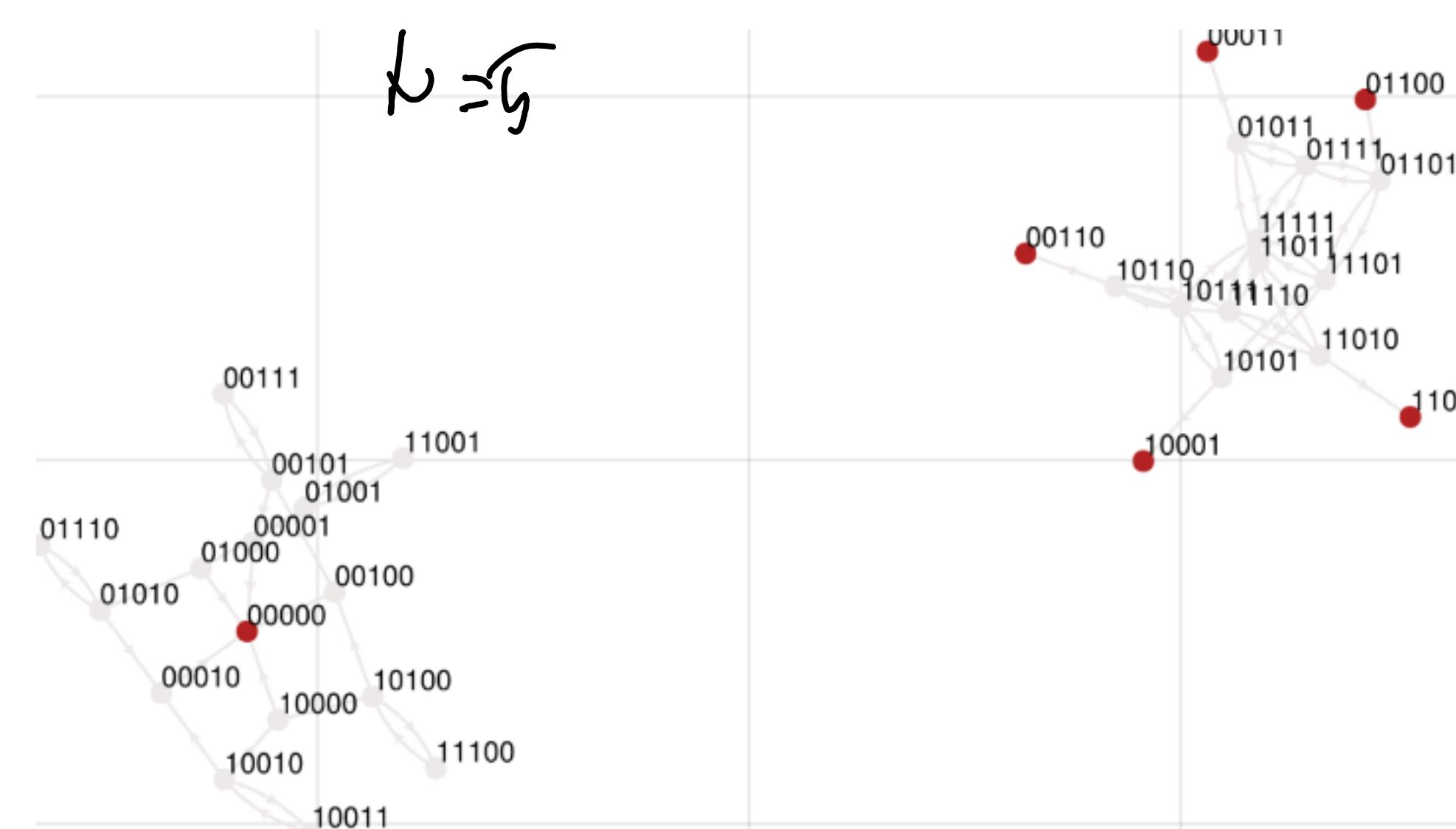
$N = 7$



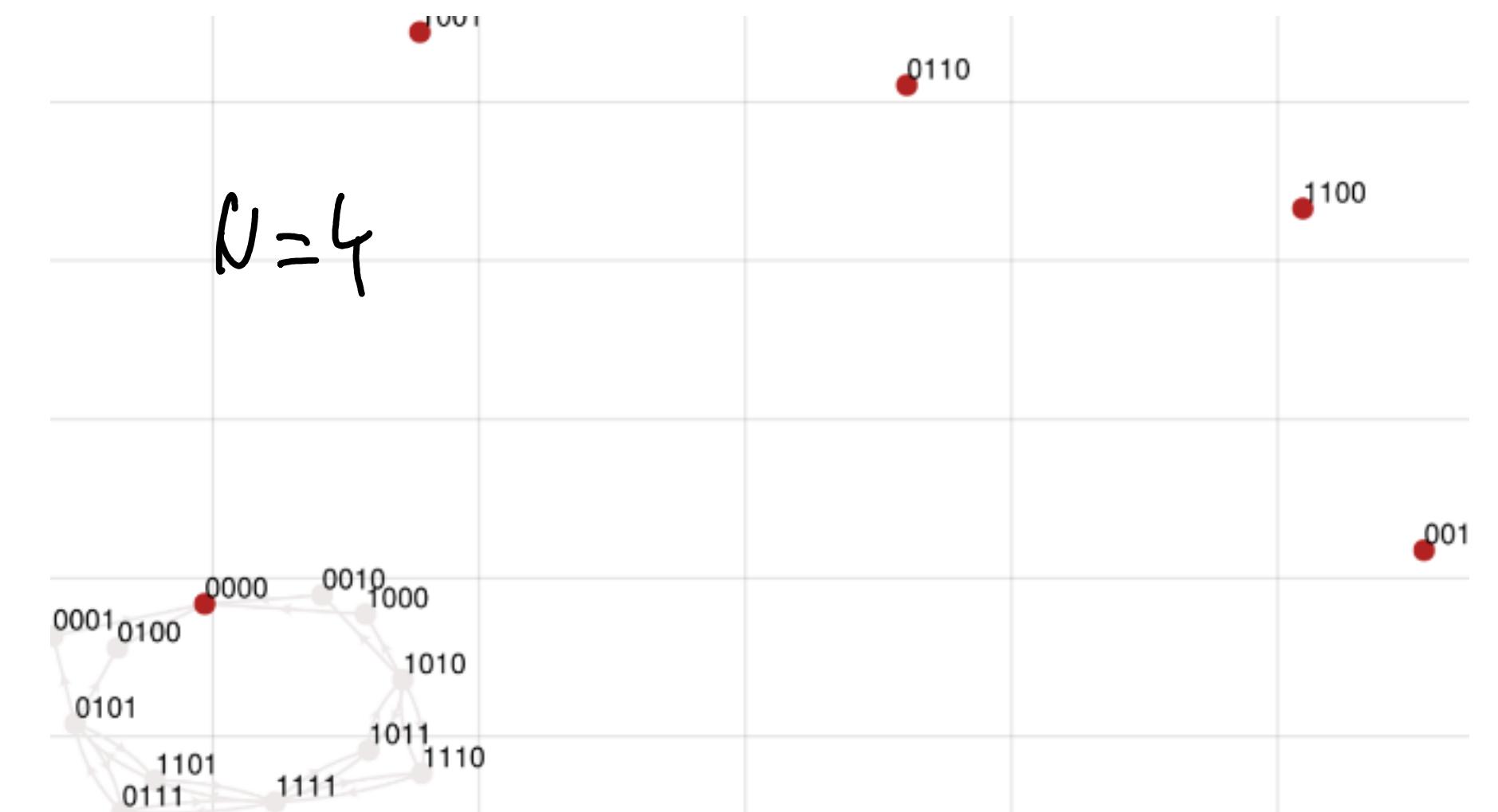
$N = 6$



$N \leq 5$



$N = 4$



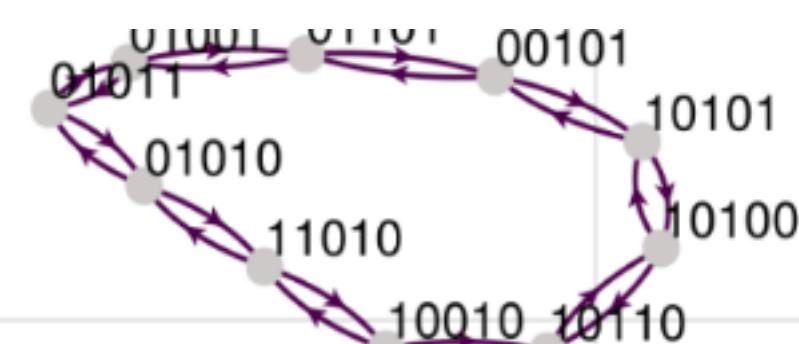
Eq rule 150

01 01
10 10

all boundaries can move both ways but
no seeding/completion

"canonical" loops where a wave moves around
gets isolated all 0s and all 1s and also alternating if they exist
most loops branch but if N is odd there's always
1 single state loop

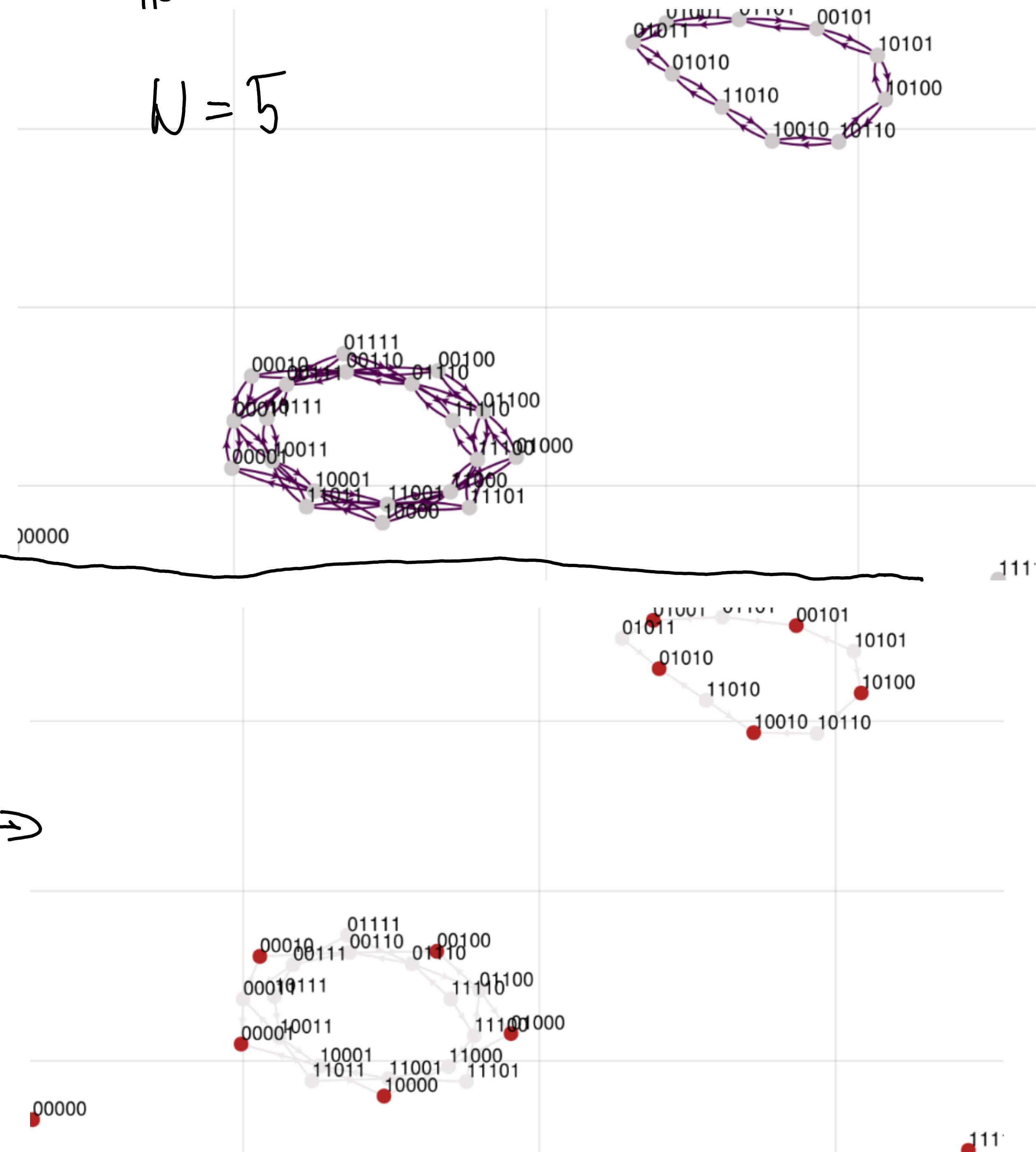
$N = 5$



Lengigne subrules

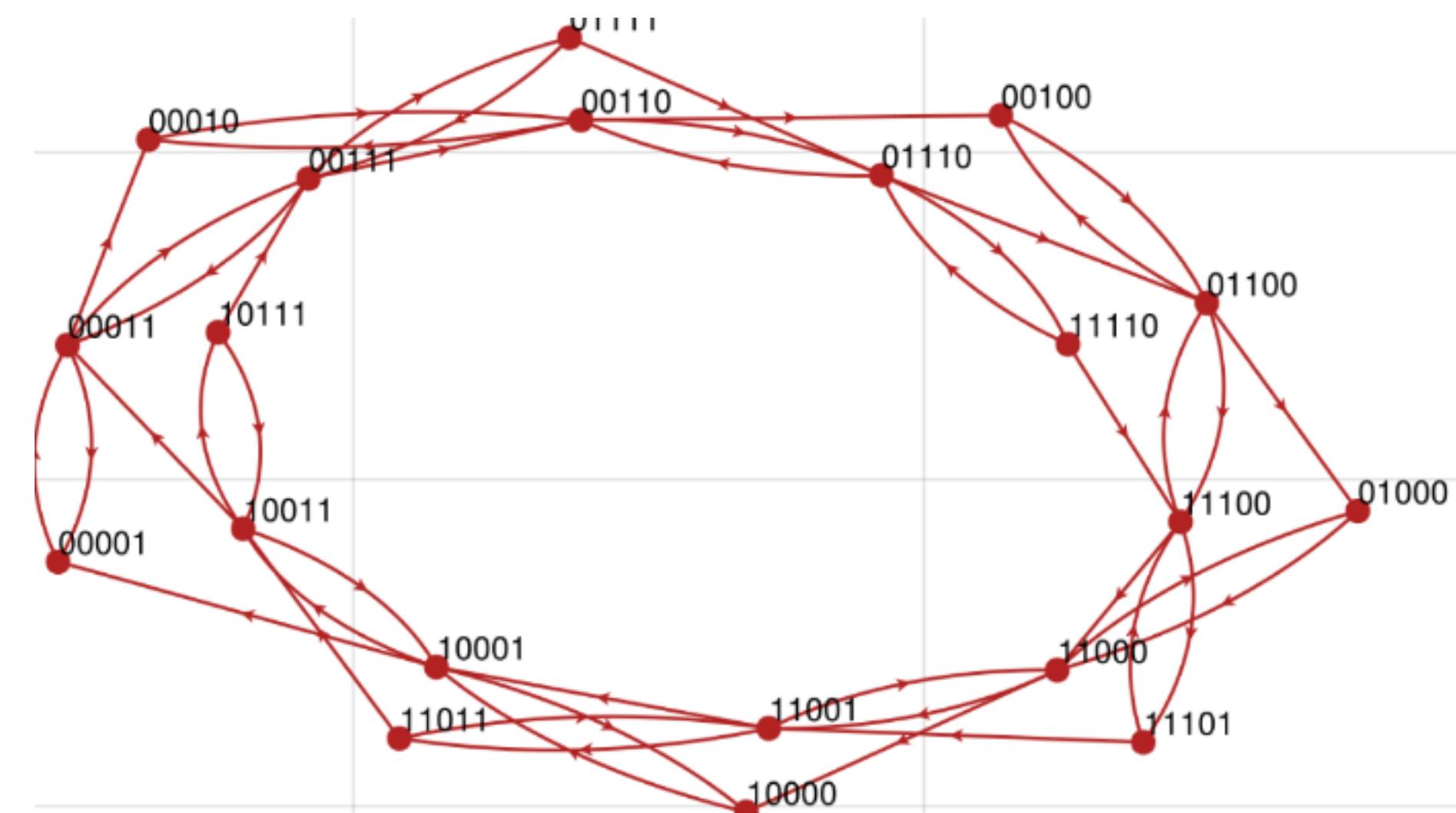
142 - directed moving
wave of all arrows
directed

137 - breaks apart the
acs into single states! →
00 01
00 10



3engigne subrules

134 - partially directed loops,
every other arrow is
directed, works even
for branched loops

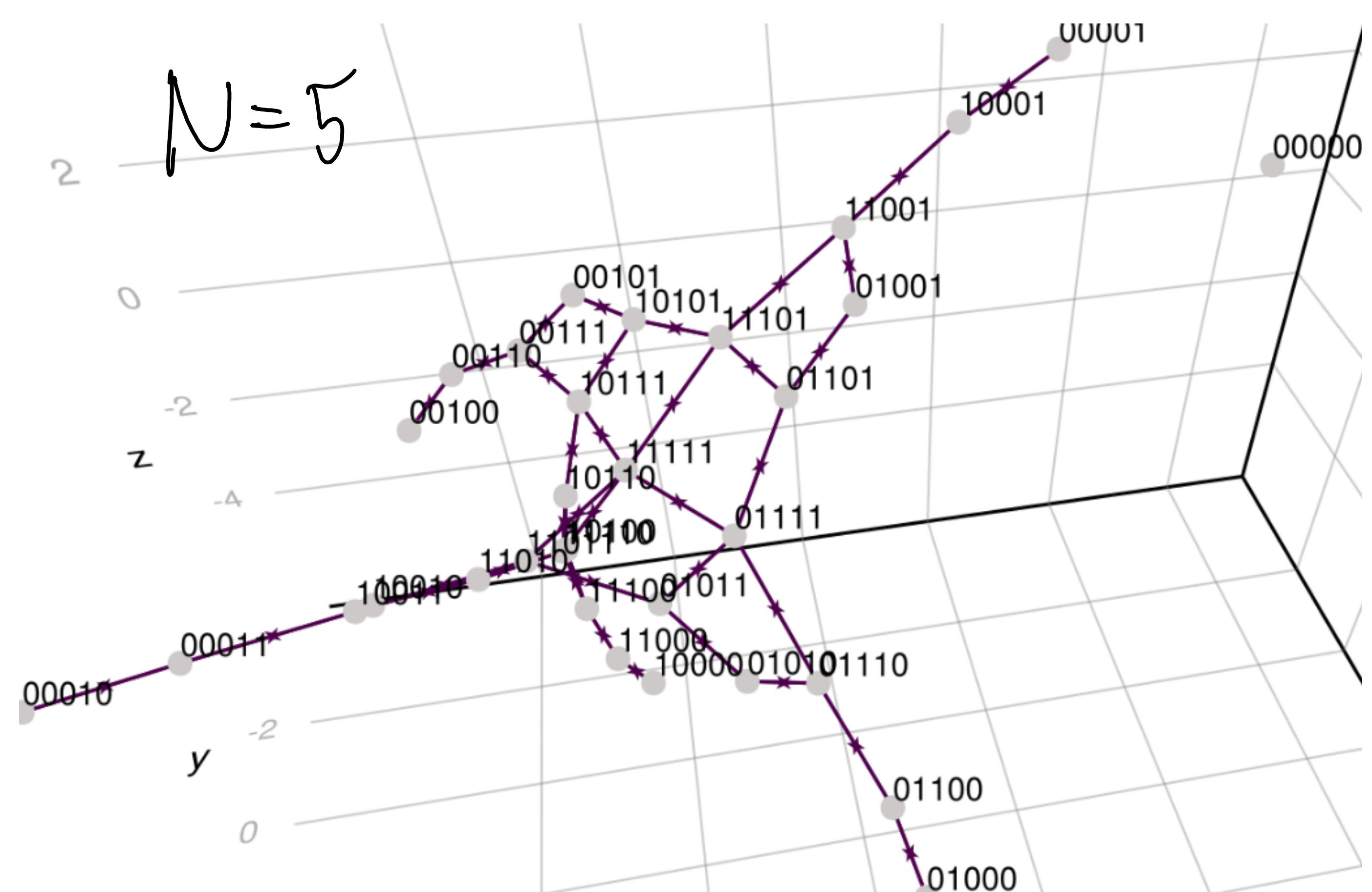


Eq rule 60

Forms "nets" expanding from all 1s (all 0s is isolated)

00 00
11 11

the net having distinct "tips" each ending
in a state with one isolated 1



Lengme subrules

12 \leftrightarrow 252
00 00 T 00 00
00 11 11 00

strongly biased, all single acs

252 only acs are all 1s and all 0s

12 acs are interspersed and include network tips

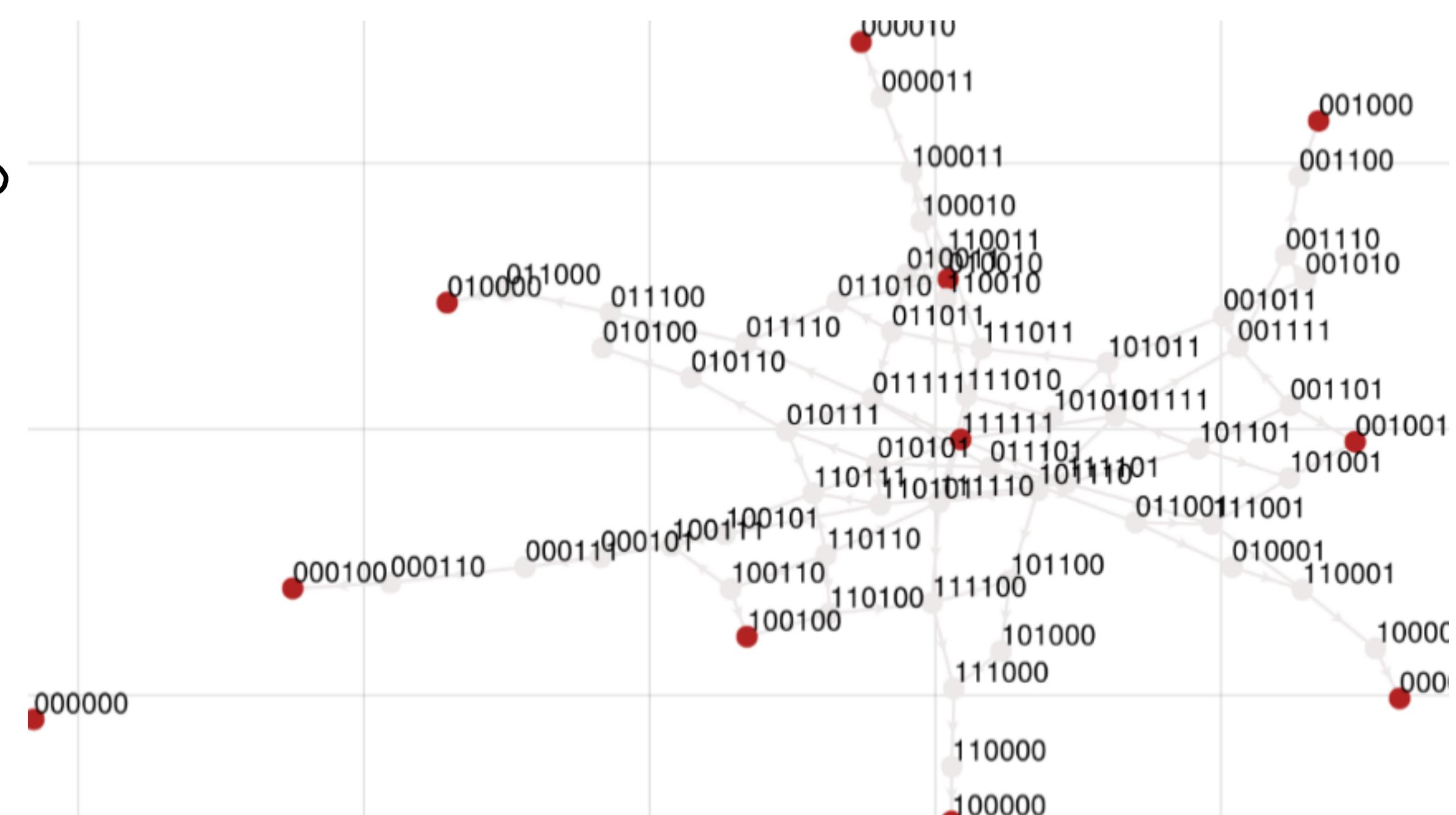
172 \leftrightarrow 92
00 00 T 00 00
01 10 10 01

also only single acs

92 interspersed close to middle

172 always all 0s, all 1s and tips

N = 6

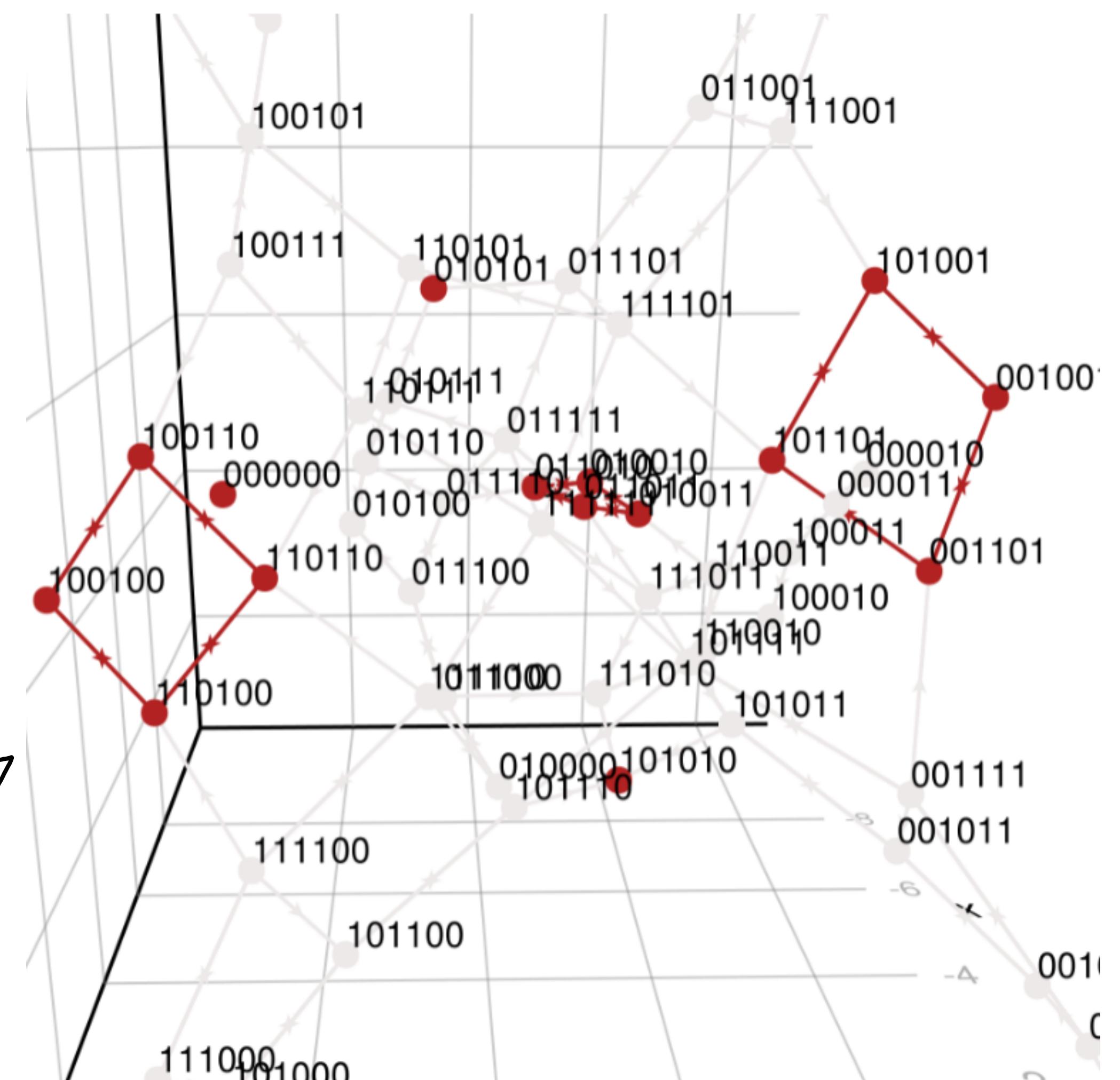


3rd regime subhalos

188 - all 1s and all 0s only
 $\begin{matrix} 00 & 00 \\ 11 & 10 \end{matrix}$
 the accs

$\downarrow T$

28 - has many small diffusive
 $\begin{matrix} 00 & 00 \\ 10 & 11 \end{matrix}$
 non-single accs due to
 a 1100 boundary shifting
 back and forth

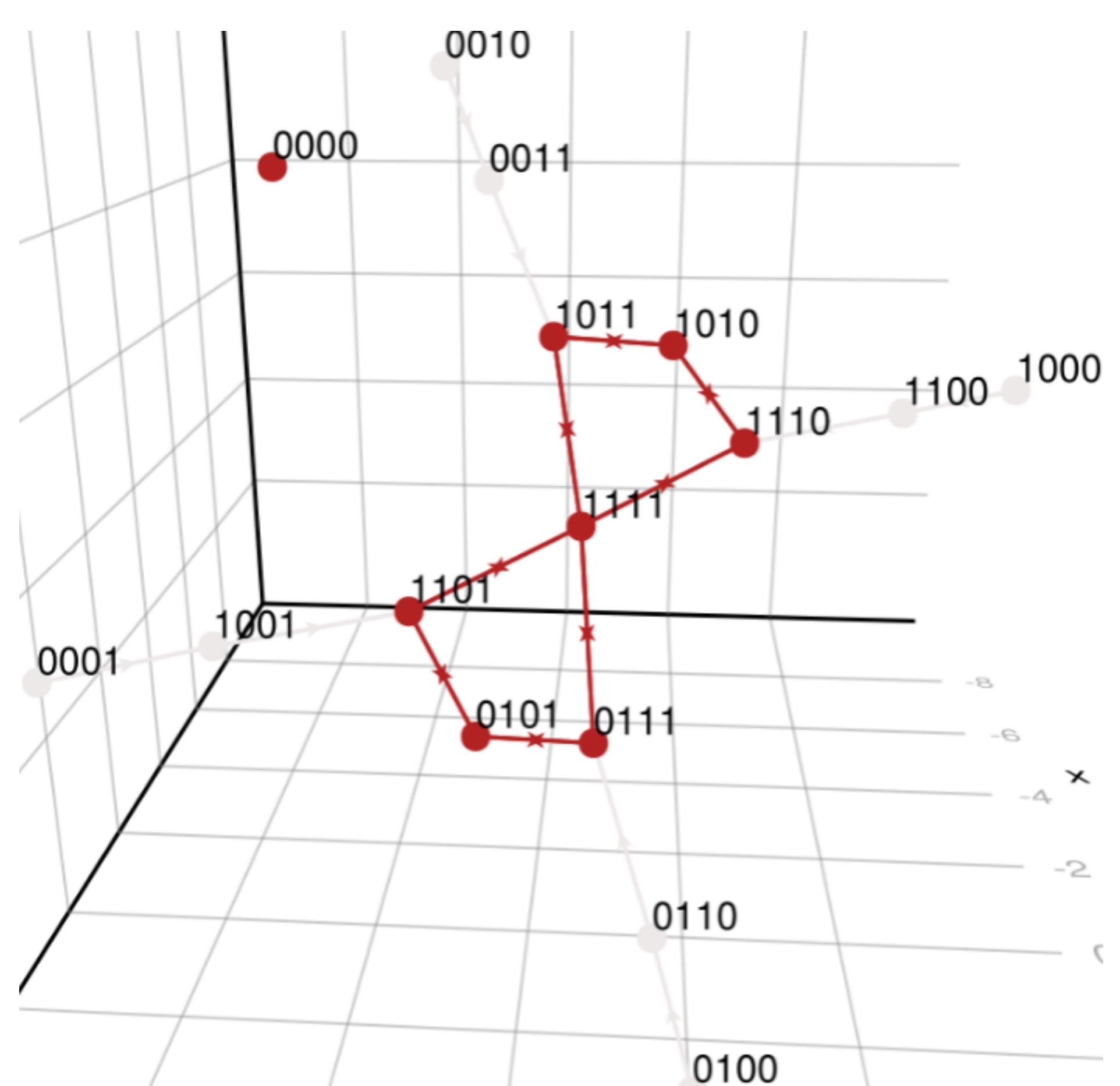
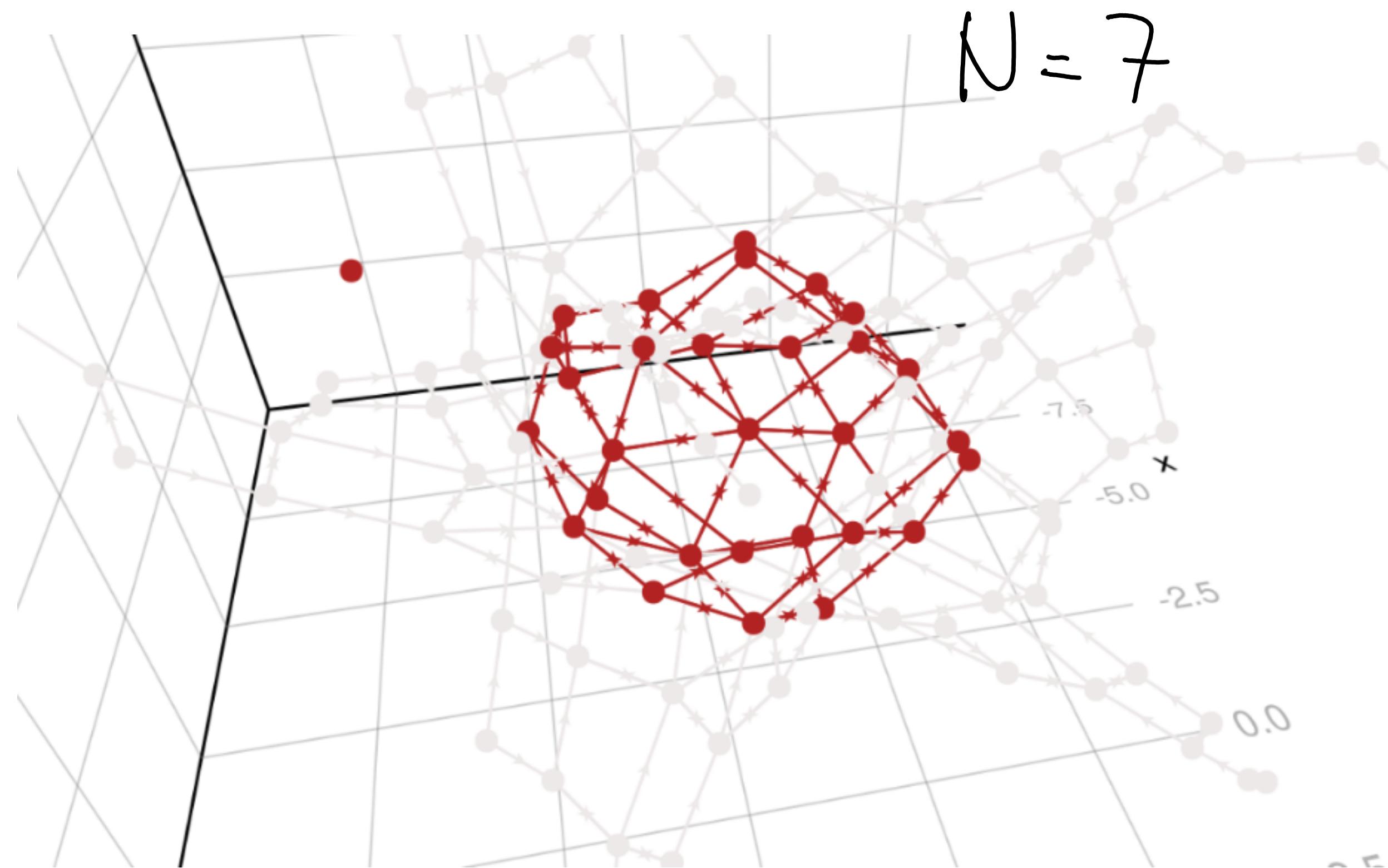


44 - bunch of single accs
 $\begin{matrix} 00 & 00 \\ 01 & 11 \end{matrix}$
 including the vert tips

\downarrow

124 - has a diffusive lensing
 $\begin{matrix} 00 & 00 \\ 11 & 01 \end{matrix}$
 ac around all 1s

$N = 7$

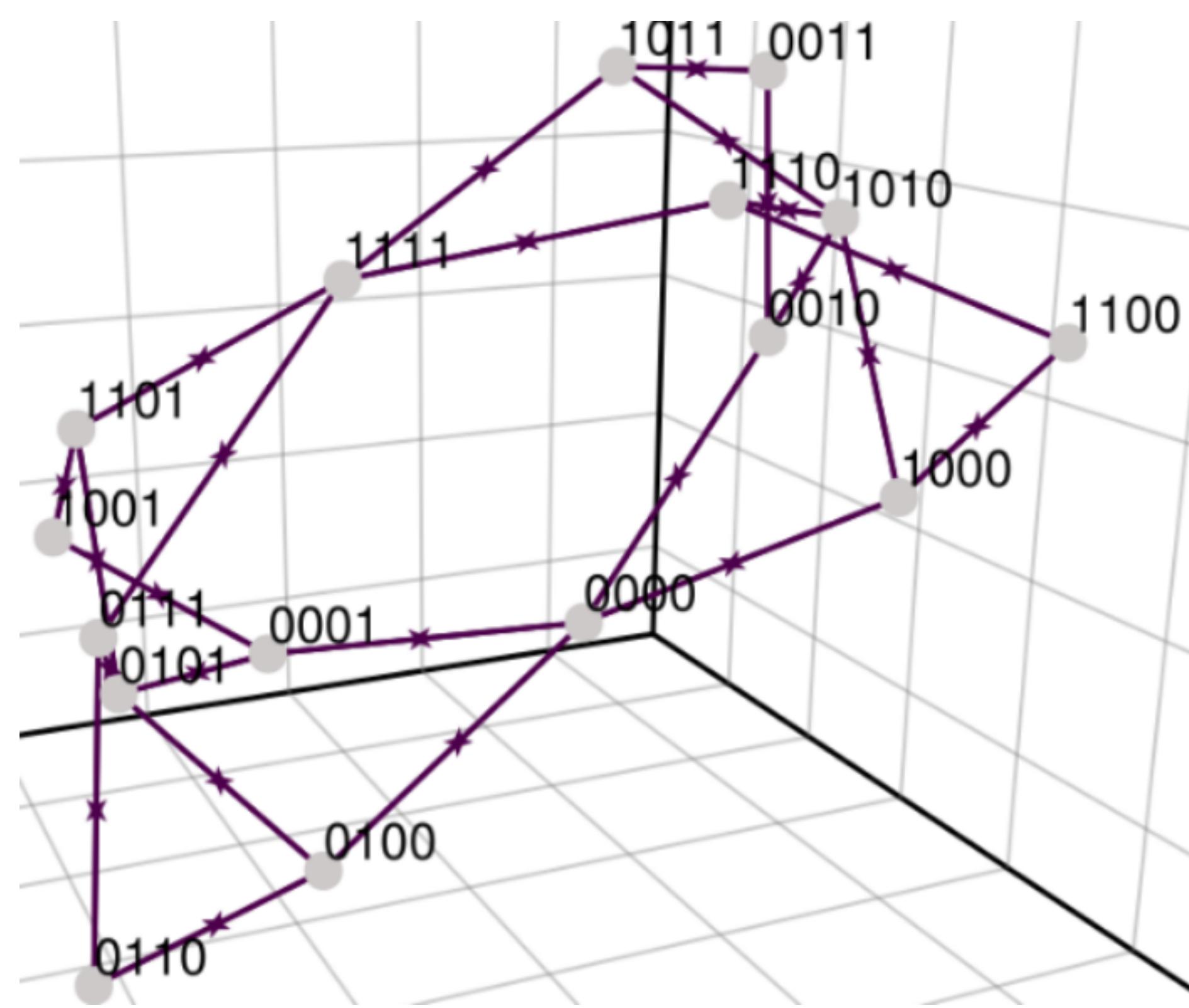


E_9 rule 57

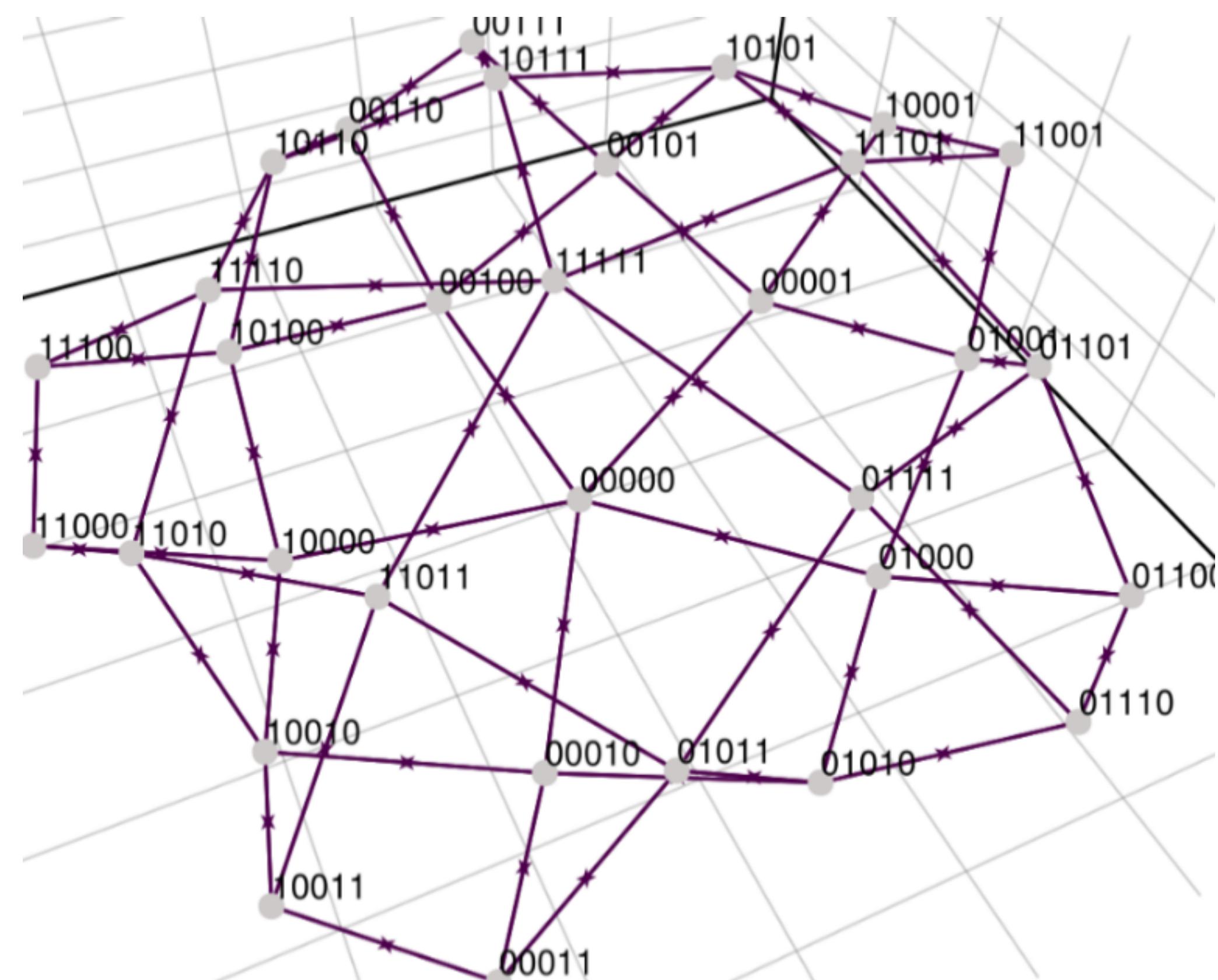
$\begin{smallmatrix} 10 & 10 \\ 11 & 11 \end{smallmatrix}$ - everything but moving a ..0011.. boundary

Forms very pretty symmetrical structures with all 0s and all 1s "opposite"

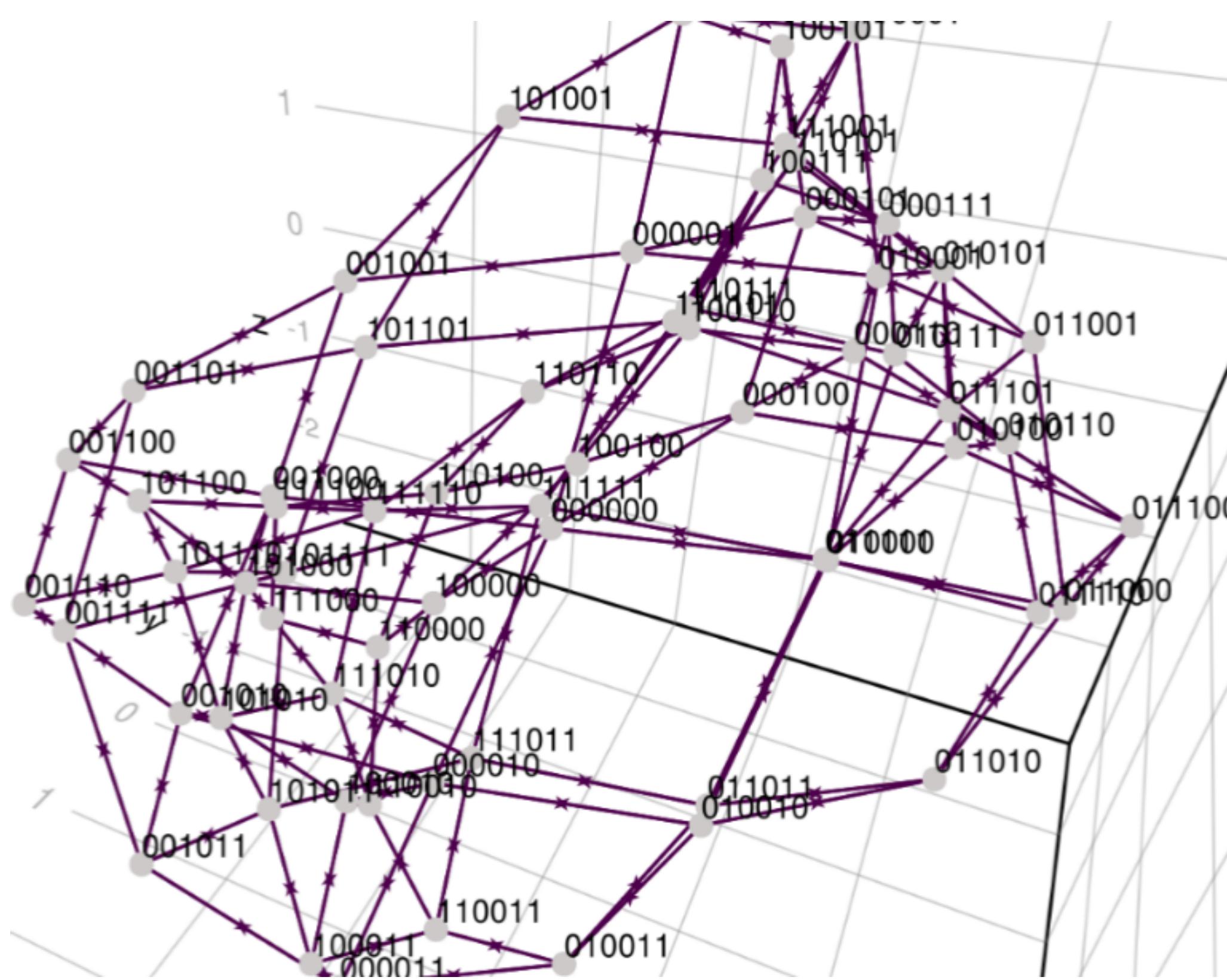
$n=4$



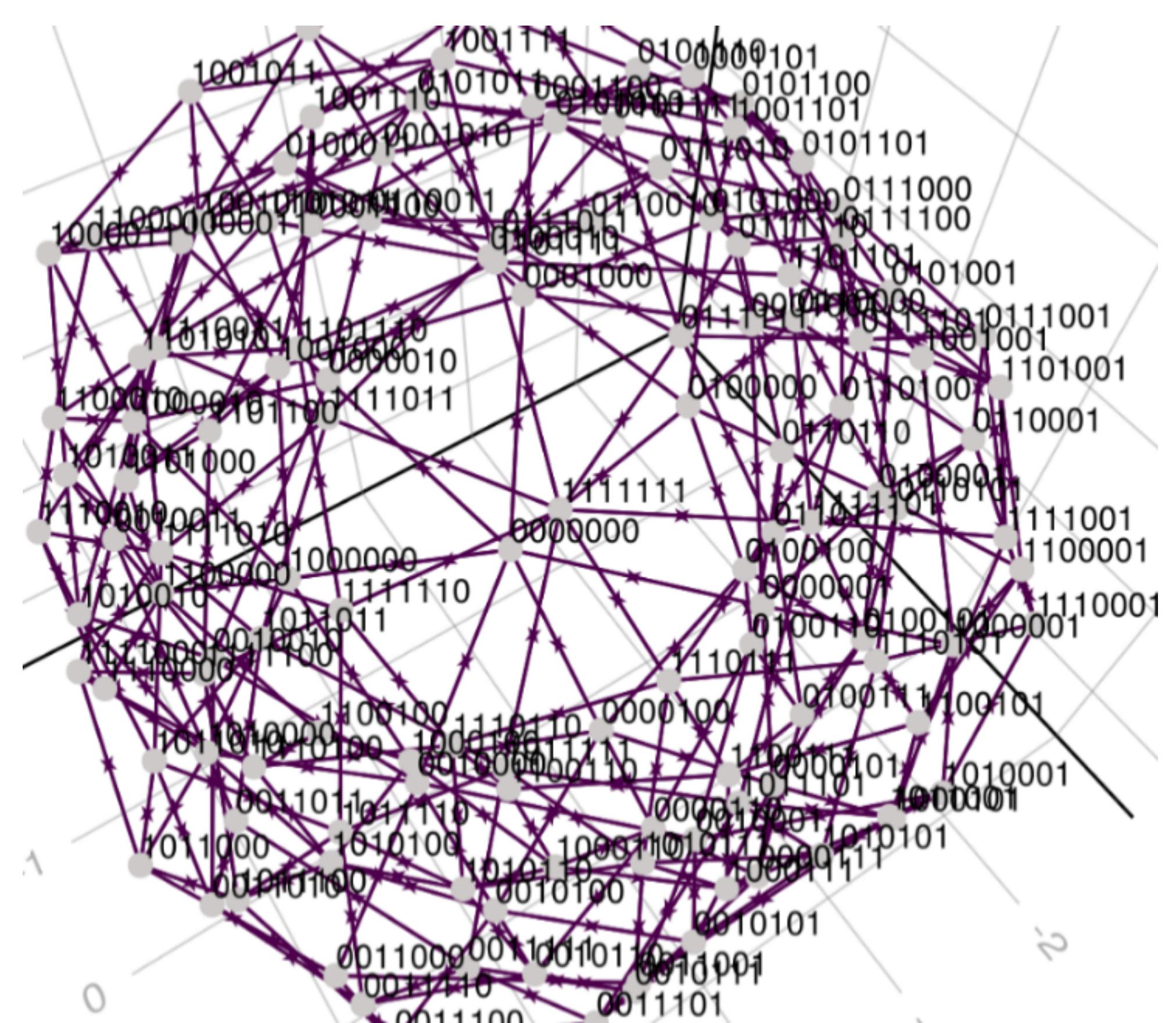
$N=5$



$N=6$

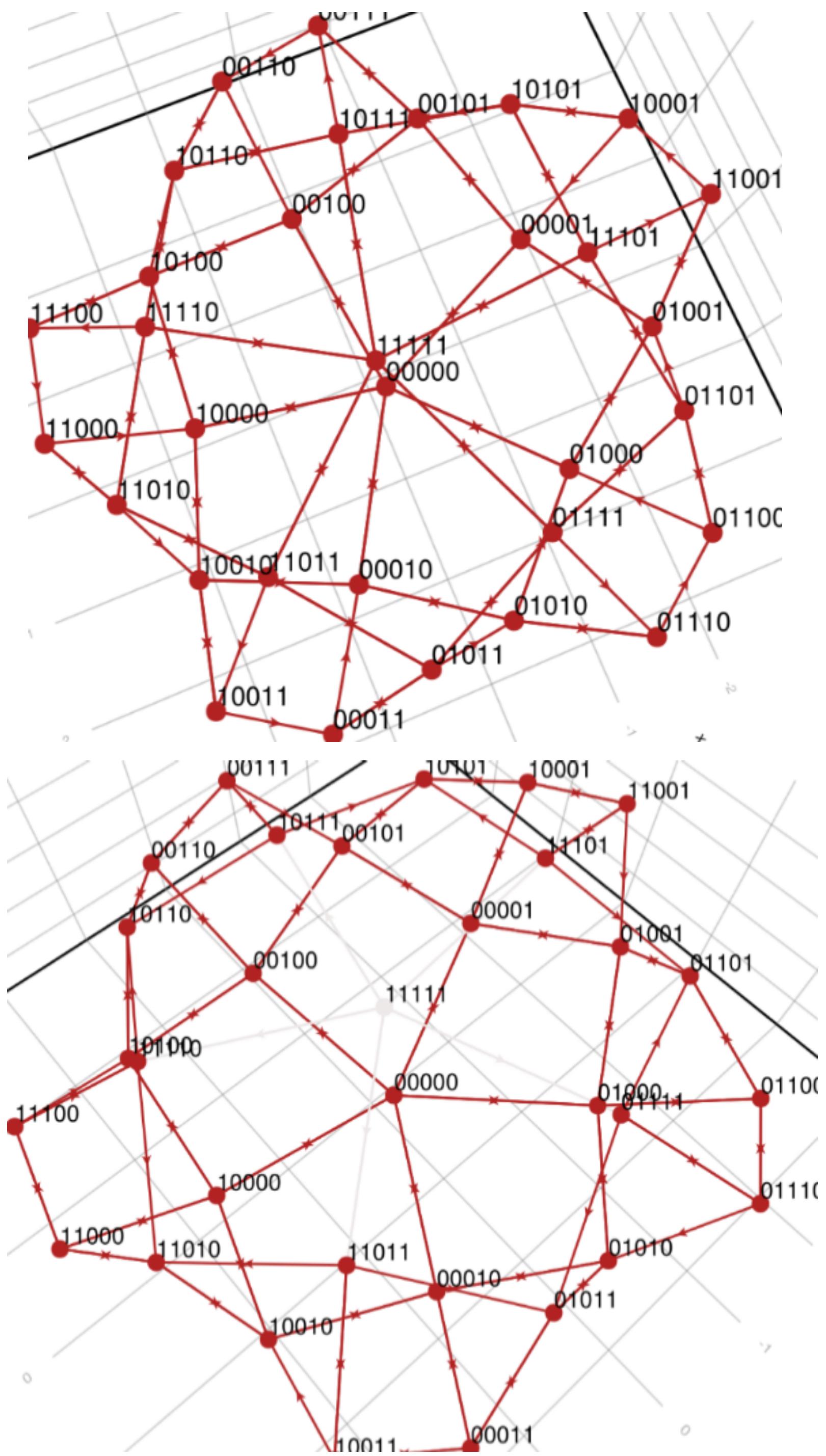


$N=8$



5 enzyme subunits

41 - biased towards all 0s
 $\begin{matrix} 1 & 0 \\ 1 & 1 \end{matrix}$ (as 0 domains cannot shrink)
 $\begin{matrix} 0 & 1 \\ 1 & 1 \end{matrix}$ but remains a single large ac



56 - makes all 0s inescapable

$\begin{matrix} 0 & 0 \\ 1 & 0 \end{matrix}$ all 0s is only ac

$\begin{matrix} 1 & 1 \\ 1 & 1 \end{matrix}$

$$\downarrow T + 01 + LR$$

25 - somewhat similar to 41, has 1 ac but there are some directed arrows, this time toward all 1s which cannot be reached



3 enzyme subunits

B - all 0s only ac

$\begin{matrix} 0 & 0 \\ 0 & 1 \end{matrix}$

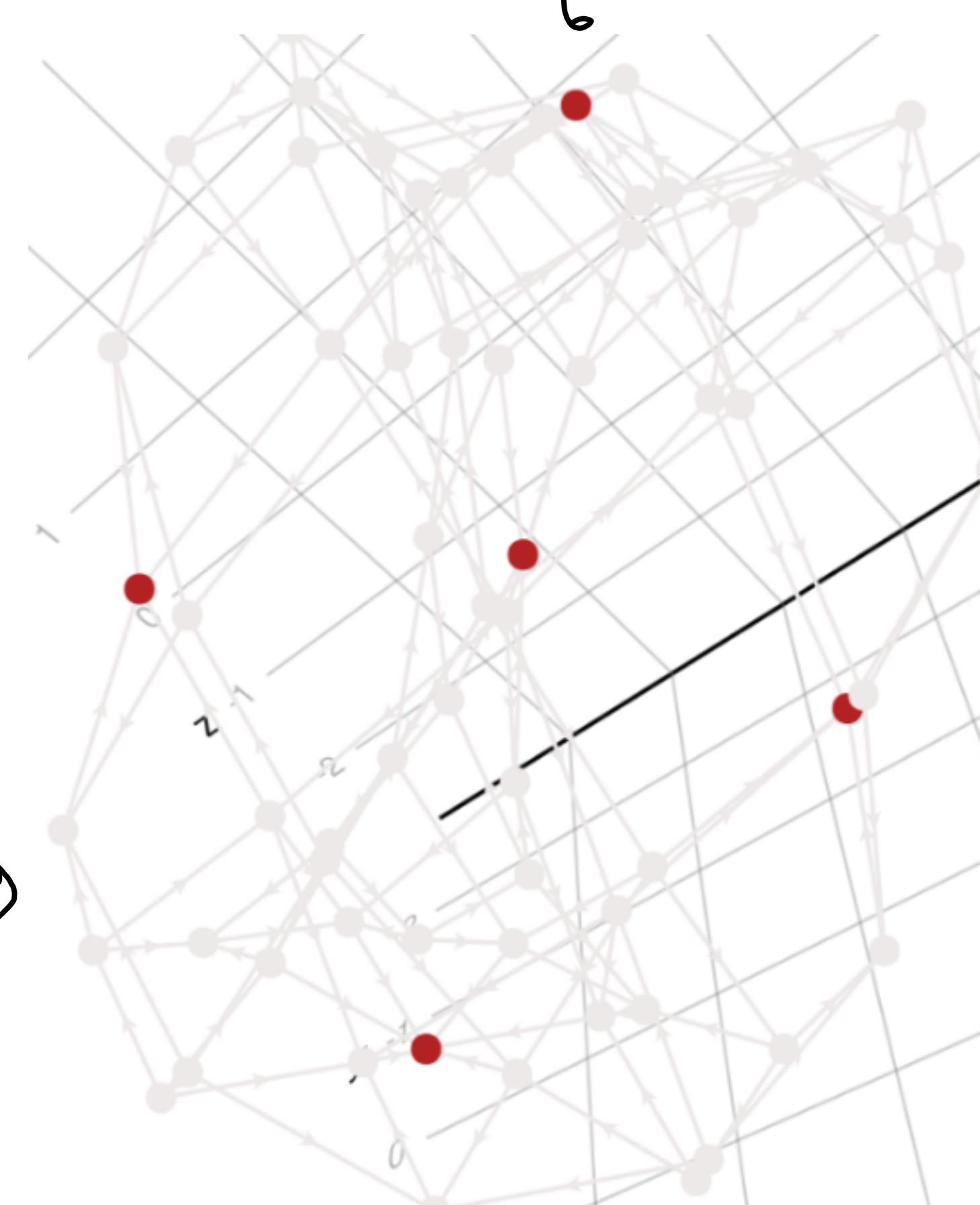
88 - all 0s + if $N \text{ div. by } 3$

$\begin{matrix} 0 & 0 \\ 1 & 0 \end{matrix}$ also repeats of $\overline{110}$

13 - always a couple of clusters dispersed acs

$$\downarrow T + 01 + LR$$

168 - all 0s and all 1s are always the only f acs



longime subrules

40 - all 0s only ac
 00 10
 01 11
 } T++

9 - 1 complex diffusive
 ac around all 0s

24 - all 0s only ac
 00 10
 10 11

120 - all 0s only ac

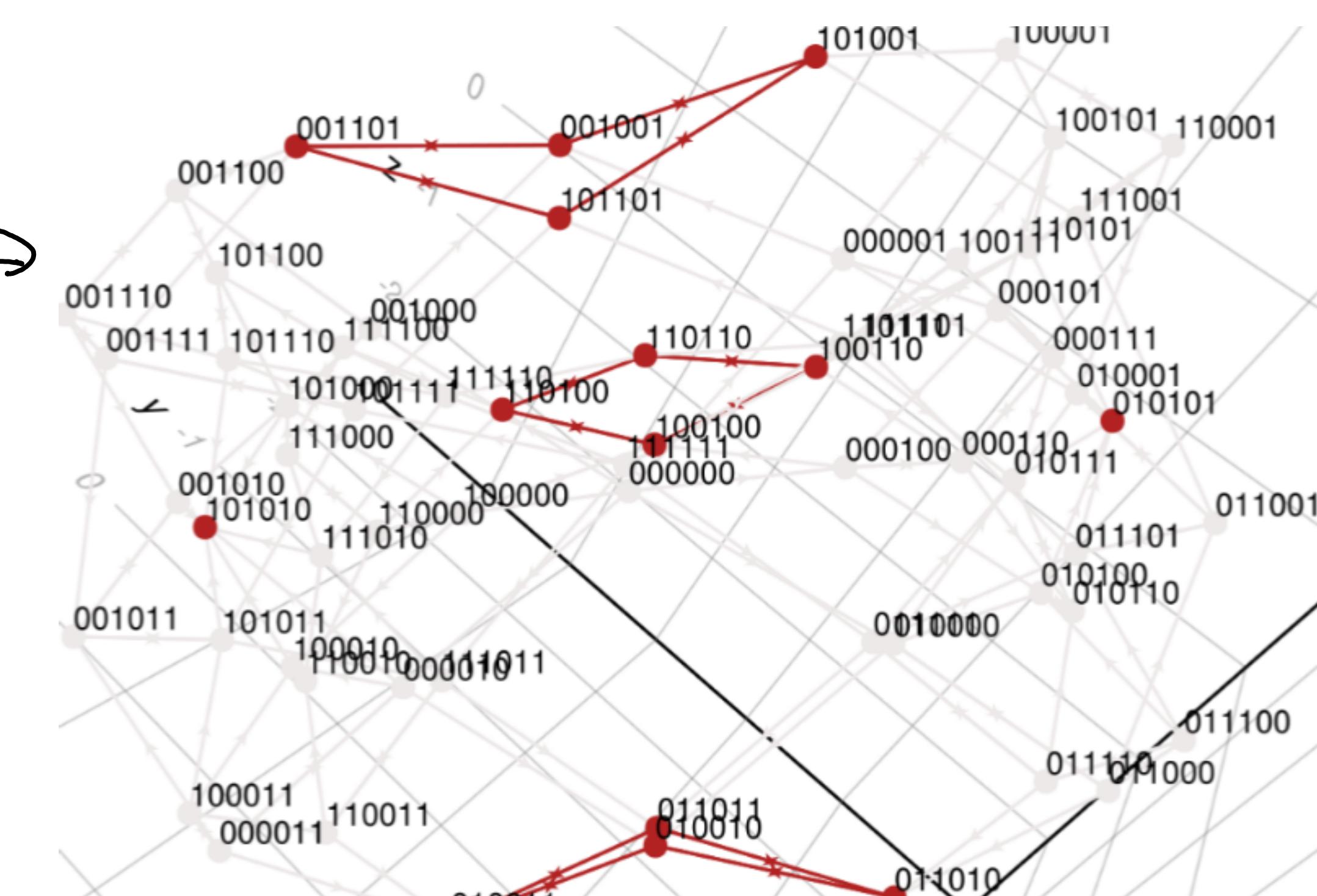
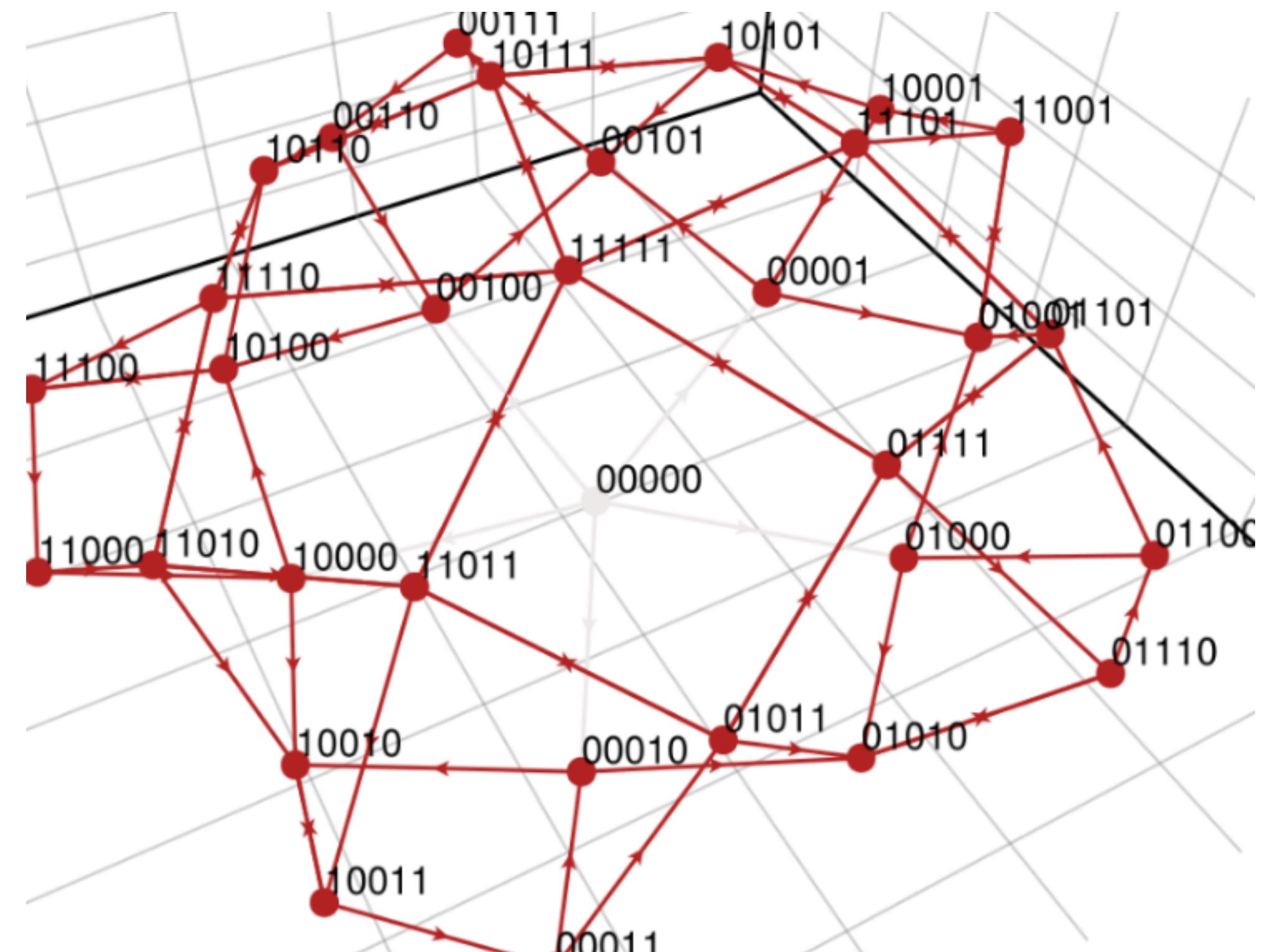
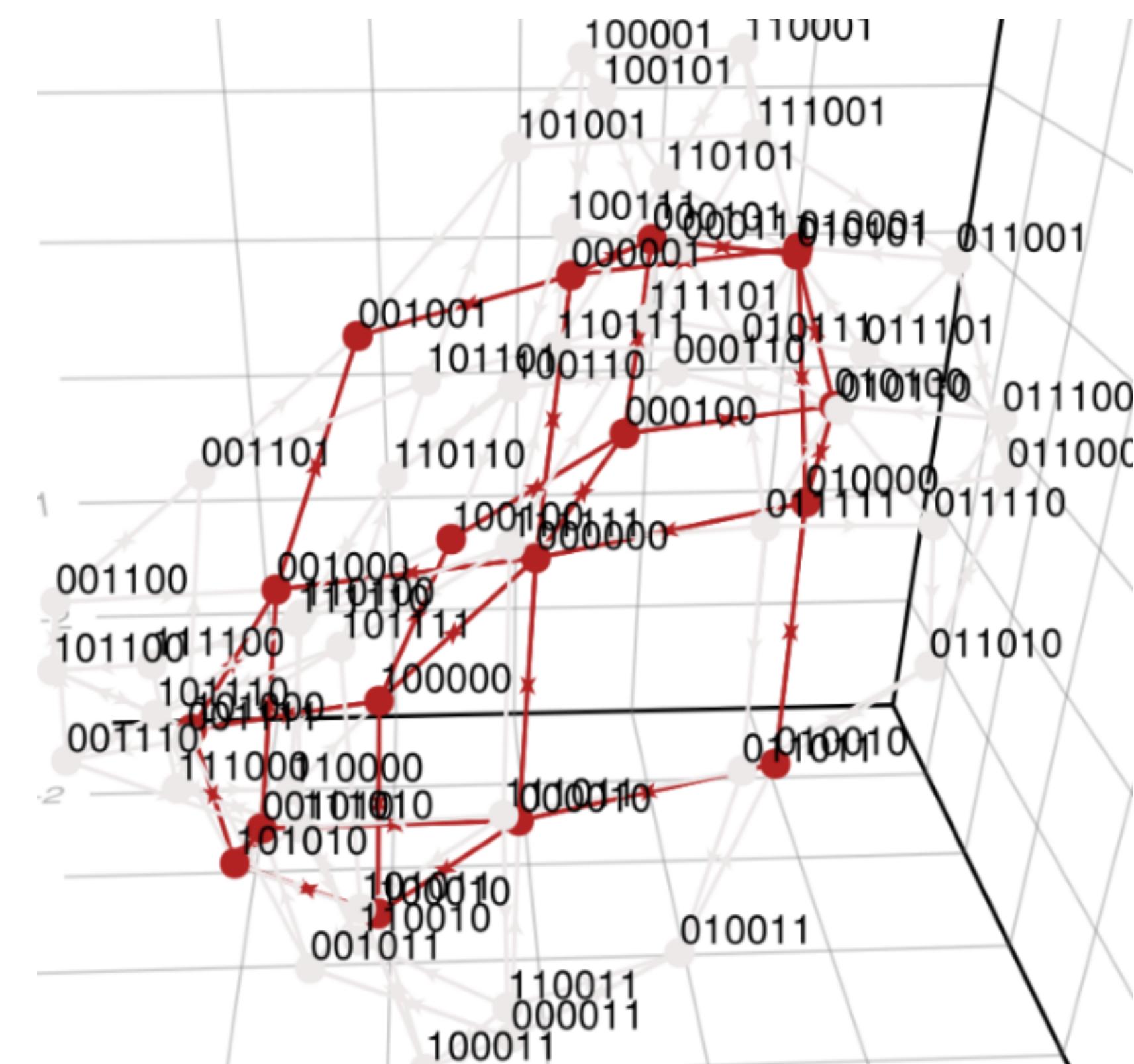
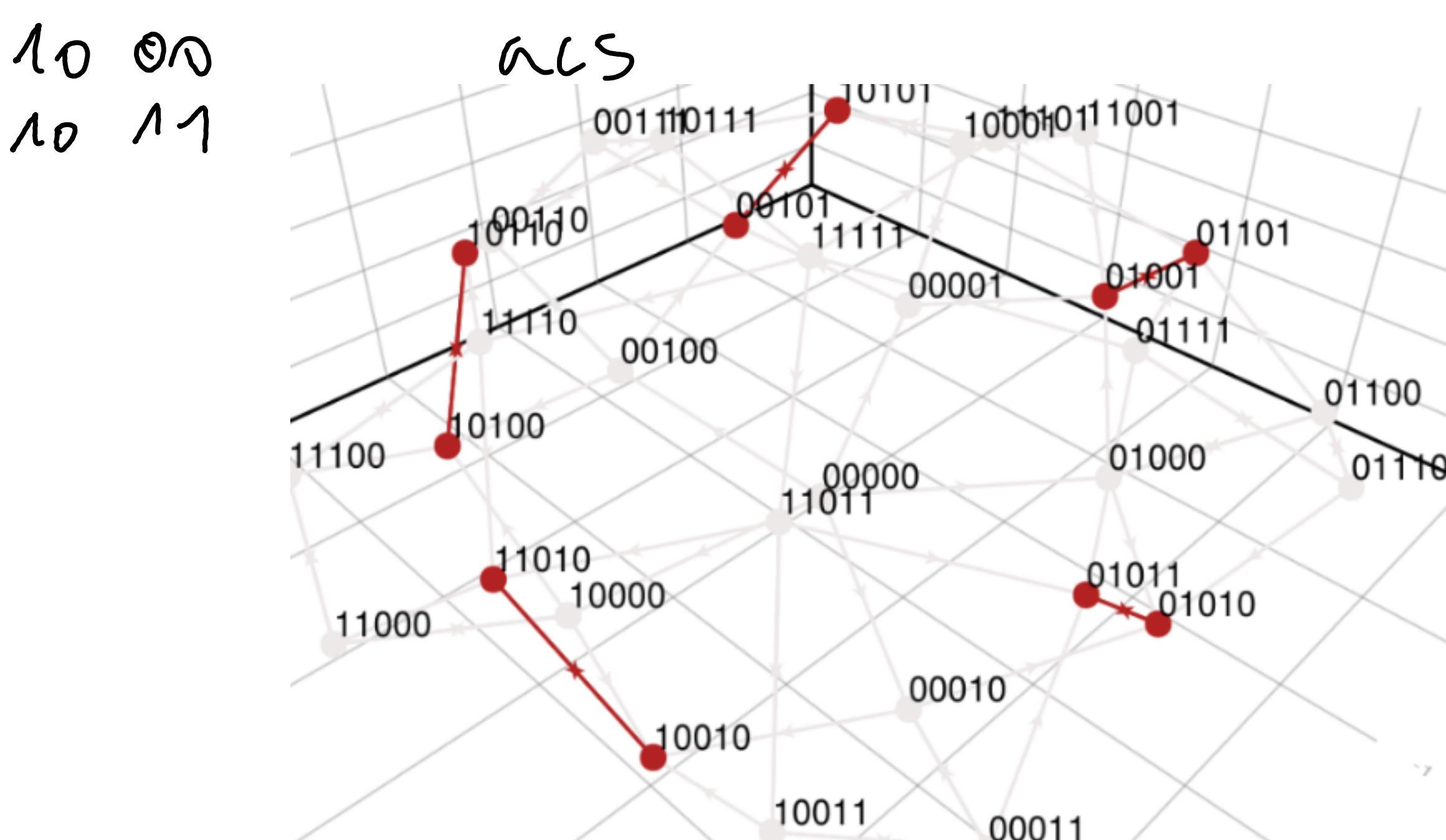
00 10
 11 01
 } T

45 - only ac is everything
 except all 0s unless N div by 3 → then gets stuck at $\overline{001}$
 10 00
 01 11

184 - all 0s and all 1s
 only acs

↑ T
 ↓ T

29 - multiple small diffusive
 acs



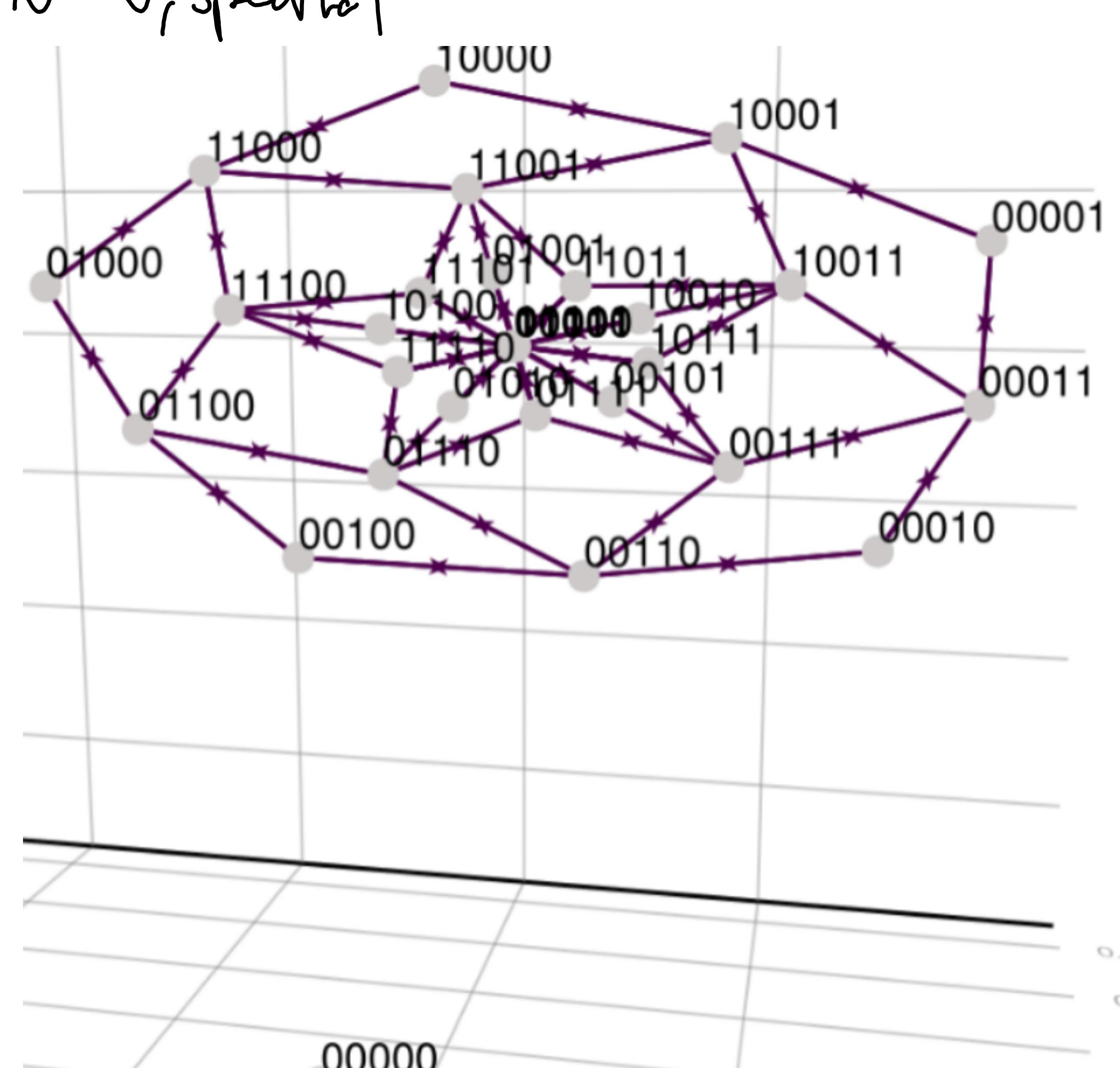
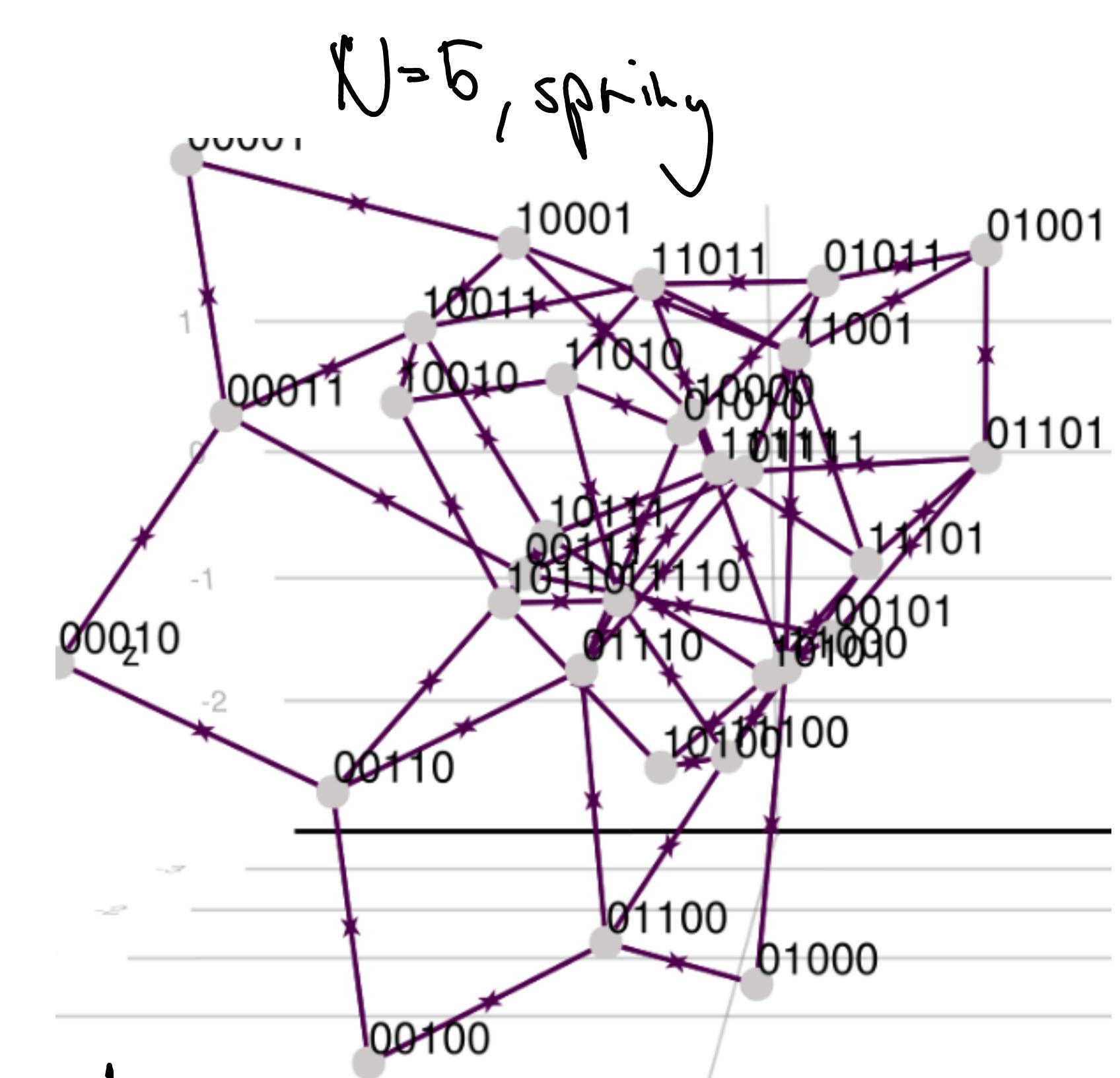
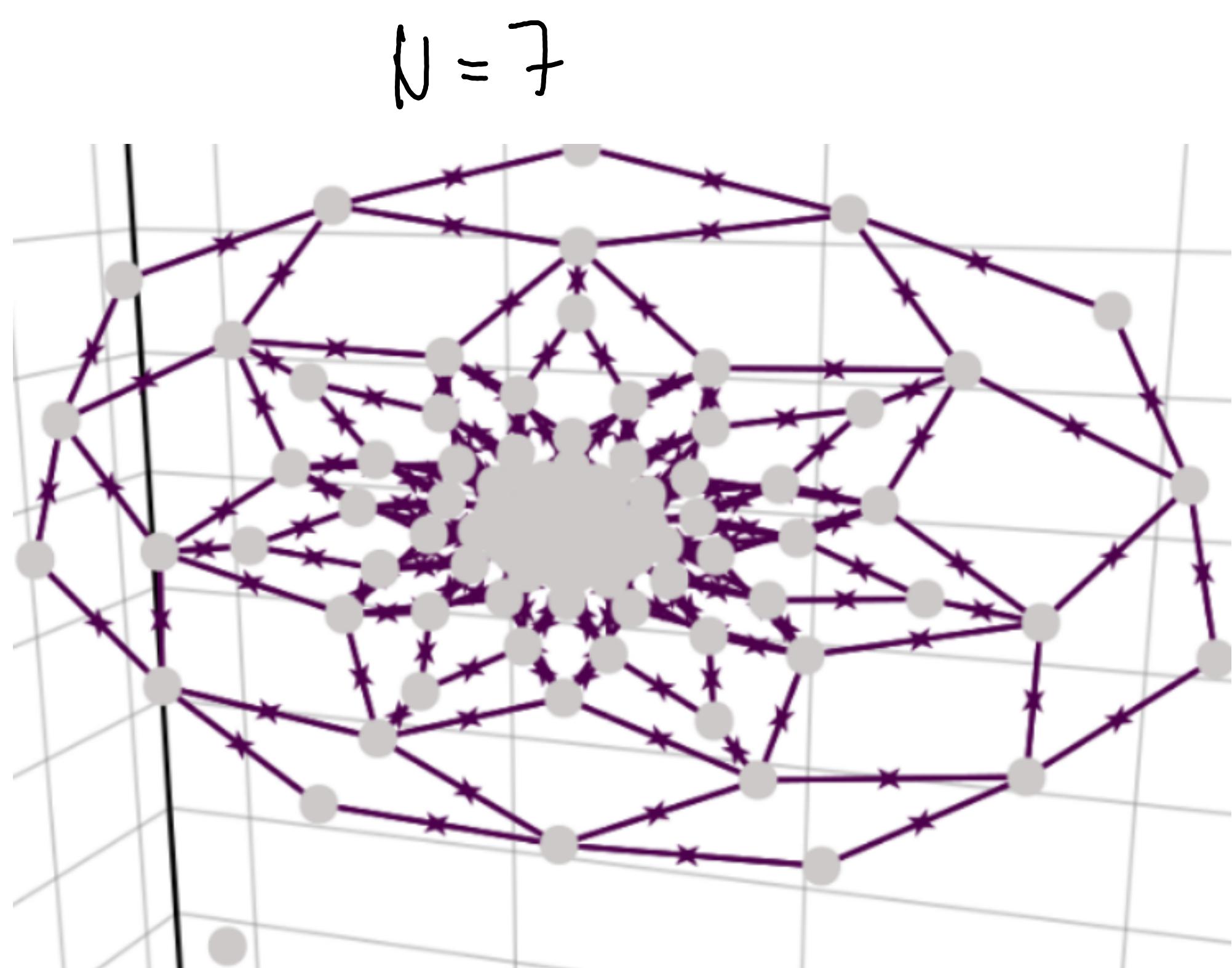
Eg rule 54

$01\ 01$ ~ cannot seed or complete a 0 chain
 $11\ 11$

all 0s is always isolated

in Spring it looks like a structured blob

Spectral always gives a star/dish shape $N=5$, spectral



5 enzyme subrules

182 - all 0s and all 1s

$\begin{matrix} 0 & 1 \\ 1 & 0 \end{matrix}$
 $\begin{matrix} 1 & 1 \\ 0 & 0 \end{matrix}$
only acs

$\uparrow T$

22

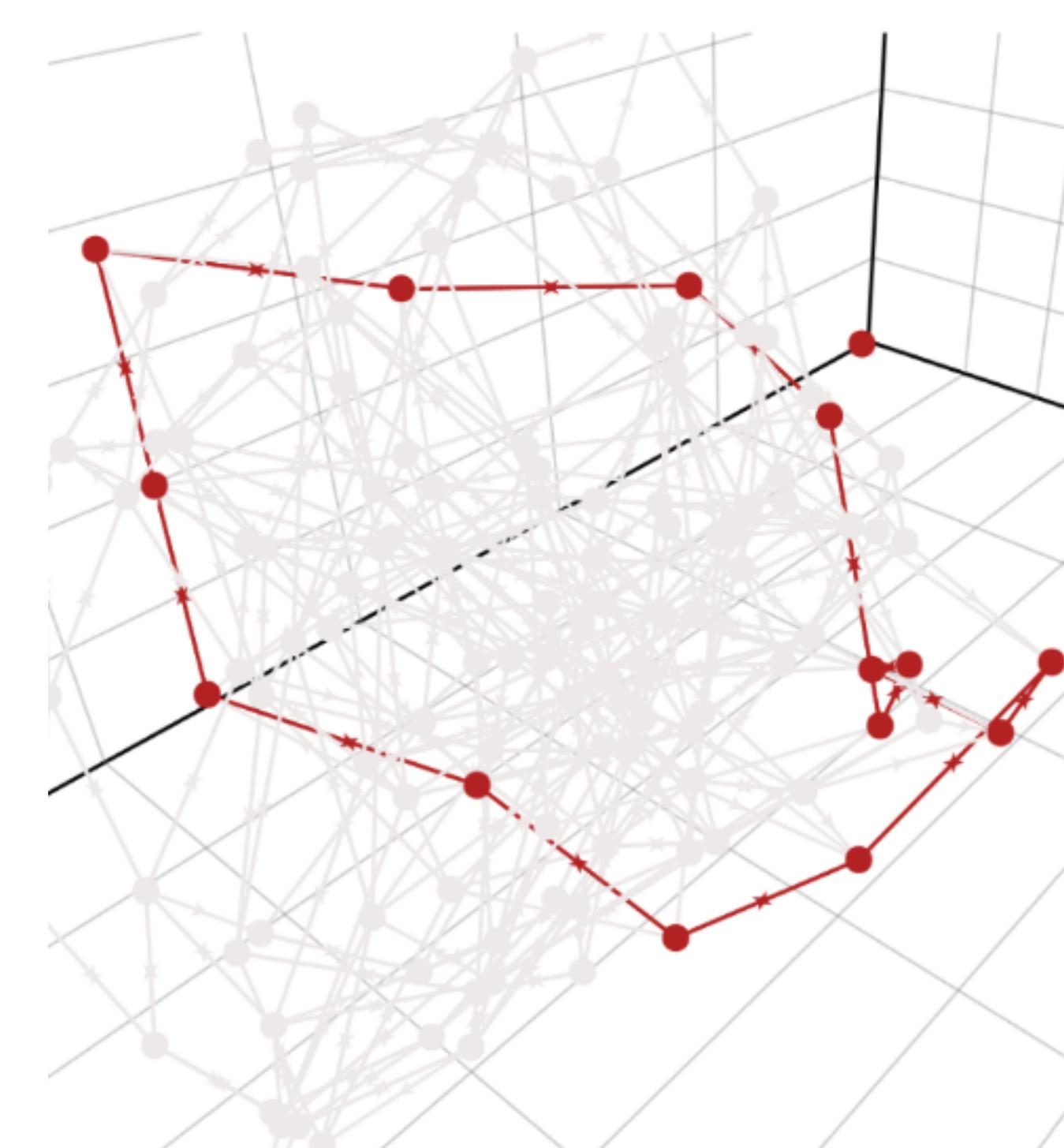
$\begin{matrix} 0 & 1 \\ 1 & 0 \end{matrix}$
 $\begin{matrix} 0 & 1 \\ 1 & 1 \end{matrix}$

- loops At odd N has

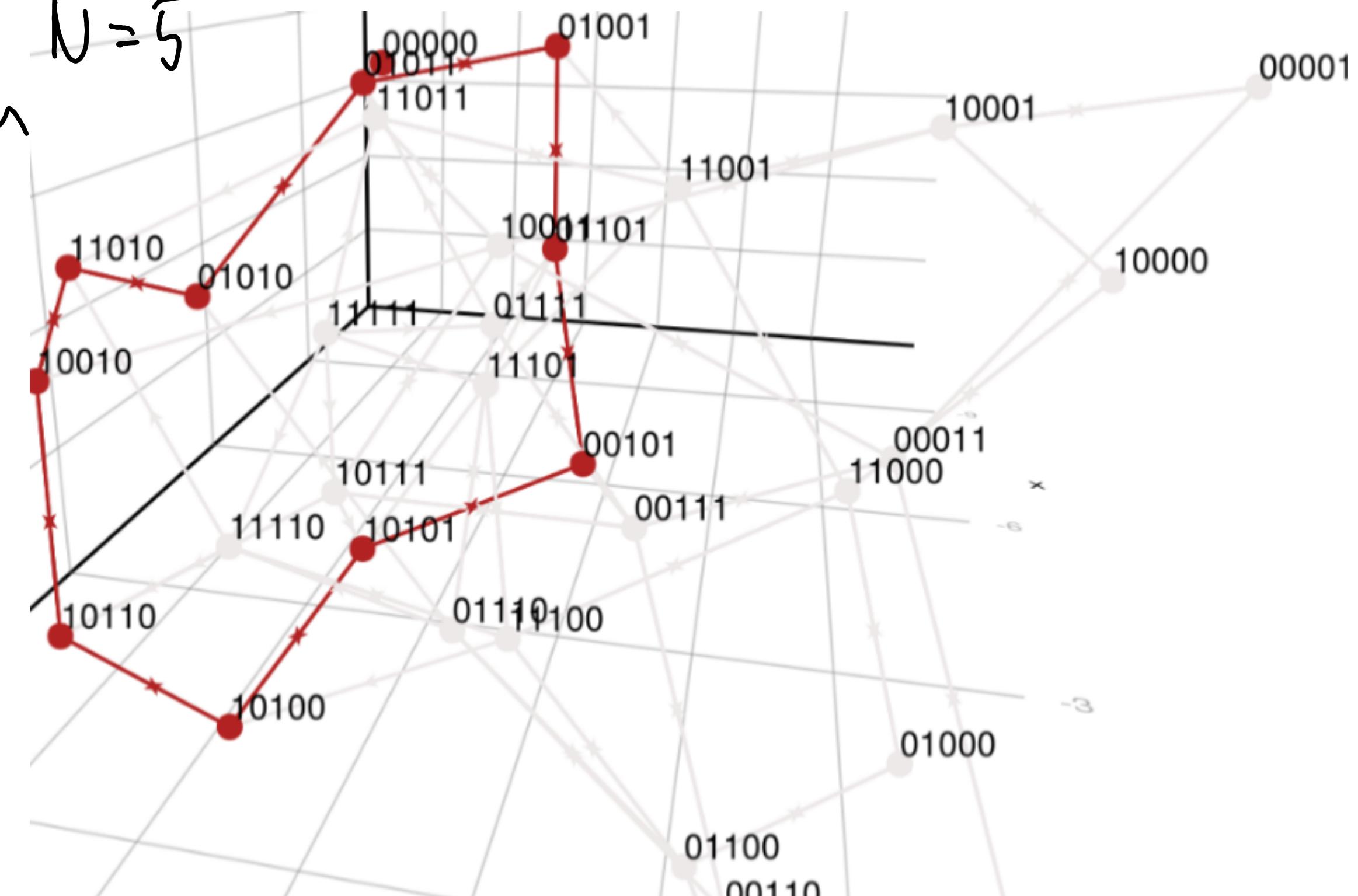
one non-single ac which
is a single state loop

At even N gets stuck
in $\overline{01}$ states

$N=2$



$N=5$



38

$\begin{matrix} 0 & 1 \\ 1 & 0 \end{matrix}$
 $\begin{matrix} 0 & 1 \\ 1 & 1 \end{matrix}$

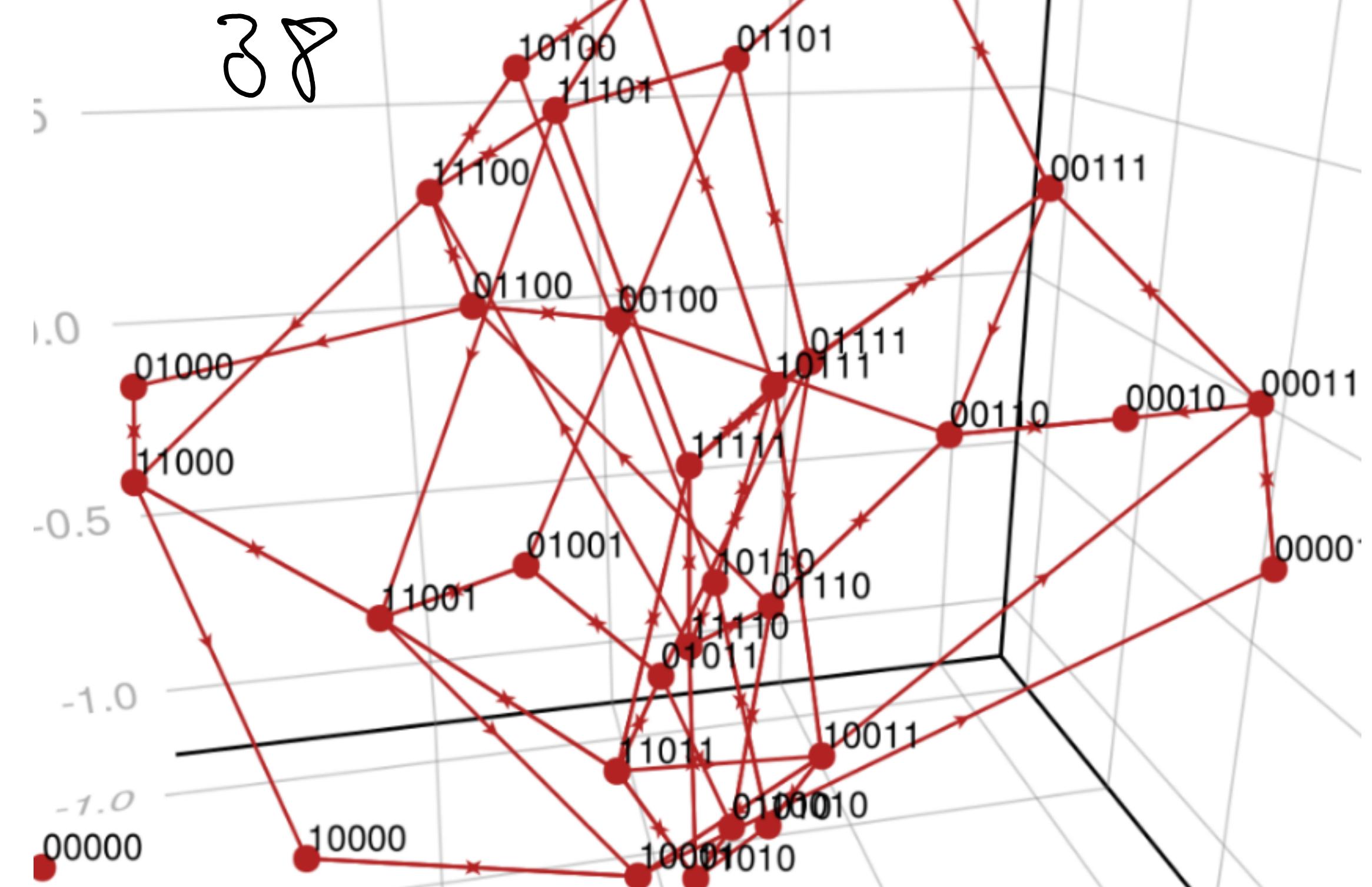
$\uparrow T+LR$

62

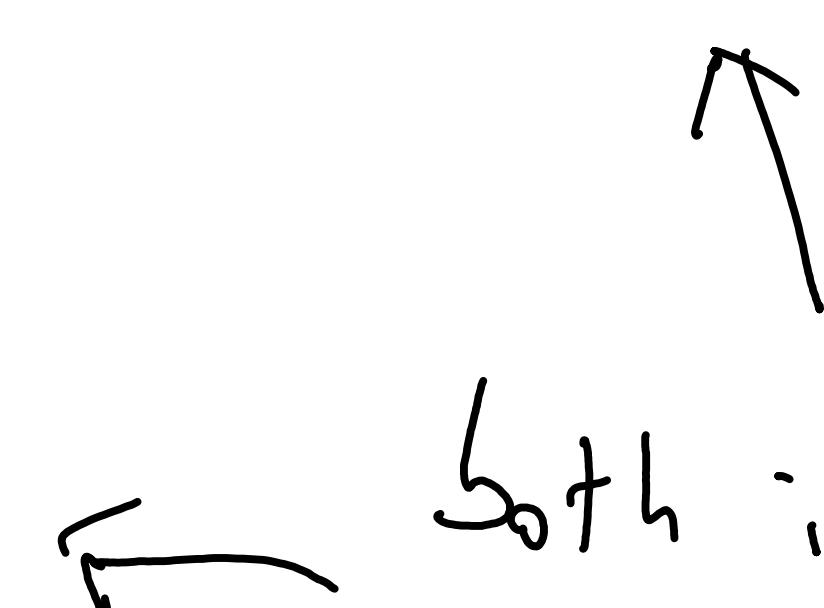
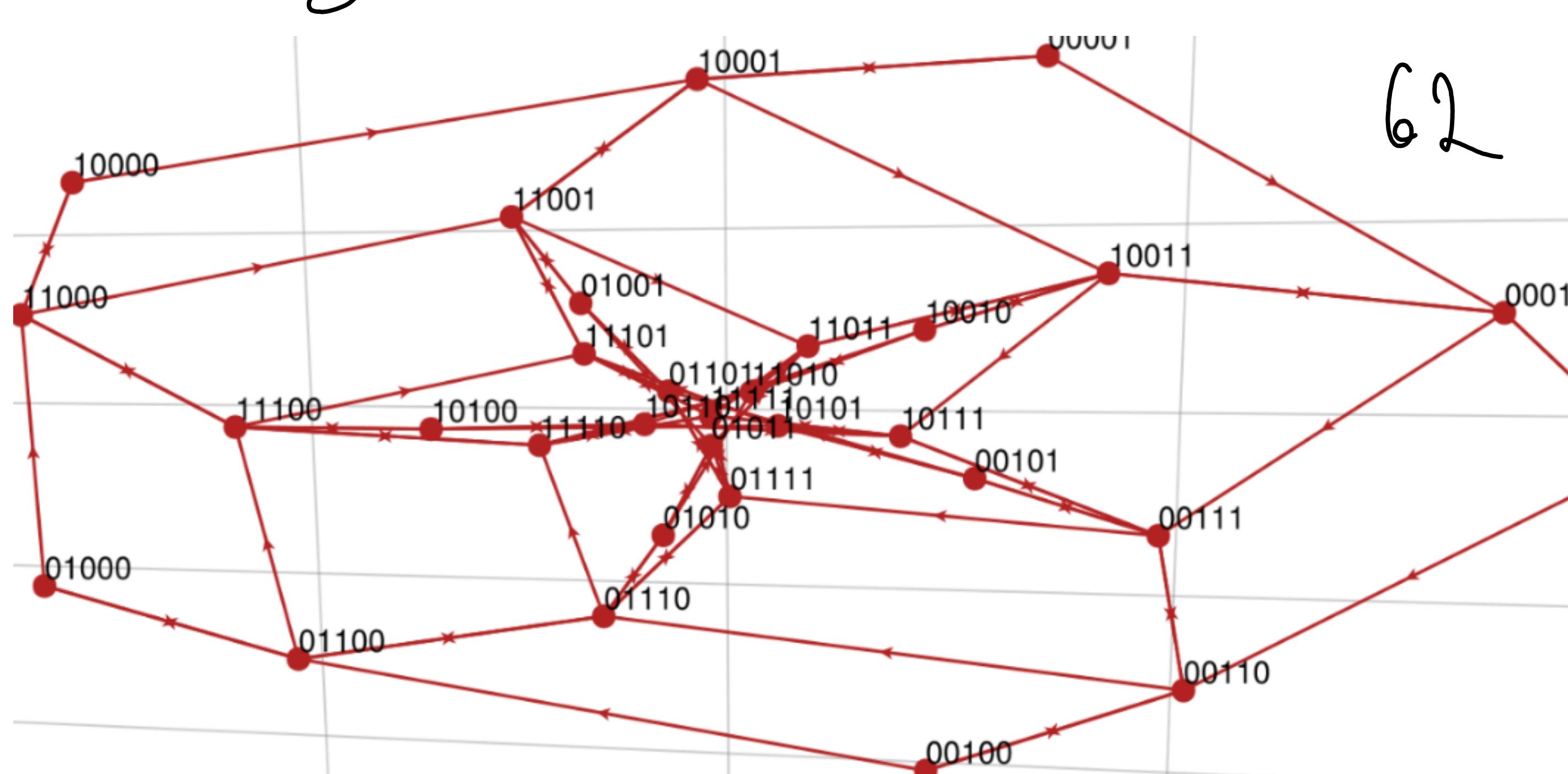
$\begin{matrix} 0 & 1 \\ 1 & 0 \end{matrix}$
 $\begin{matrix} 1 & 1 \\ 1 & 1 \end{matrix}$

both keep the
entire structure
as one complex
bc but looking
at ss makes it
clear there are
bices

38



62

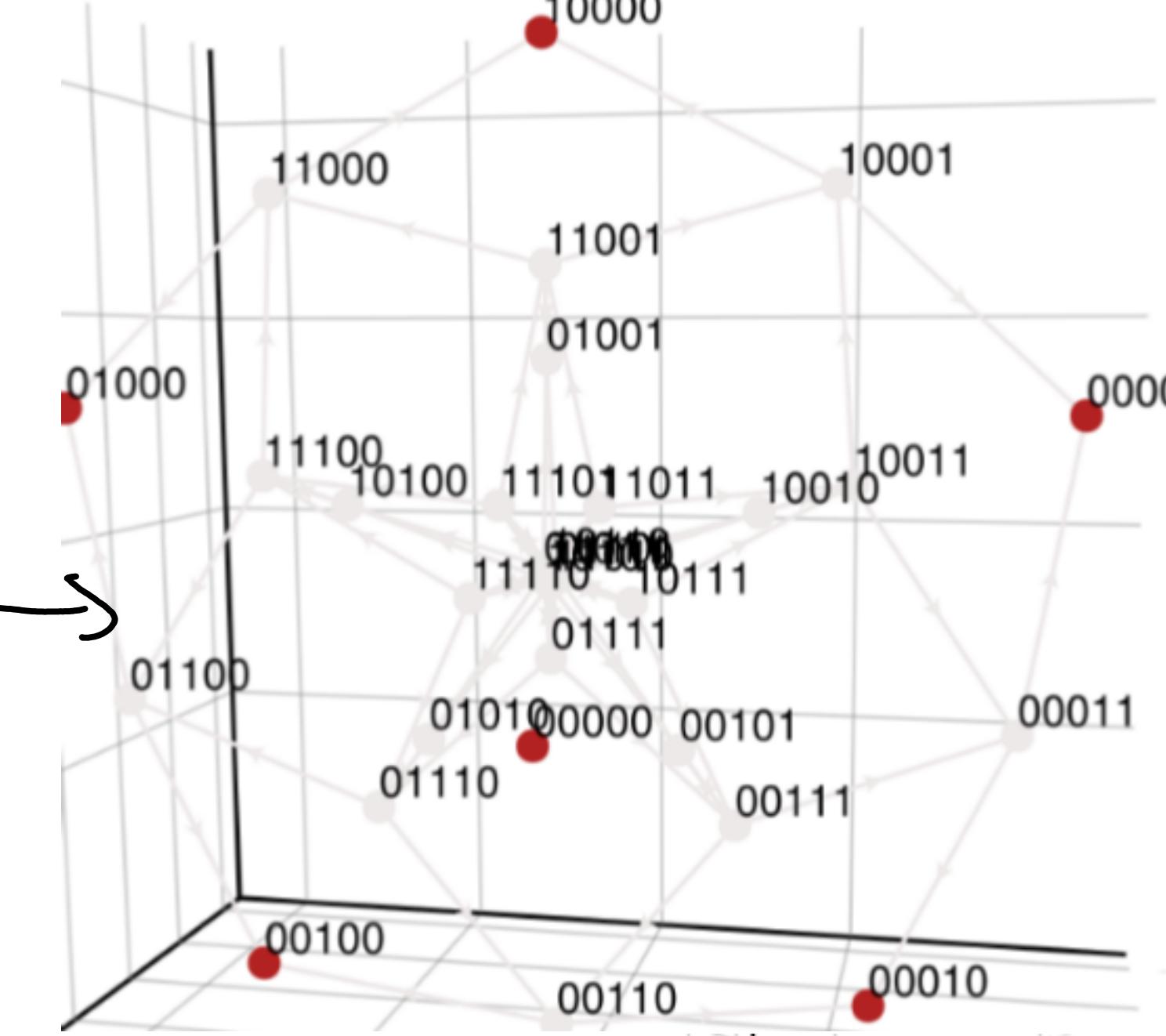


both in Spectral

enzyme subrules

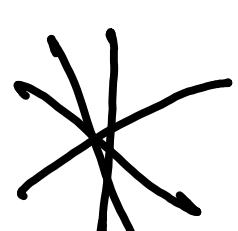
3_b
 00 01
 01 11
 ↓ T

- multiple, symmetric single acs all with isolated 1s eg "...00100..."



126
 01 00
 11 01
 ↓ T

- similar, 1 diff. ac all one step away from all 1s, so isolated 0s

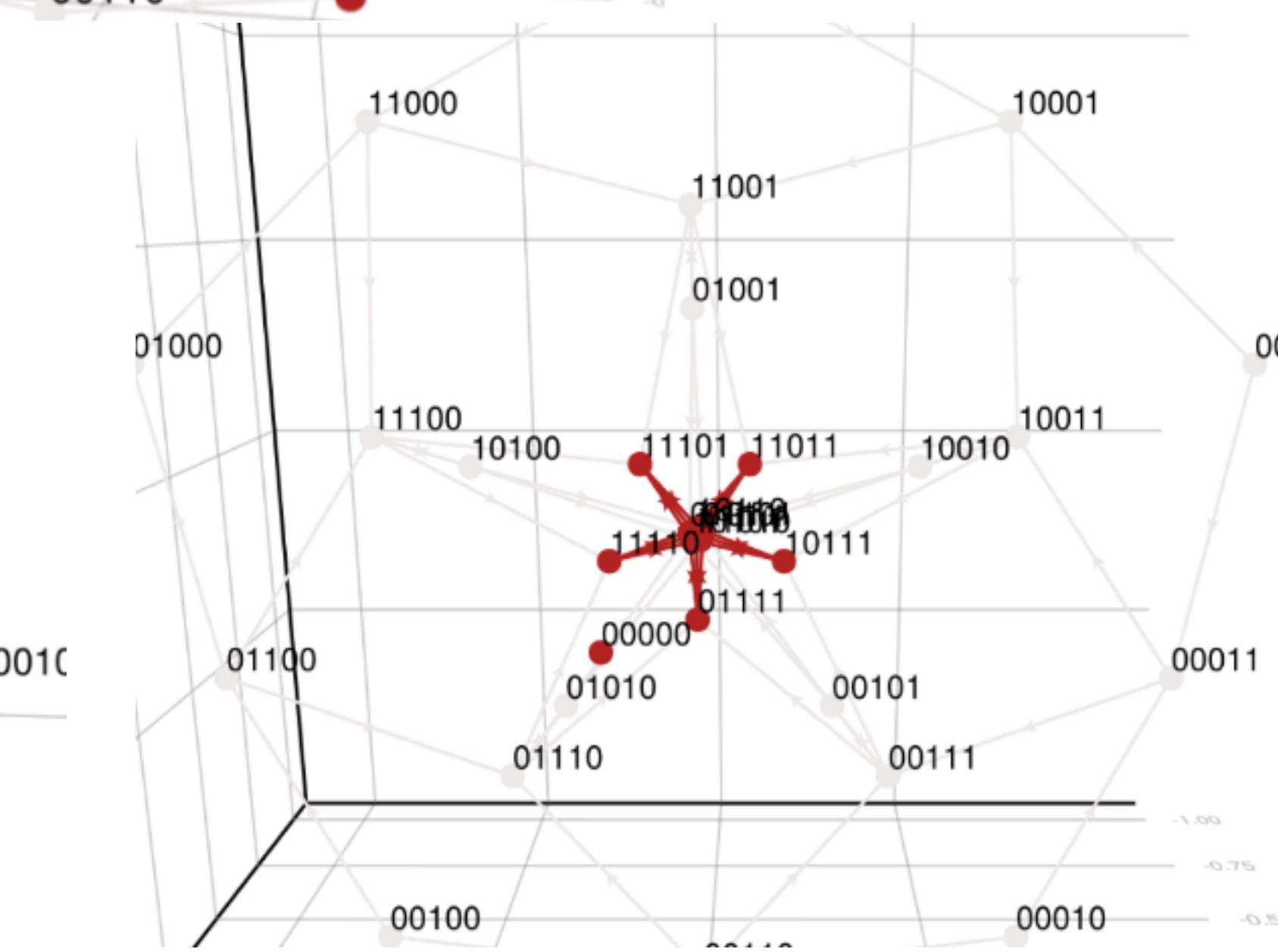


- loops at odd N at even N gets stuck at $\overline{01}$ states

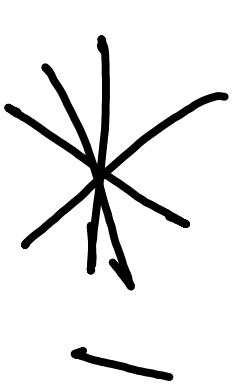


6
 01 01
 00 11
 ↓ T+

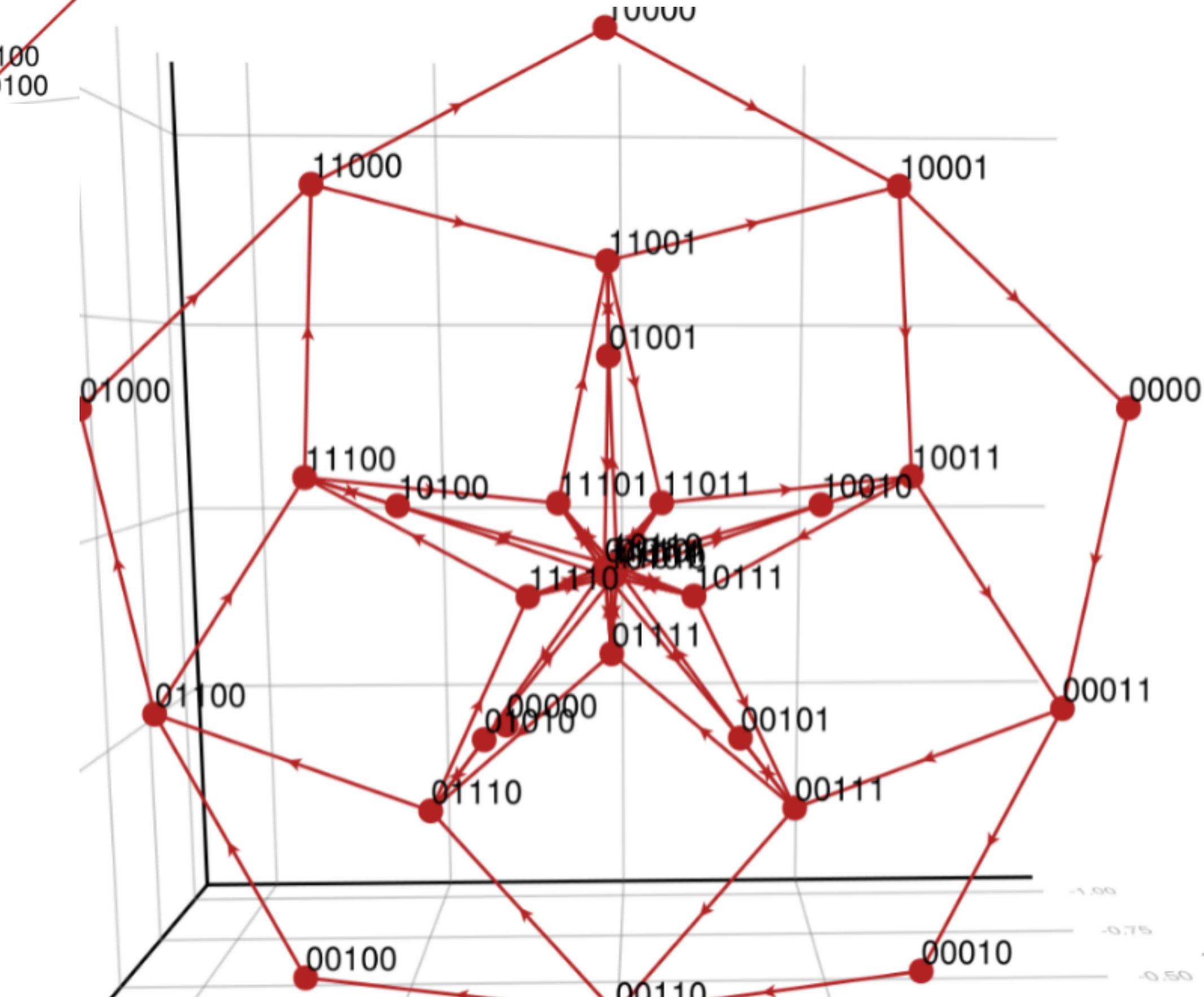
- all 1s and all 0s only acs



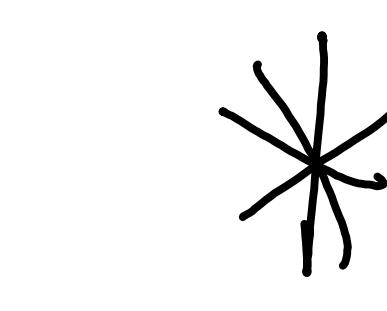
140
 01 00
 11 10
 ↓ T+



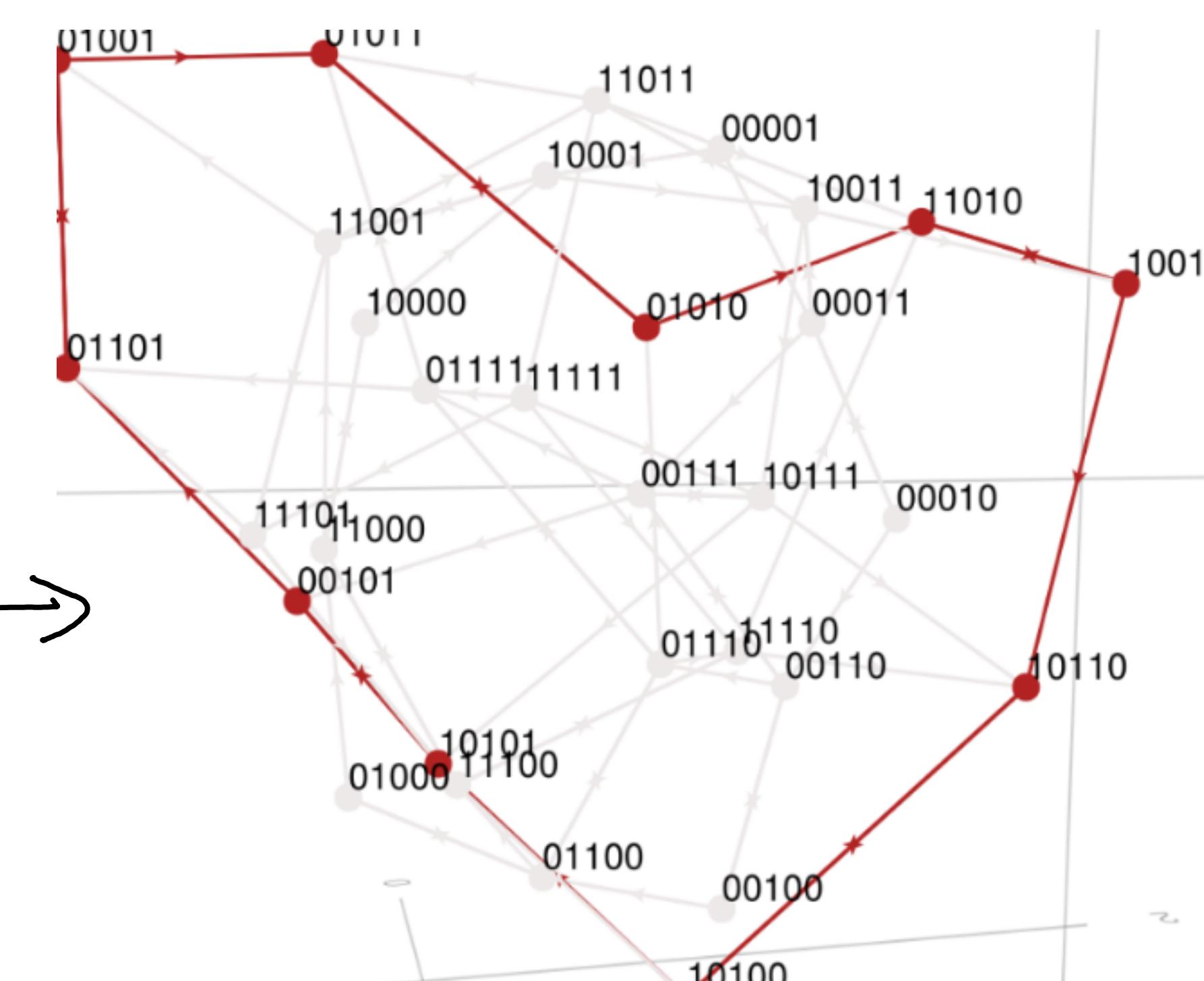
- all states remain in one complex ac which is however clearly directed



166
 01 01
 01 10
 ↓ T+



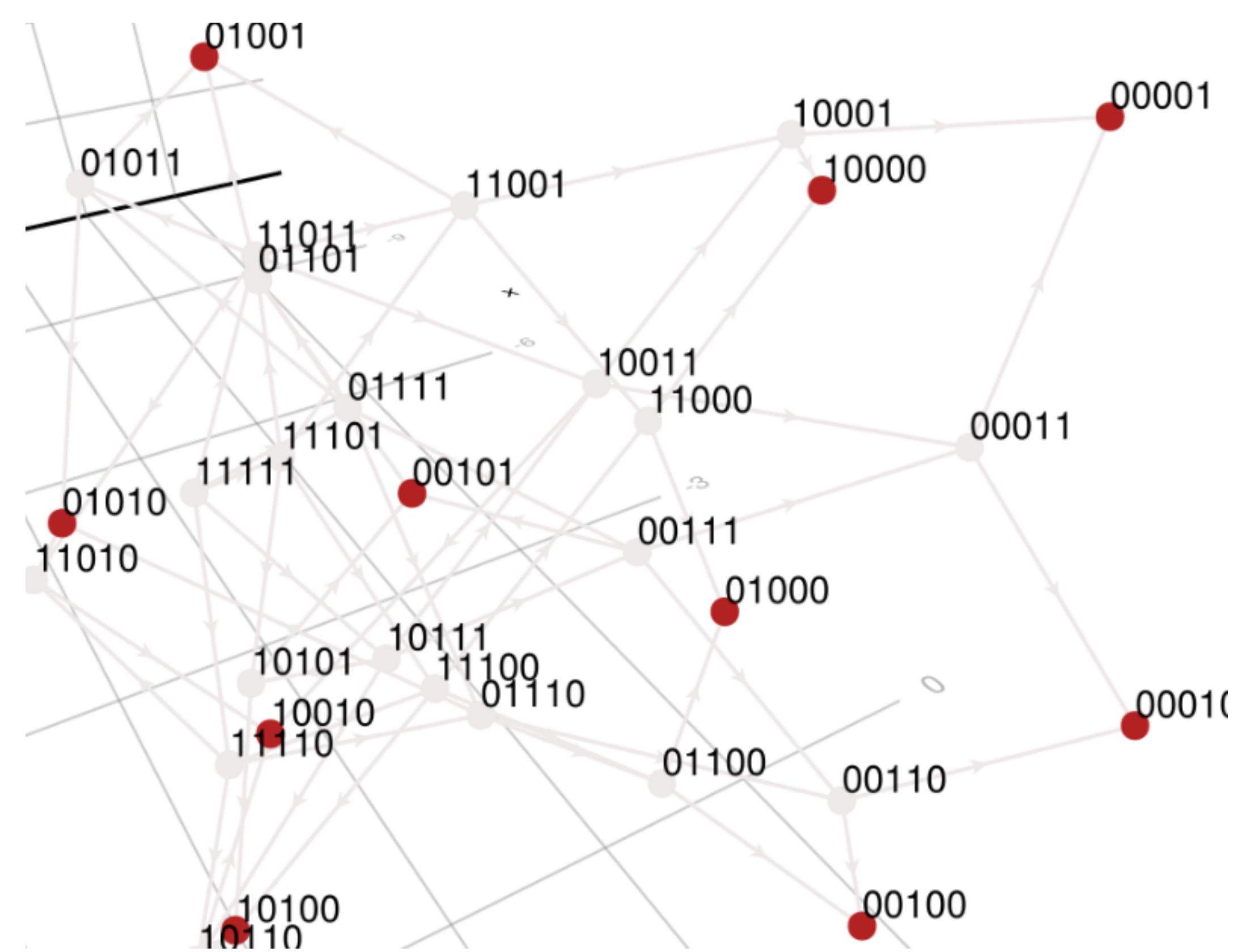
- same loops as 46 but the other arrows are directed



3 enzyme subunits

4 - many single state acs,
 $\begin{matrix} 00 & 01 \\ 00 & 11 \end{matrix}$ can only go towards 0s
 $\downarrow T$ but gets stuck at isolated 1s

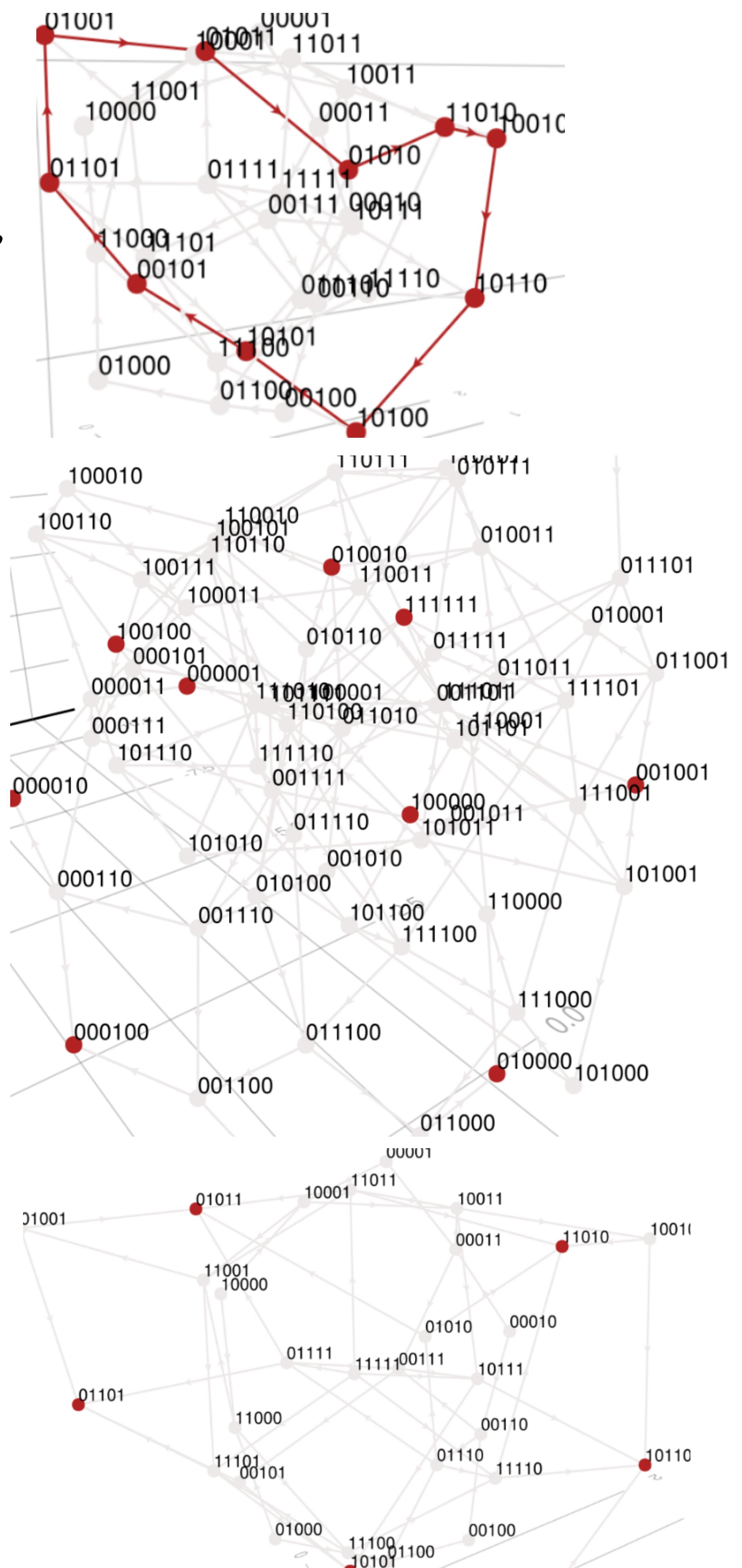
254 - all 0s and all 1s
 $\begin{matrix} 01 & 00 \\ 11 & 00 \end{matrix}$ only acs



14 - at odd N has the same loops as 6, 30 but all arrows are directed
 $\begin{matrix} 01 & 00 \\ 00 & 11 \end{matrix}$ at even N gets stuck at $\overline{01}$
 $\downarrow T++$

174 - all 0s and all 1s
 $\begin{matrix} 01 & 00 \\ 01 & 10 \end{matrix}$ only acs
 only 0 domains can spread but cannot be completed
 - but 1 domains cannot be broken either - many small acs include all 0s, all 1s and isolated 1s
 $\downarrow T$
 94

$\begin{matrix} 01 & 00 \\ 10 & 01 \end{matrix}$ 1s can be broken but can't ever shrink, bunch of single acs each pixel of isolated 0s

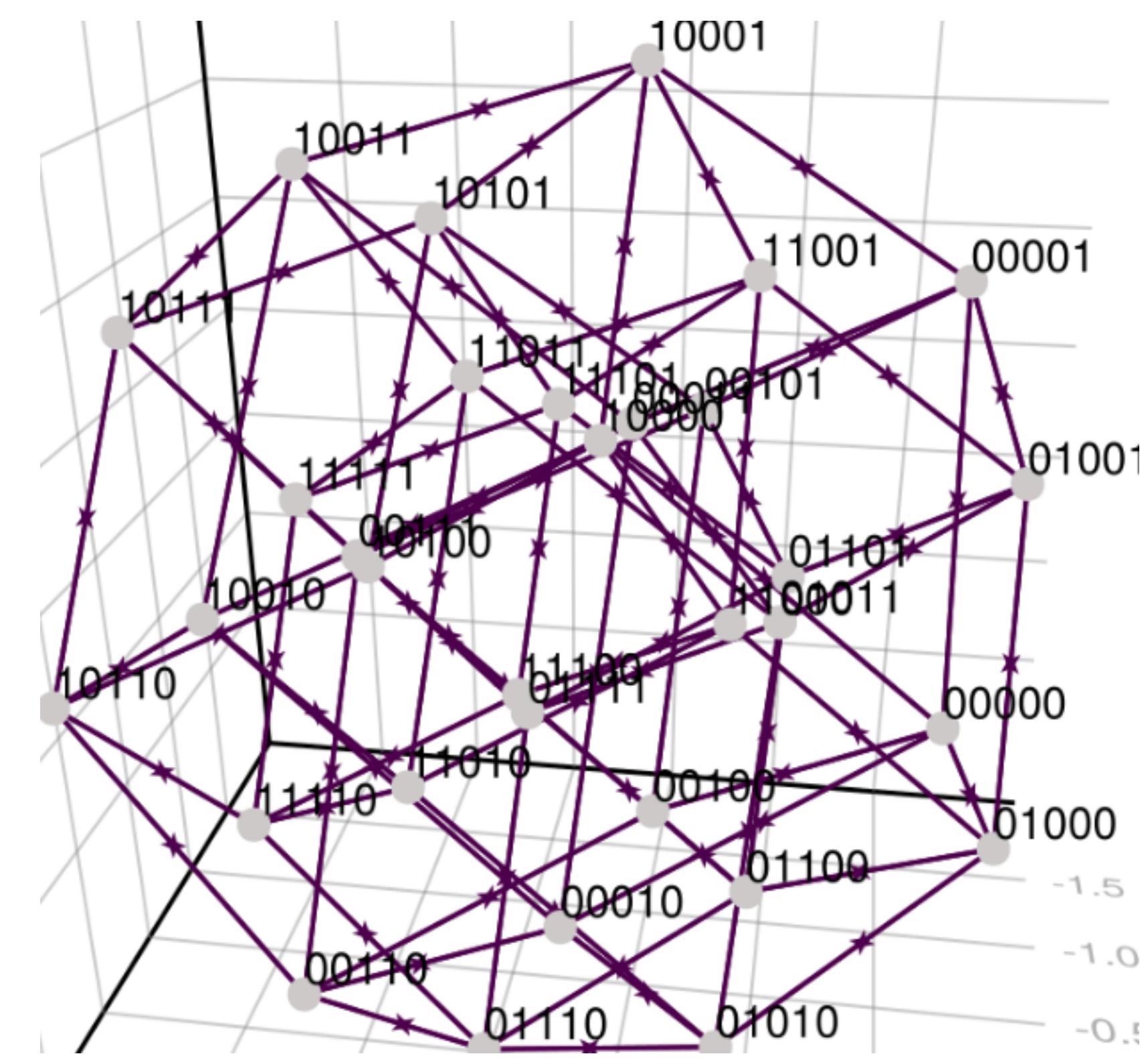


Eg rule 51

1111
1111

- not much to say,
everything is allowed

Spring
layout
Spectral
Tools
Similar



Fengmei subrules

50

- all 0s only cc,
makes sense as cannot
be escaped

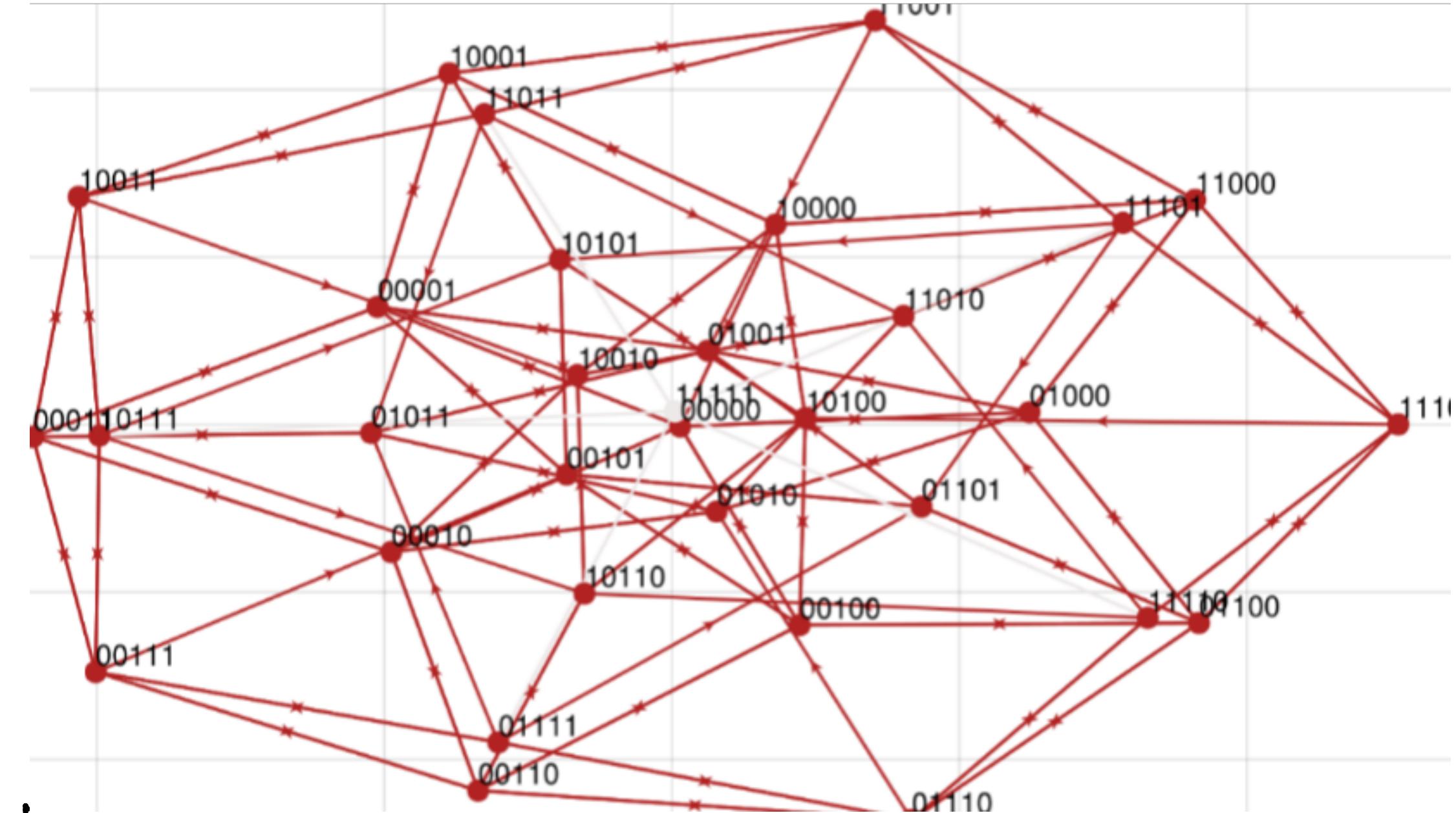
61 11
11 11

↑ T++

19

1111
1011

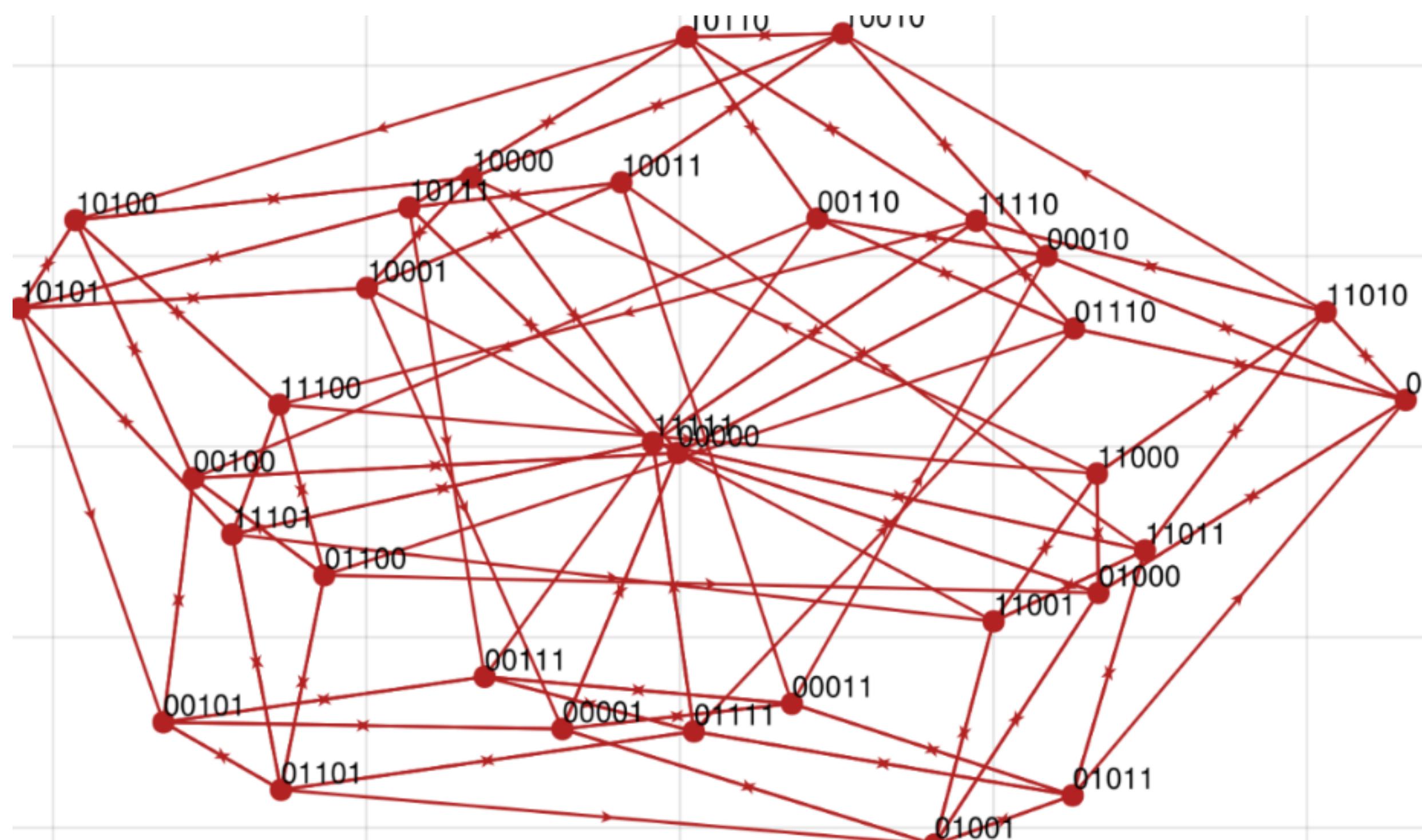
- all except all 1s Ts in one big cc,
note that cc is not fully diff.
as it is biased towards 0s



35

11 11
01 11

- all the big cc biased (but only partly) towards 0s
and seemingly somewhat
chiral



6 energy sublevels

starting with the more based ones

34 - all 0s only ac

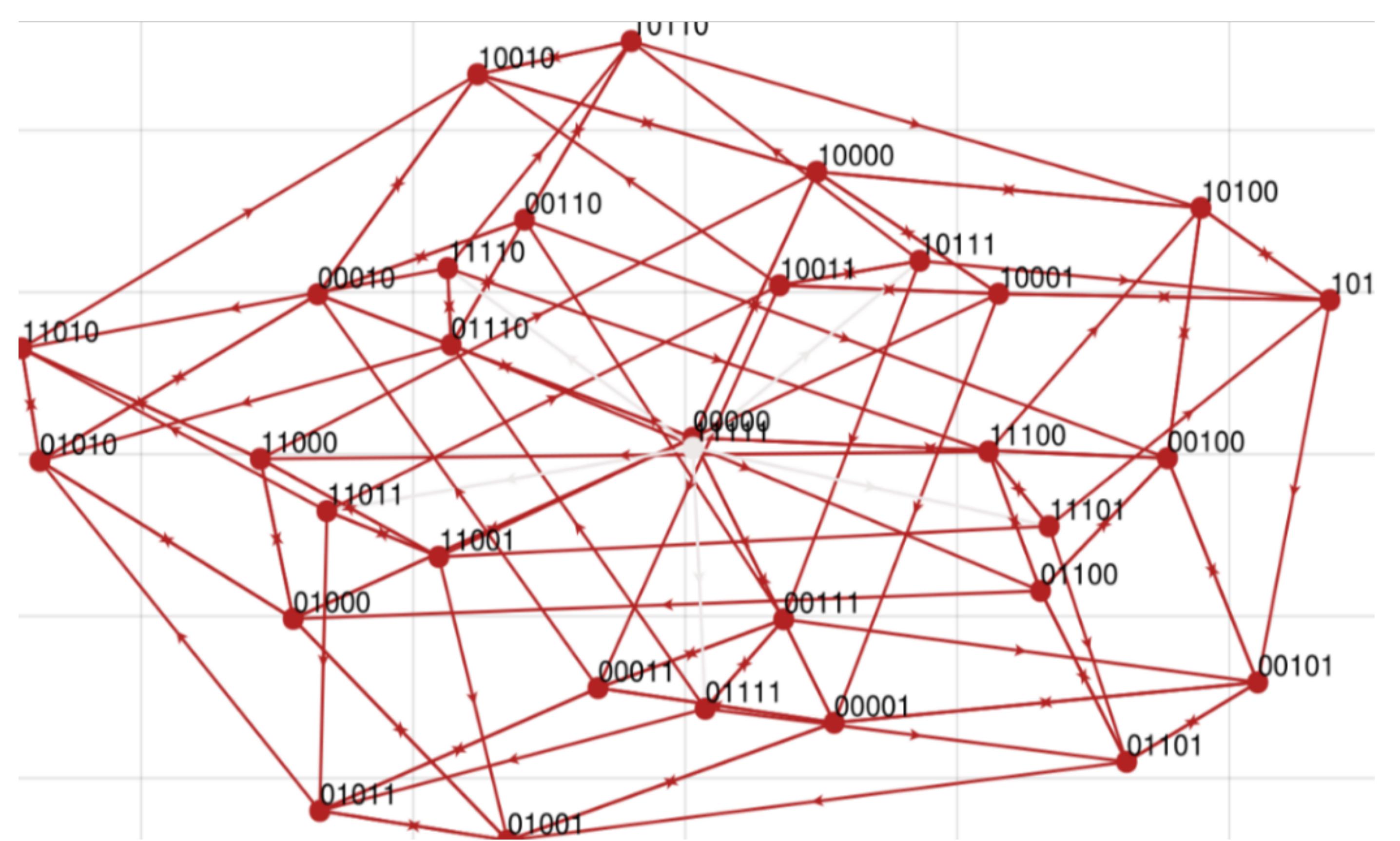
01 11

01 11

↓
T+H

3 - logically, mix of 19 and 35,

11 11 has one complex band-lift. ac
00 11 which includes everything
except all 1s



18 - all 0s only ac

01 11

10 11

one complex ac includes all states

- Spectral layout changed significantly though

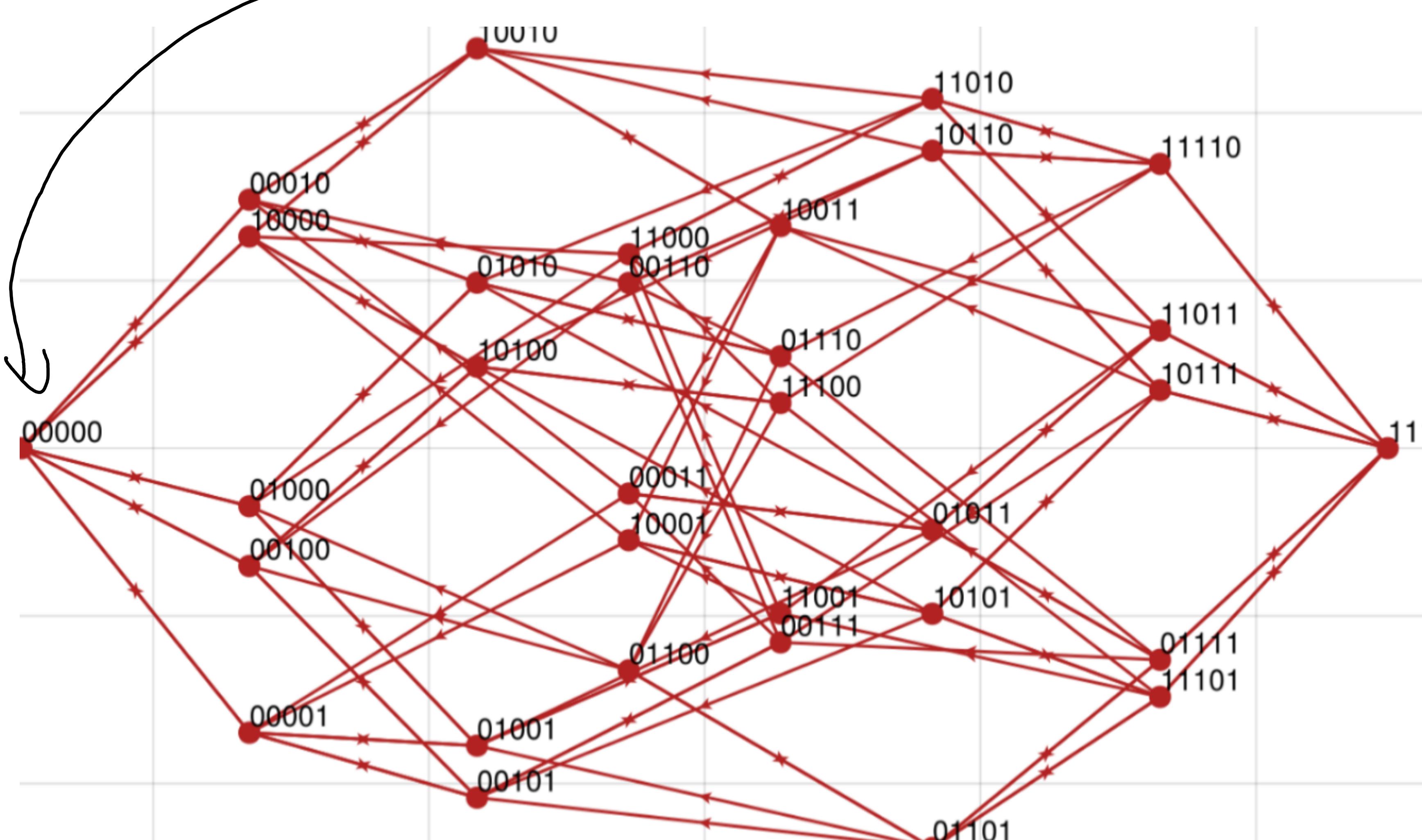
how all 1s and all 0s are opposing each other !

33

10 11

01 11

↓



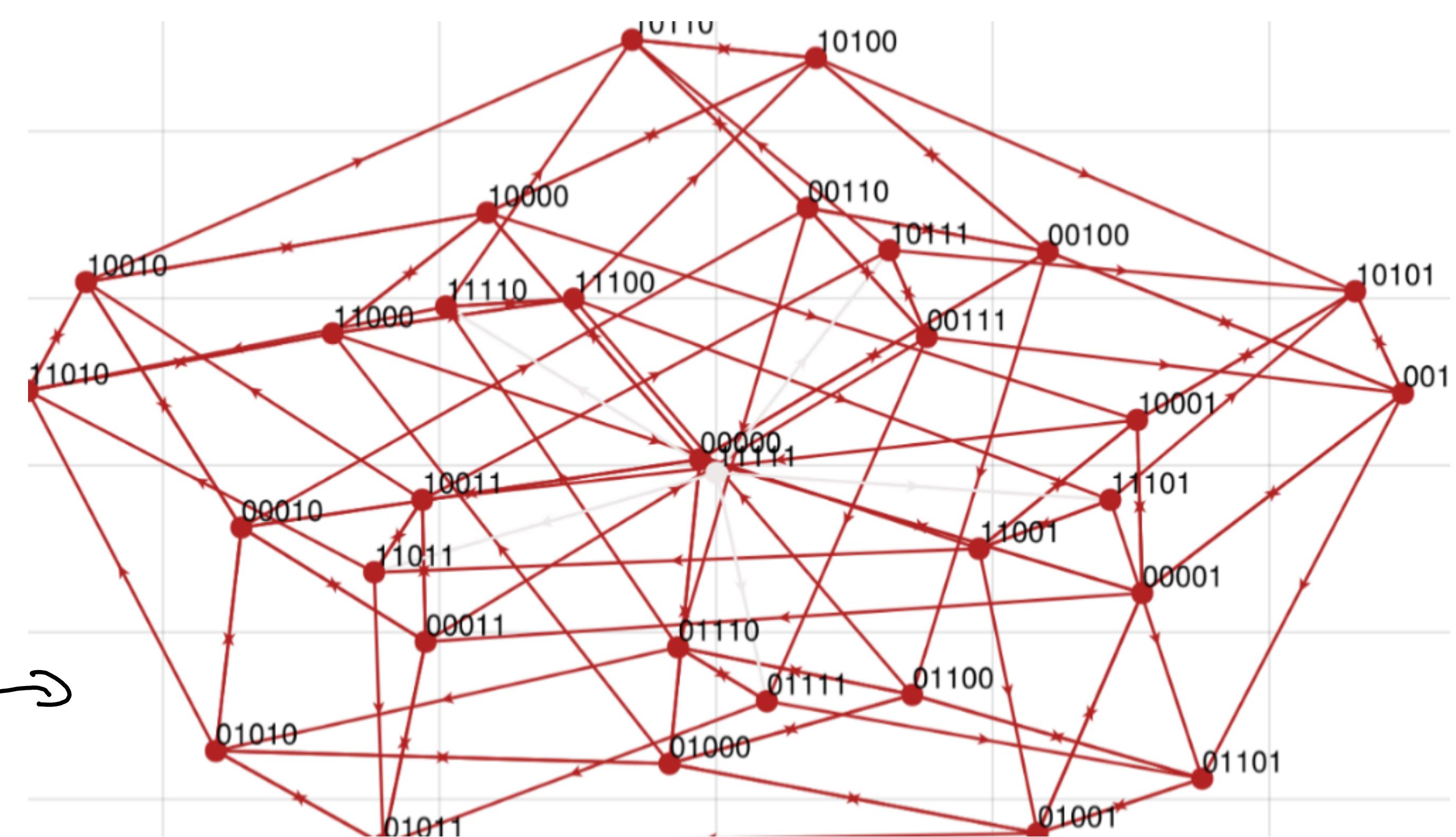
58

- all 0s only ac

01 10
11 11
 $\downarrow T+L$

27

- one complex ac including
everything but all 1s,
also looks chaotic



178 - all 0s and all 1s

only cc5

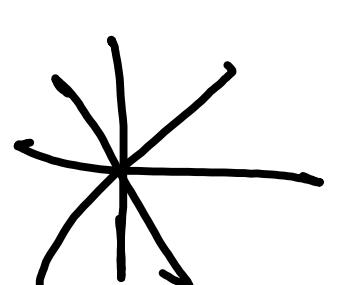
01 11
11 10

 $\downarrow T++$

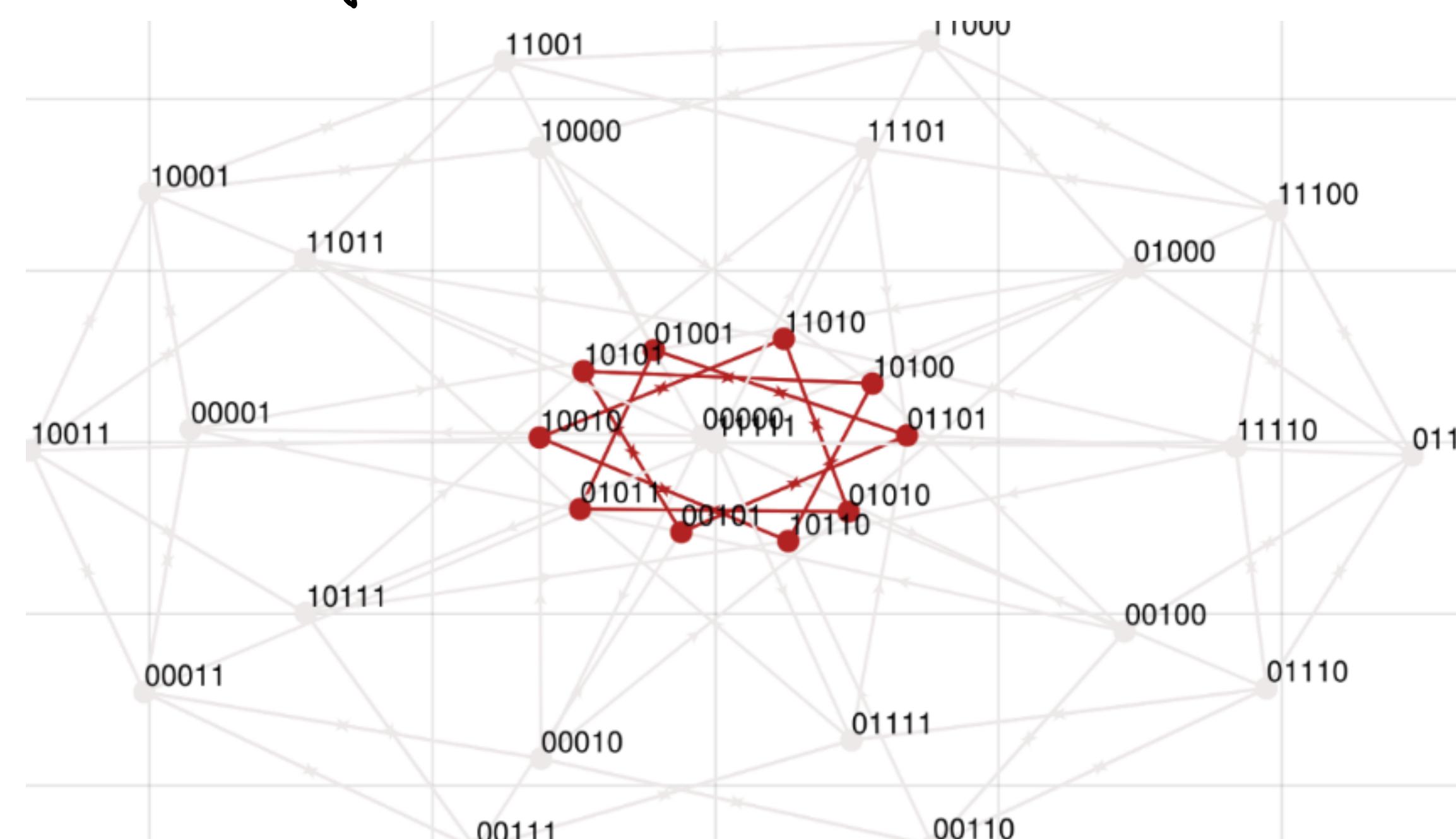
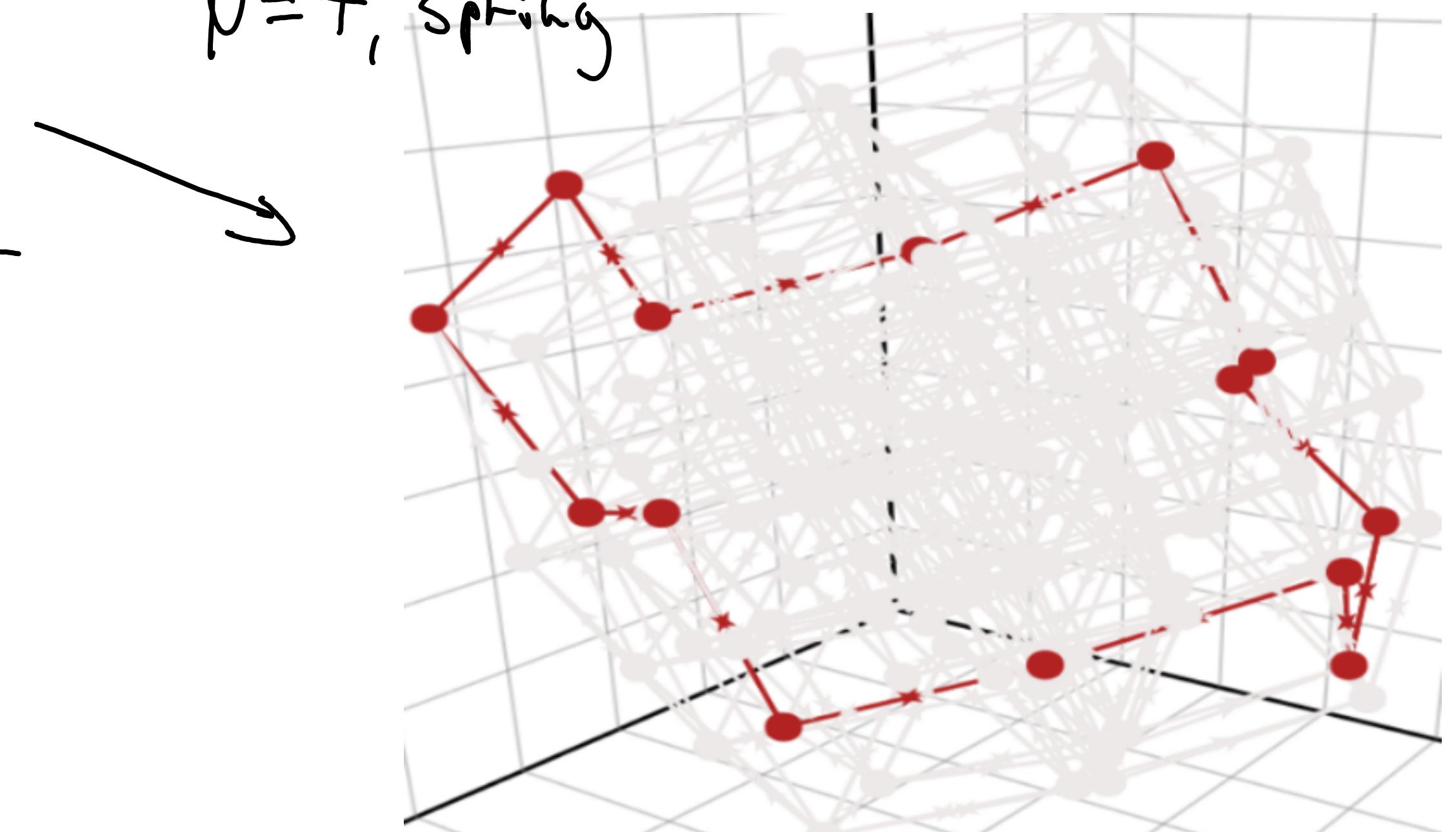
23

at odd N makes a single
single-state loop ac
and a very interesting one
↓

11 01
10 11



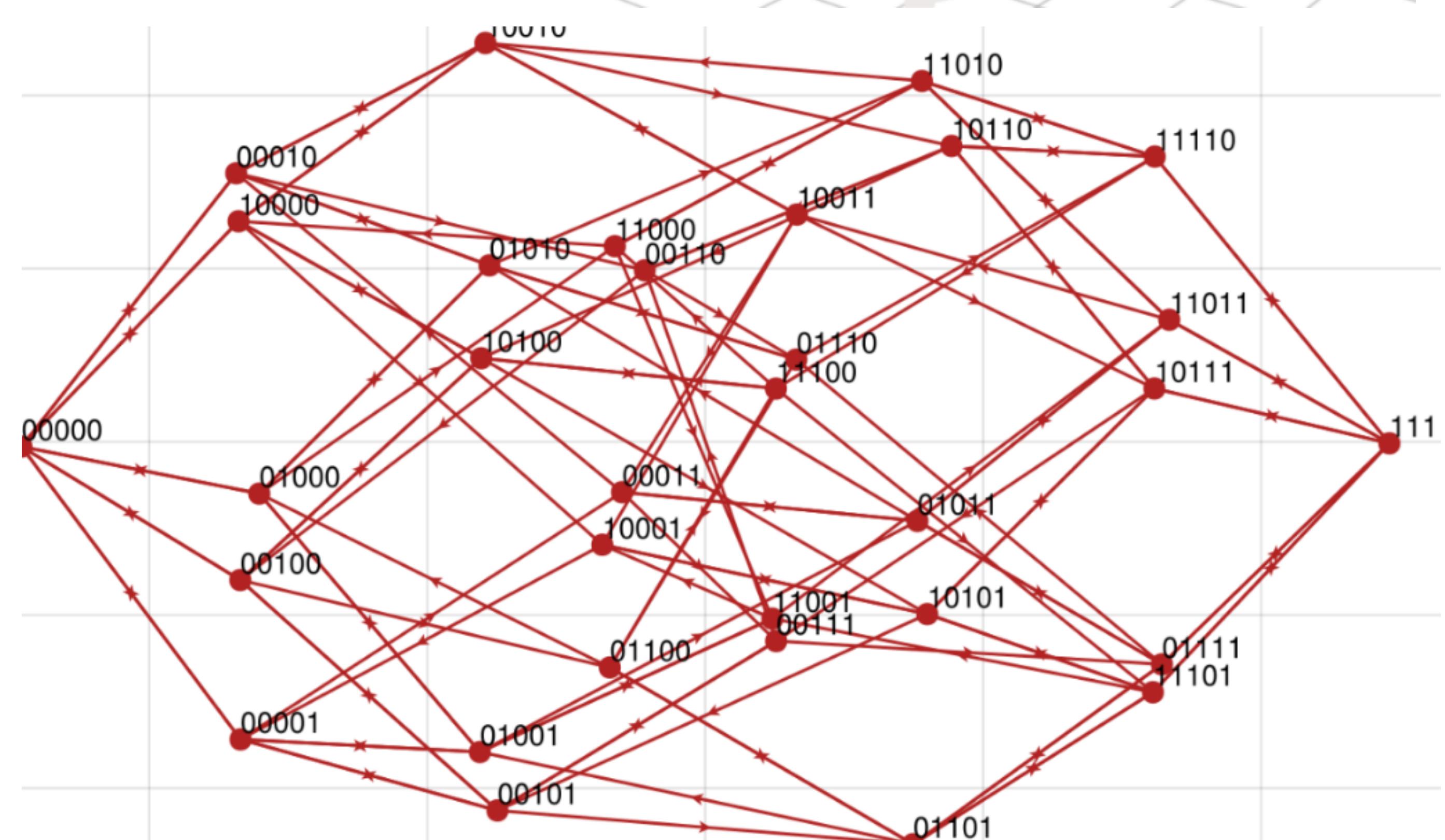
the system gets almost stuck
full of many domains and
they shift one after another
(diffuse though)

at even N gets stuck in $\overline{01}$ $N > 5$, spectral $N=7$, spring

43 - very similar to 33

but unbiased

11 10
01 11



5 engine subroutines

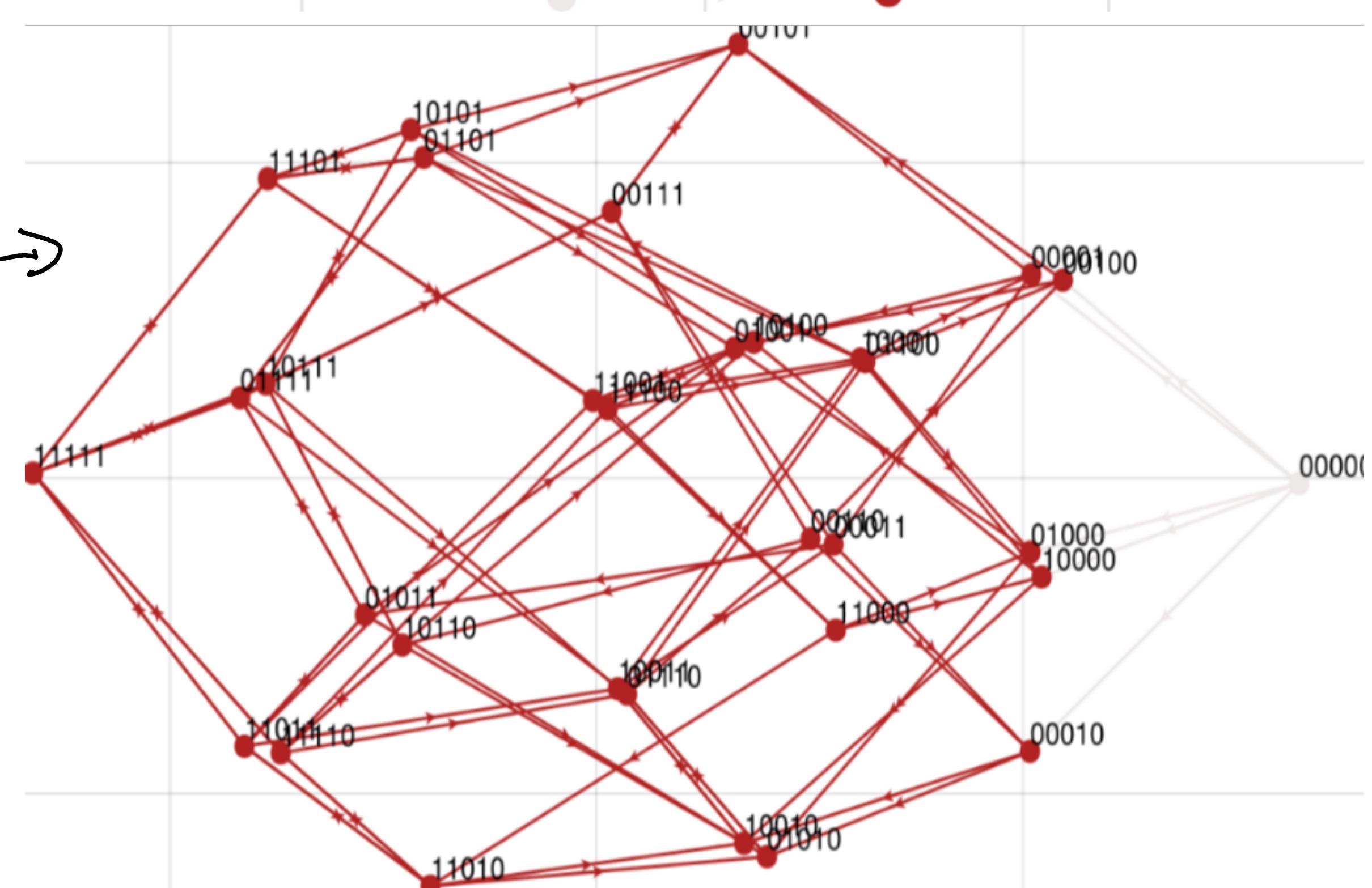
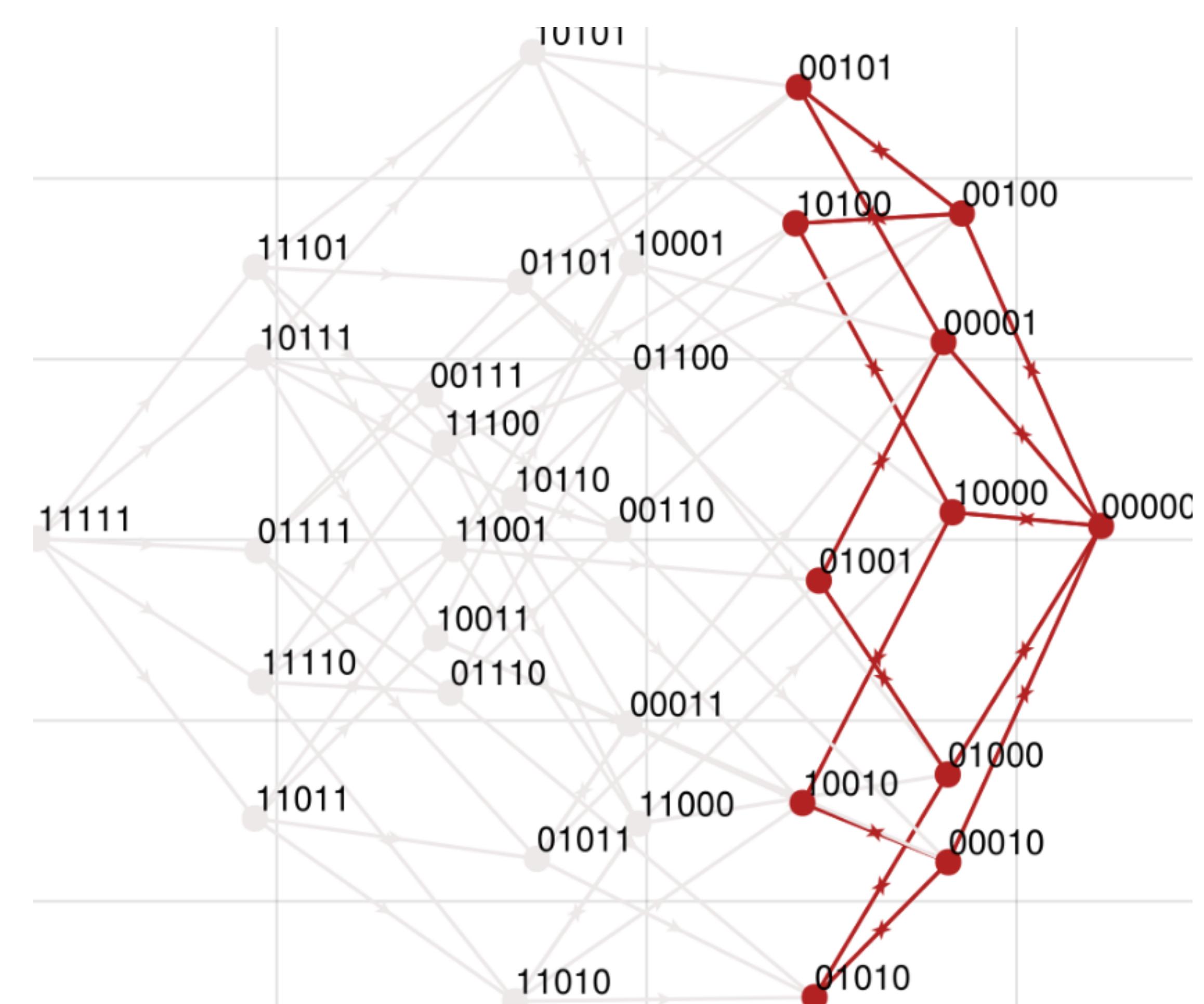
1 - 1 diff ac connecting to all 0s
 $\begin{array}{c} 10 \\ 00 \\ \downarrow Ttt \\ 11 \\ 01 \\ 11 \end{array}$

32 - all 0s only ac
 $\begin{array}{c} 00 \\ 01 \\ 11 \\ 01 \\ 11 \end{array}$

2 - all 0s only ac
 $\begin{array}{c} 01 \\ 00 \\ 11 \end{array}$

37 - ac including all but all 0s
 $\begin{array}{c} 10 \\ 01 \\ 01 \\ 11 \\ \downarrow T \\ 11 \\ 01 \\ 11 \end{array}$
at evenN gets stuck in $\overline{001}$

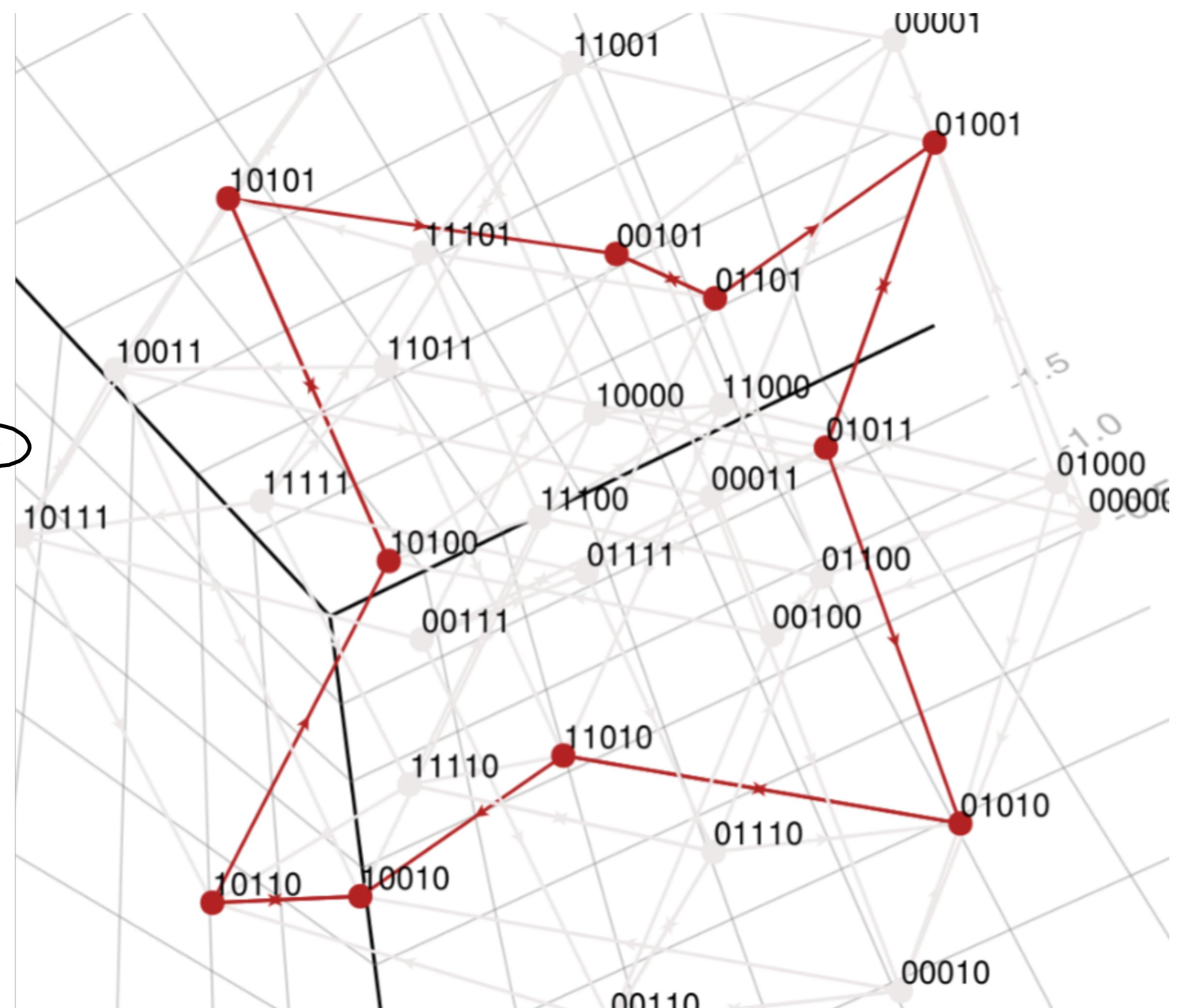
122 - all 0s only ac
 $\begin{array}{c} 01 \\ 10 \\ 11 \\ 01 \end{array}$



interesting loops at odd N
gets stuck in $\overline{01}$ at even N

7 - very similar to 23 but
every other arrow in loop →
is directed *

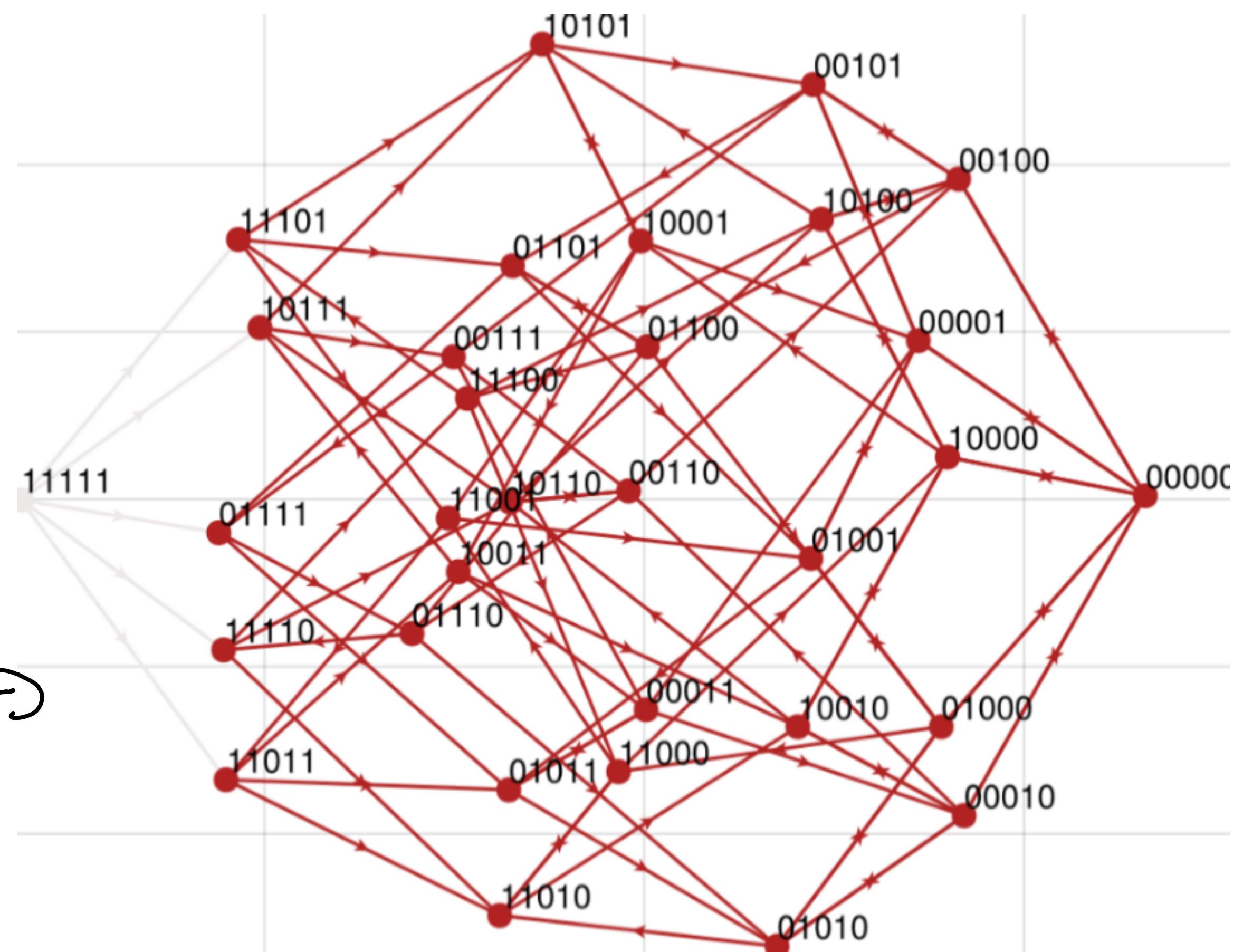
162 - all 0s and all 1s
only acs
 $\begin{array}{c} 01 \\ 11 \\ 01 \\ 10 \end{array}$



42 - all 0s only ac

01 10
01 11
} T+
11

- very similar to 37, has one complex ac connecting all but → all 1s



26 - all 0s only ac

01 10
10 11

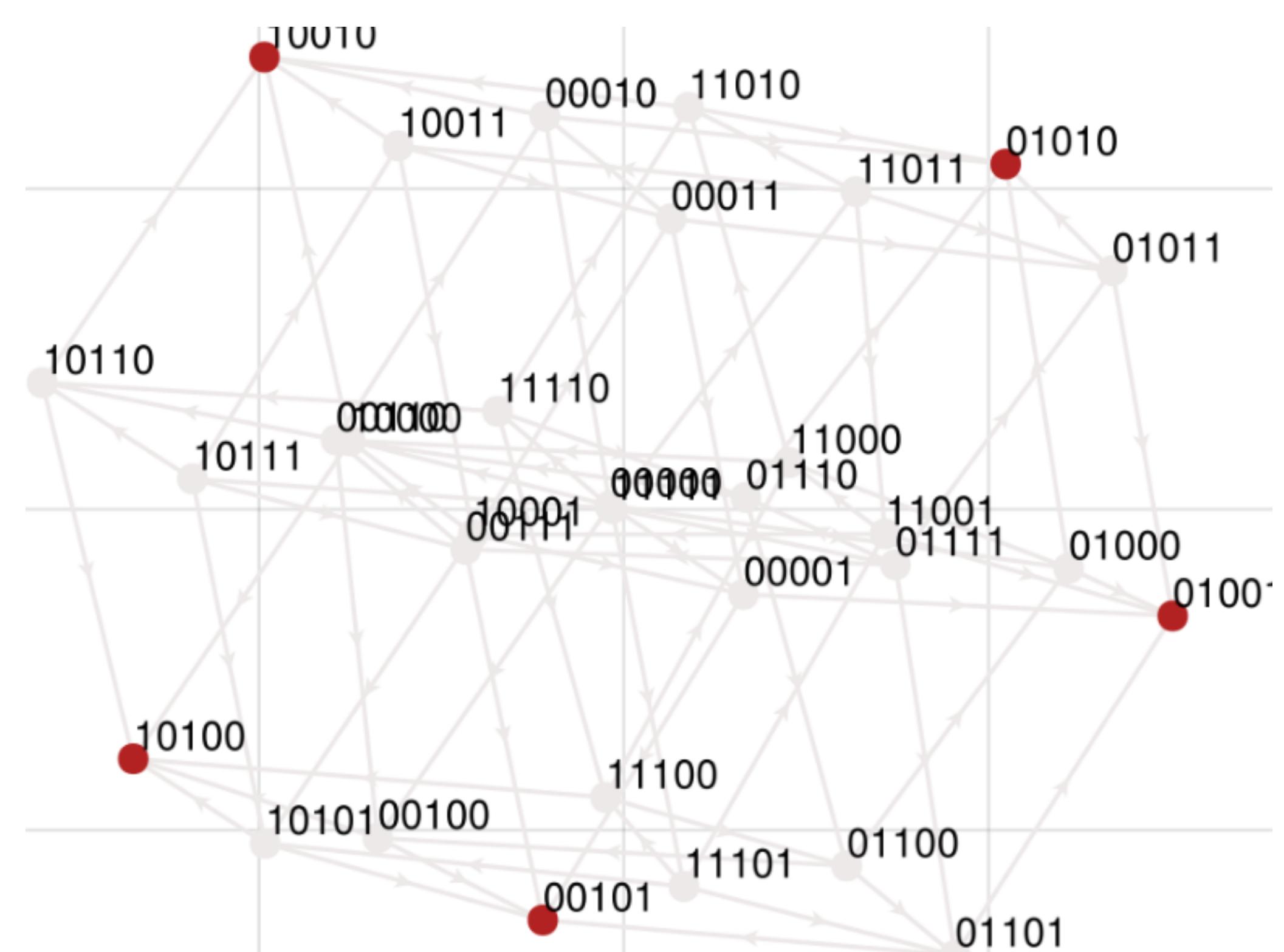
4 engine subrules

0 - all 0s only ac

00 11
00 11

10 - all 0s only ac

01 10
00 11



5 - multiple single-state acs - all full of isolated

10 01
00 11

} T++
11

160 - all 0s and all 1s only acs

00 11
01 10

120 - all θ_5 and all 1_s only as

$$\begin{array}{ccc} 0 & 1 & 10 \\ 0 & 1 & 10 \\ \downarrow & & \overline{T++} \end{array}$$

15 - final continuation of

11 00
00 11

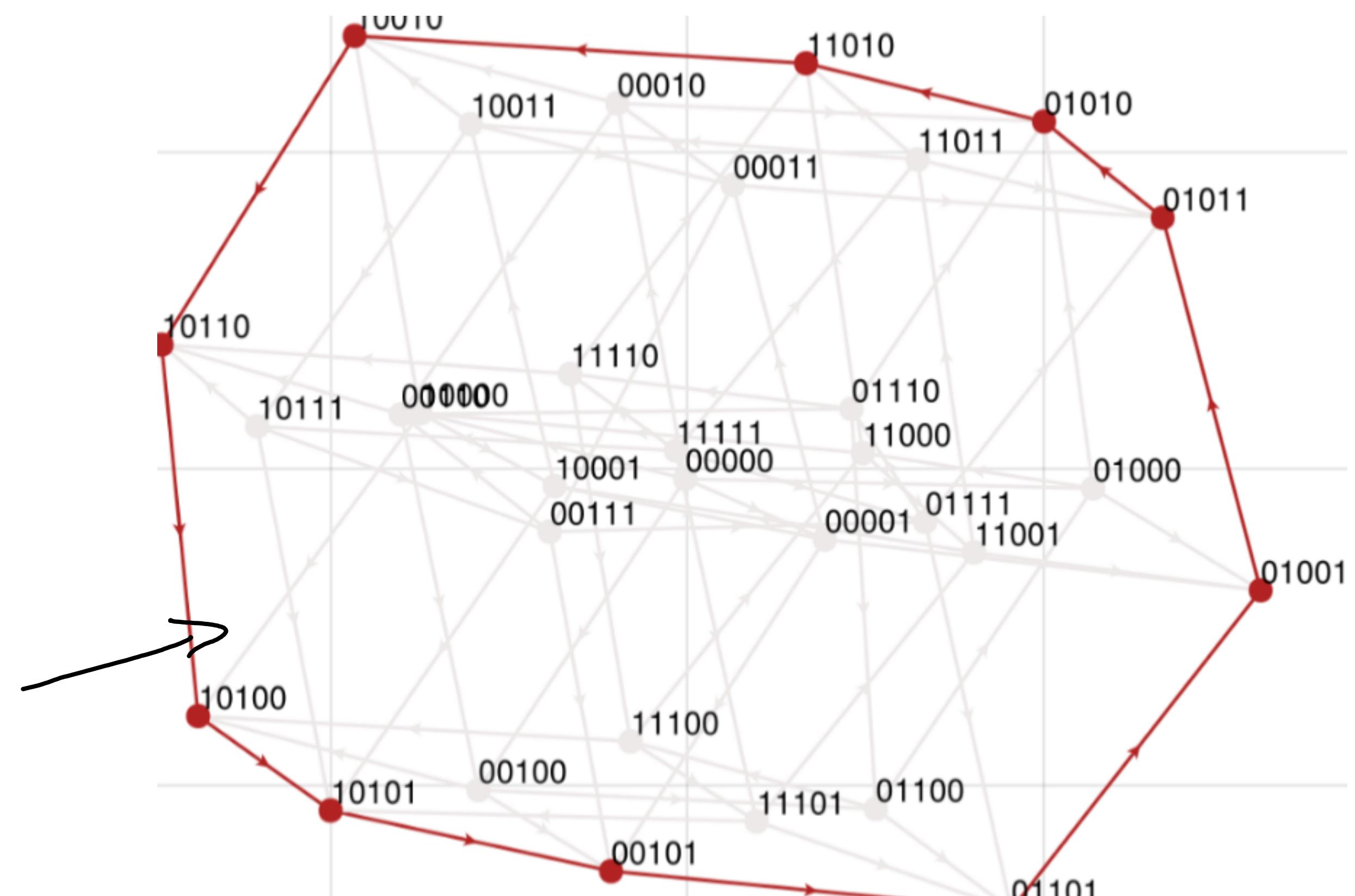
23 awl 7,

has how full, I needed

loops at o.l.l.n

and gets stuck at $\overline{G_1}$

ihren



90 - all Os only as unless

0110
1001

N is divisible by

3 in which case
it gets stuck at $\overline{110}$
which are 3 additional

als

