Noise Engineers

Nontrivial steady states and noise-resilience

Slow noise

If the noise is slow, we can cancel local relaxation to $|0\rangle$

and instead relax to any state! Apply N times:

$R_z(\omega\text{-}h)$ | X | $R_z(\omega+h)$ | X

Steady state should be $|0\rangle$ for $h<0$ and $|1\rangle$ for $h>0$

RESULT: no effect, 50:50 measurements for any ω,h

Possible reasons: (i) Noise is fast. (ii) virtual R_z doesn't work as we thought

Steady state engineering - 1 qubit

Task: create a cycle with runtime <<T_1, where the steady state of the qubits is $|1\rangle$

Solution: Apply N times

X   Wait   X

Where for Wait = T_{CPHASE} we get probability 0.76 for state $|1\rangle$ after N=120

Compare: just Wait gives probability 0.08 of state $|1\rangle$

We tricked the environment into keeping some of state $|1\rangle$

Steady state engineering - 2 qubit

A nontrivial state to engineer would be the degenerate ground state of

$H = -JZ_1Z_2$

$P_{00} = 0.5$, $P_{01} = 0$ $P_{10} = 0$, $P_{11} = 0.5$

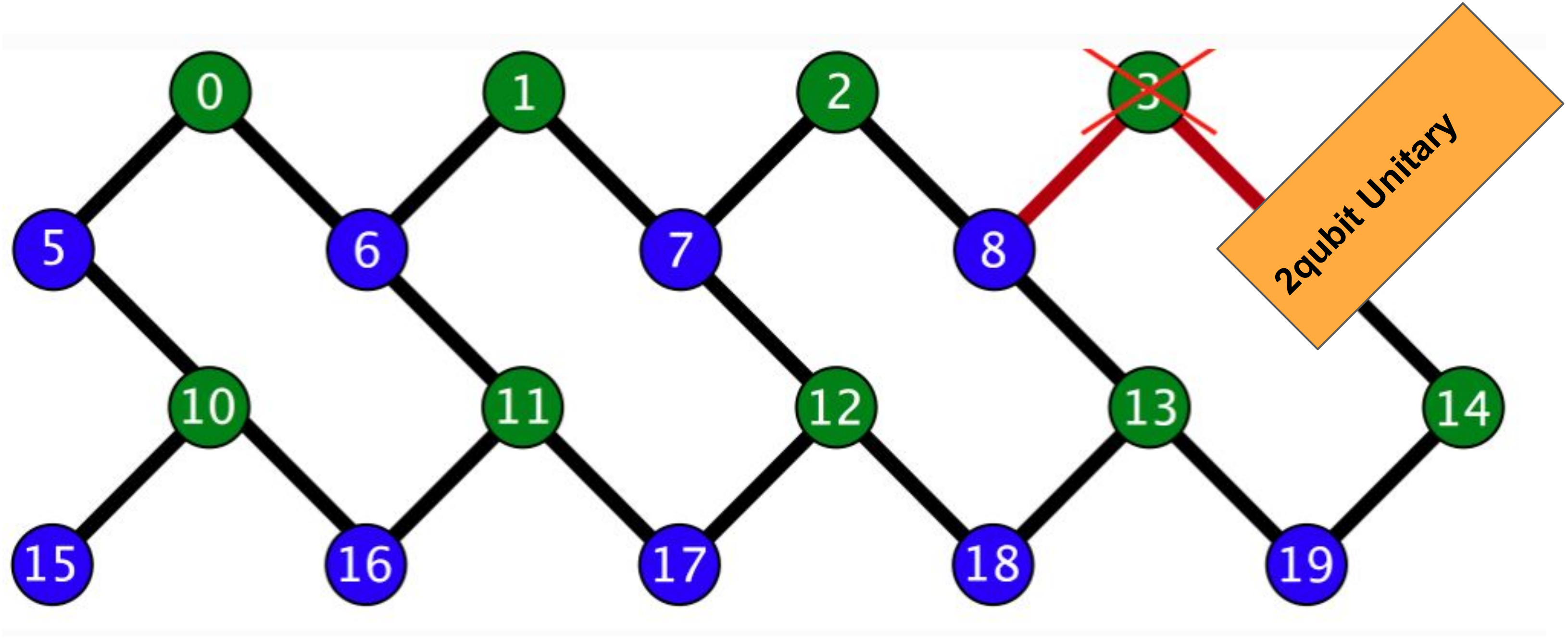
We have tried multiple circuits but we never saw a **steady** state that is like that.

Possible reasons: 2qubit gates too slow/noisy.

We couldn’t control the noise of 2qubit gates with just 2 qubits

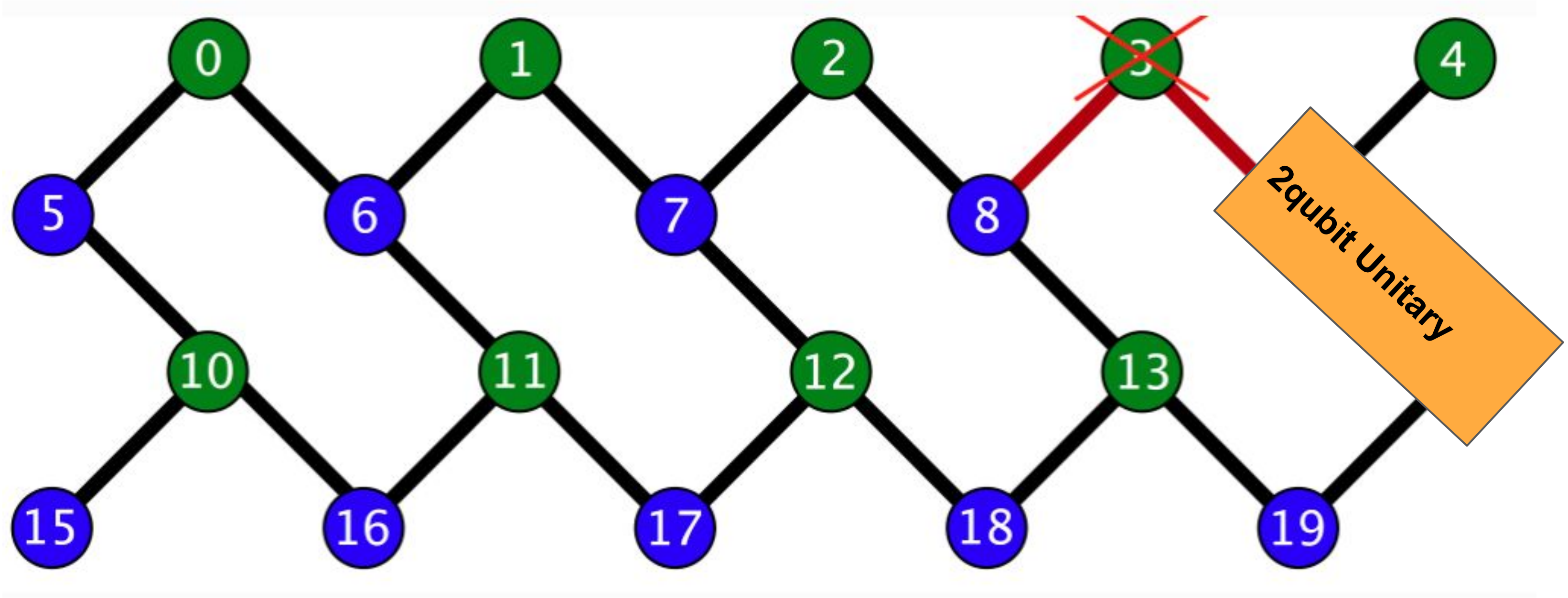
Steady state engineering - 2 qubit with Ancillas

Aka Noise-resilient circuits (Isaac Kim, 2017)



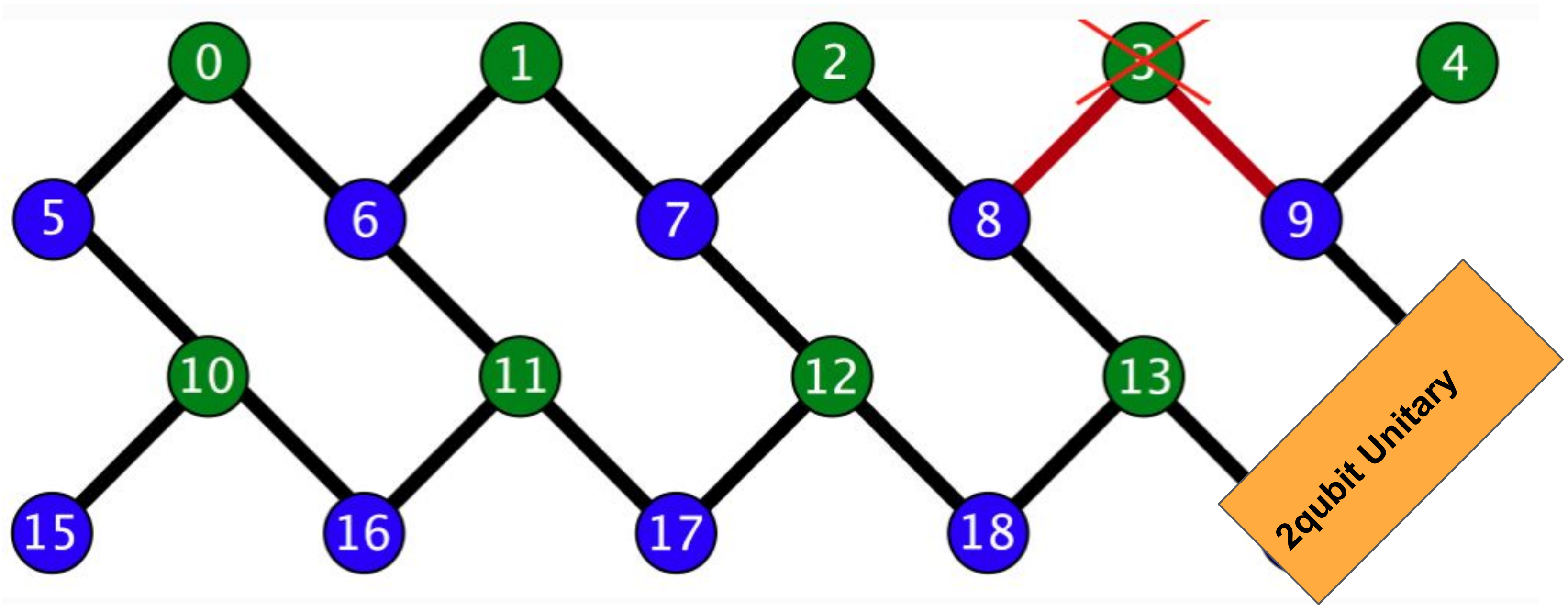
Steady state engineering - 2 qubit with Ancillas

Aka Noise-resilient circuits (Isaac Kim, 2017)



Steady state engineering - 2 qubit with Ancillas

Aka Noise-resilient circuits (Isaac Kim, 2017)



Steady state engineering - 2 qubit with Ancillas

Aka Noise-resilient circuits (Isaac Kim, 2017)

Total Error of a final 1qubit 10% ±7% at depth 16!