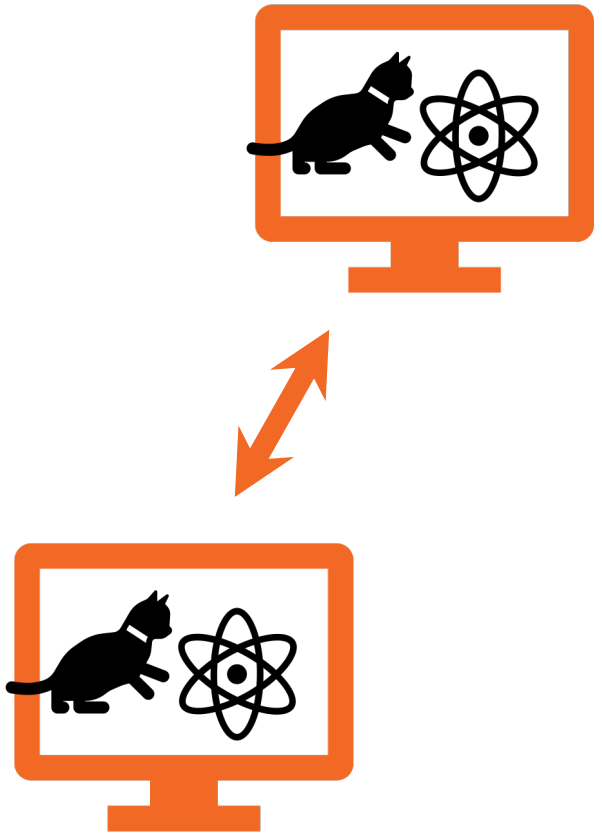
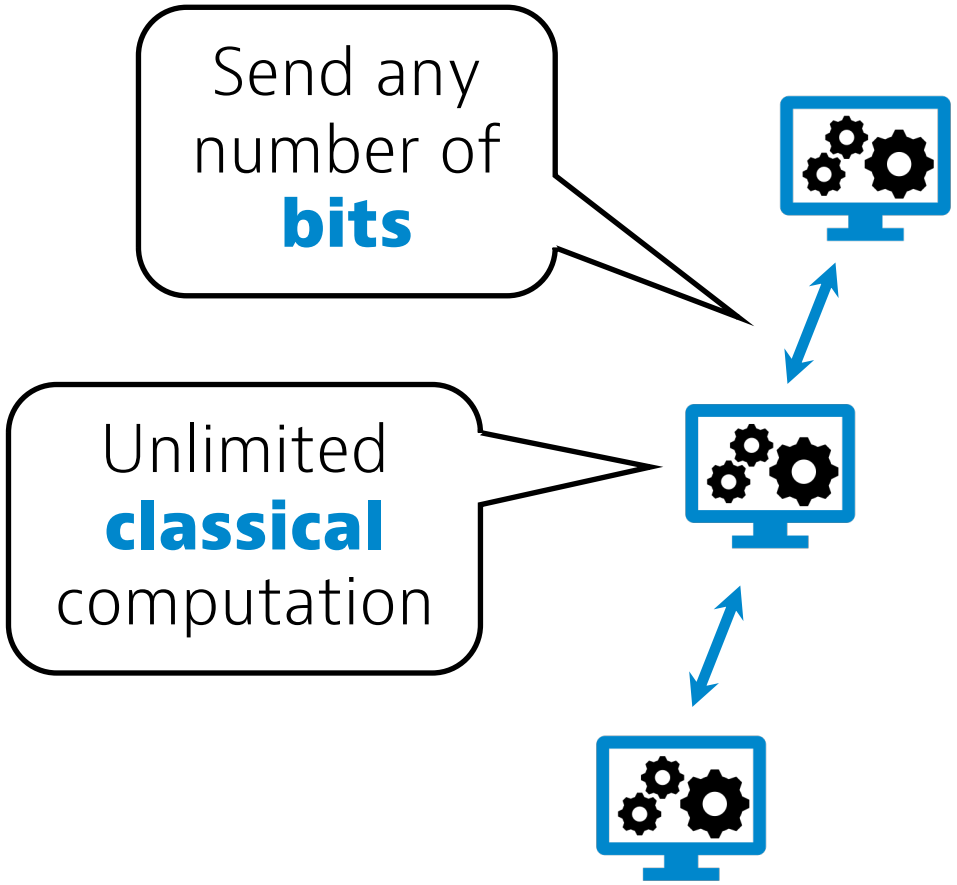
Distributed Quantum Advantage

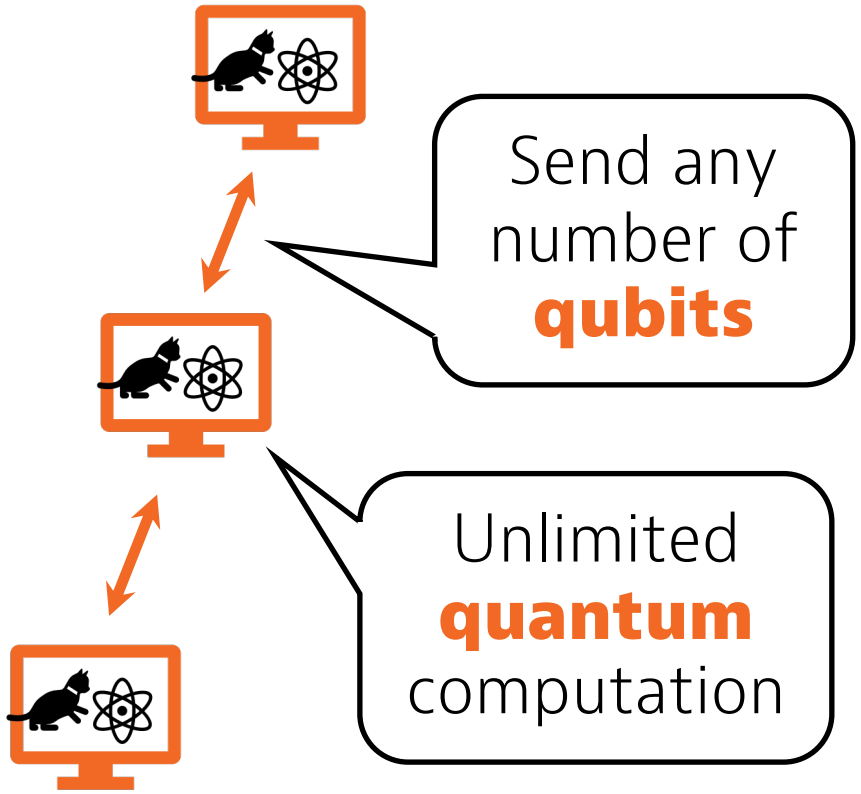


Jukka Suomela
Aalto University

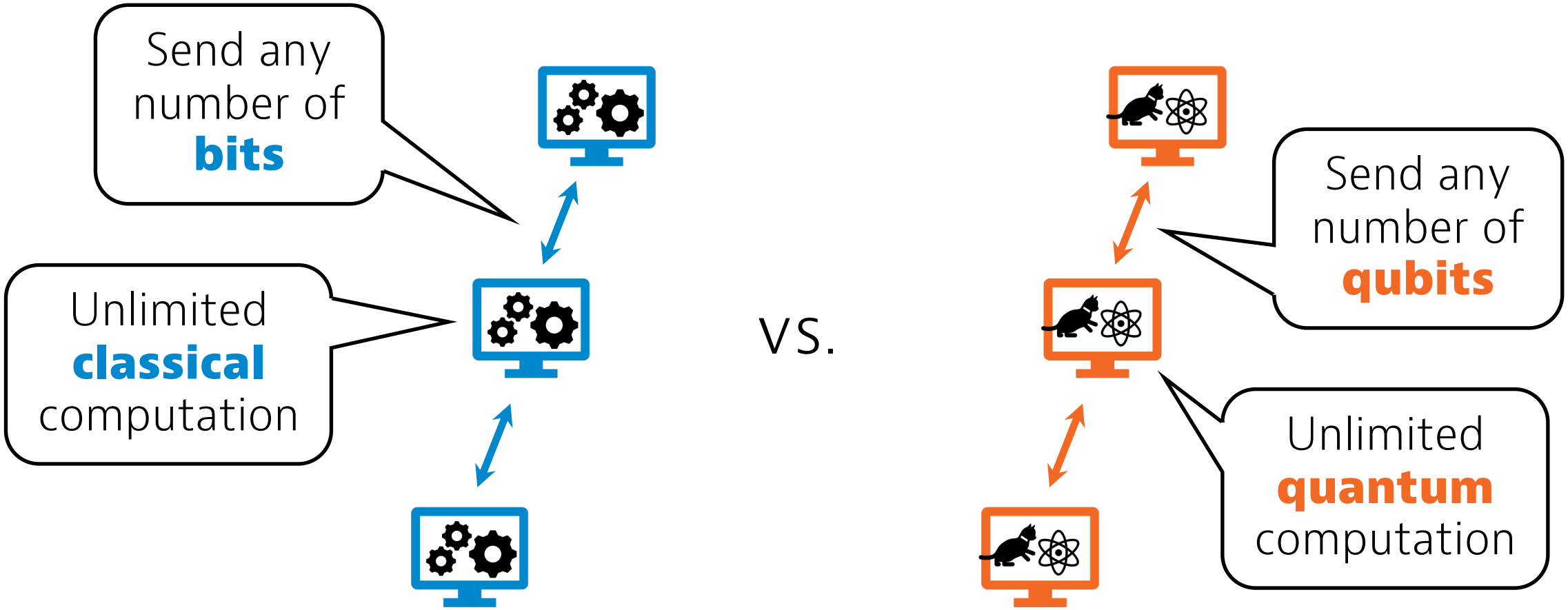


Classical computer network

vs.

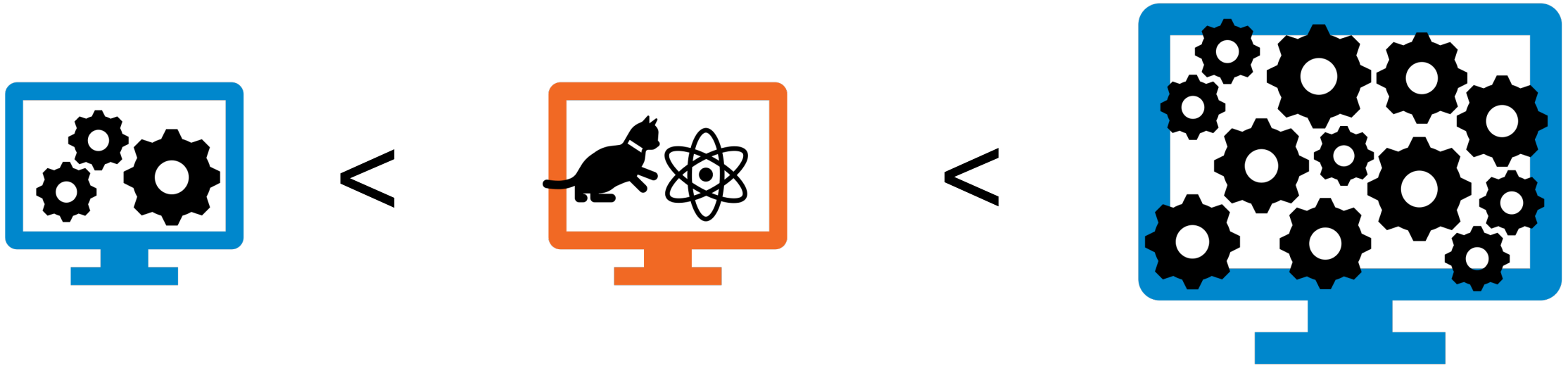


Quantum computer network

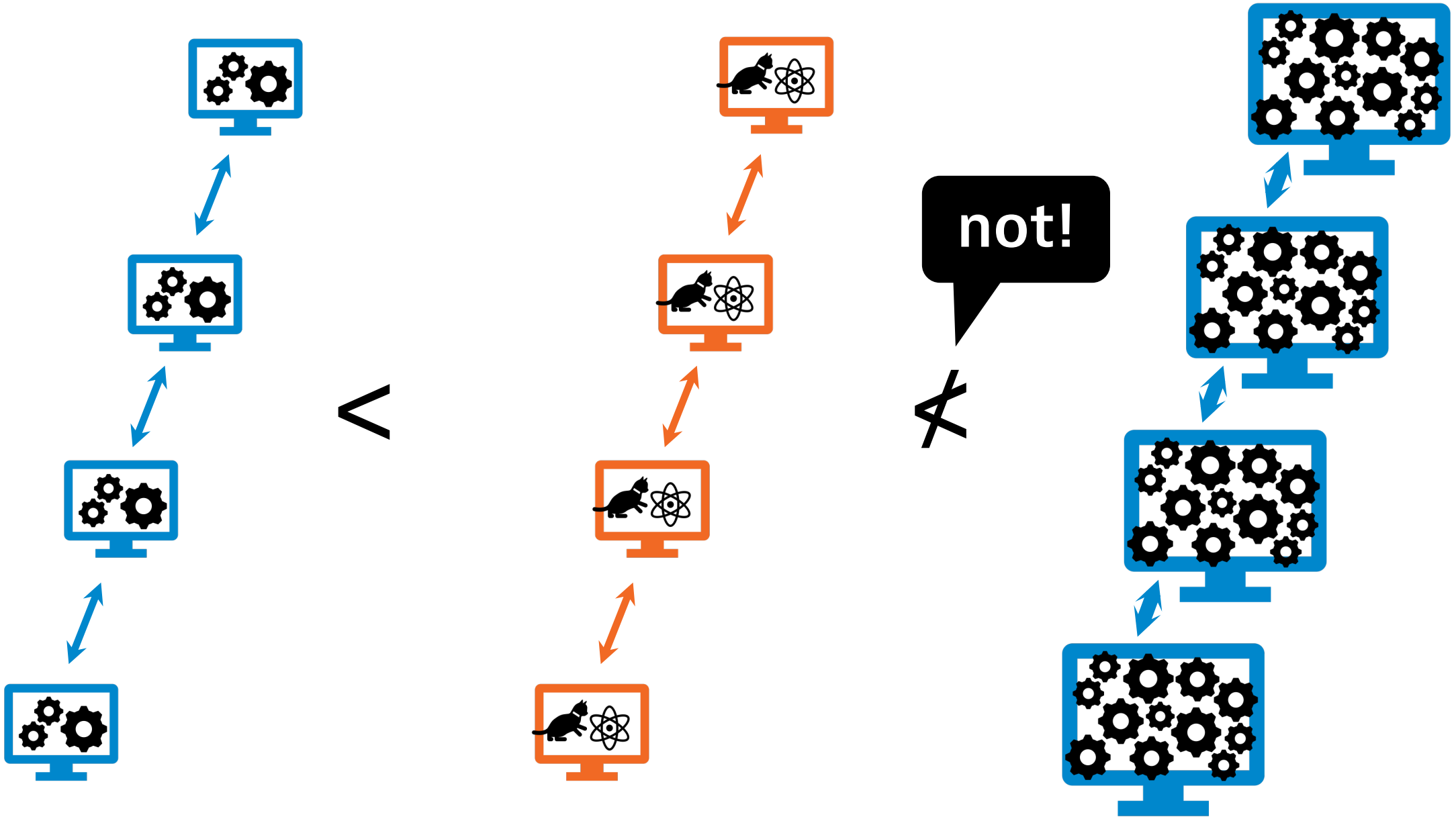


How many **communication rounds** are needed until all computers stop and announce their local outputs?

Compare with **centralized, sequential computation:**



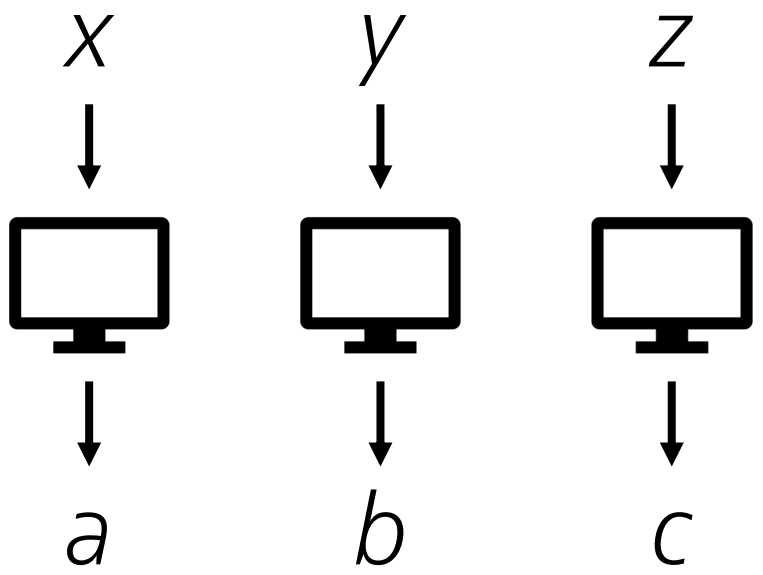
Classical < Quantum < Classical (exponentially faster and bigger)


not!

GHZ game

Greenberger,
Horne, Zeilinger

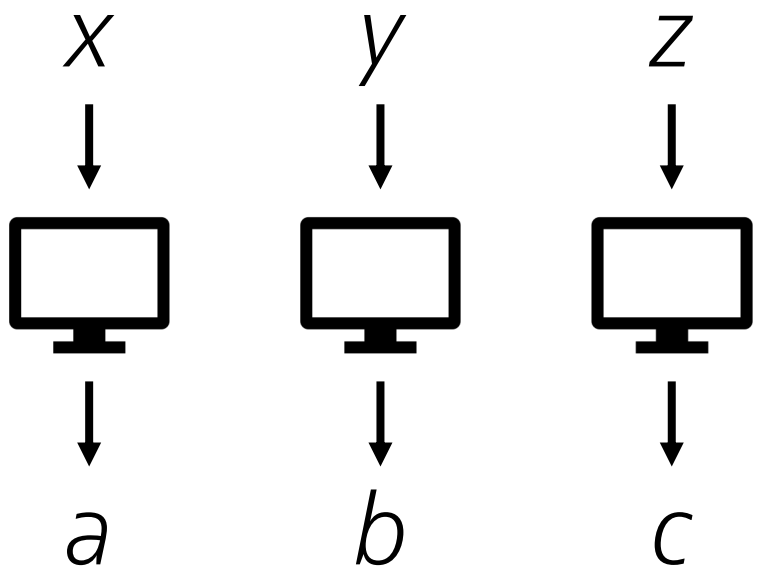
$x + y + z$	$a + b + c$ mod 2
0	0
1	(forbidden)
2	1
3	(forbidden)



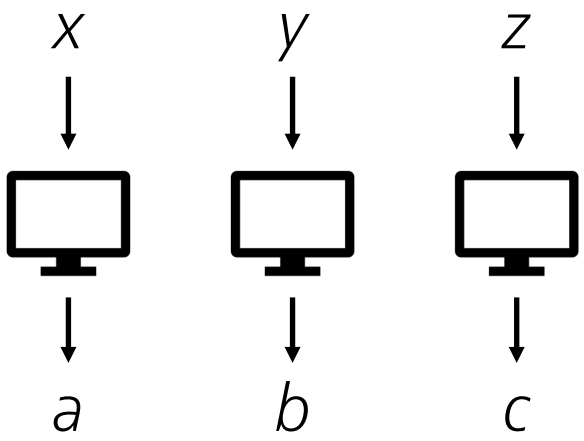
GHZ game

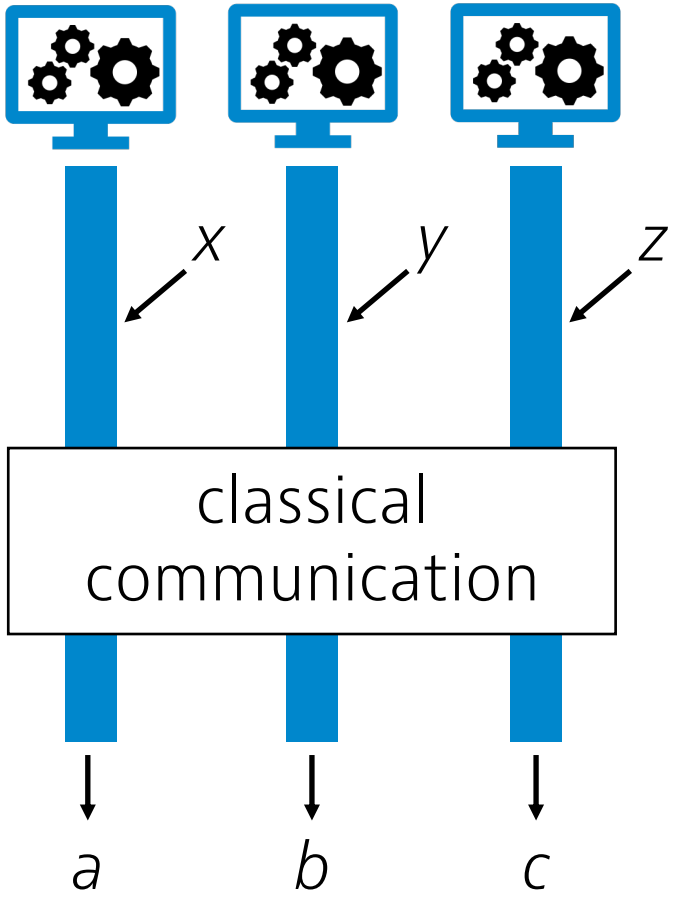
Greenberger,
Horne, Zeilinger

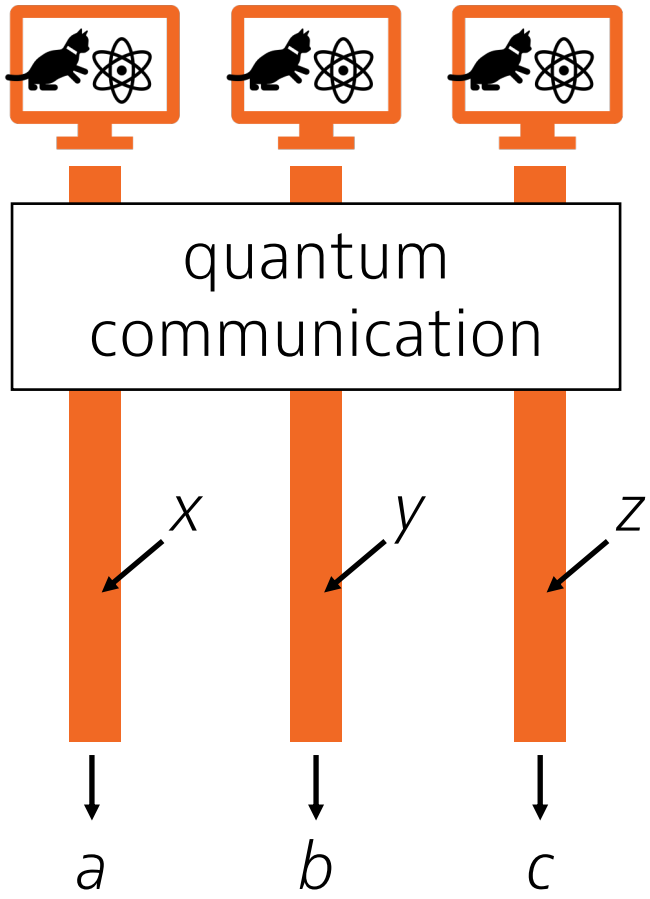
$x + y + z$	$a + b + c$ mod 2
0	0
1	0 or 1
2	1
3	0 or 1



$x + y + z$	$a + b + c$ mod 2
0	0
1	0 or 1
2	1
3	0 or 1







Le Gall, Nishimura,
Rosmanis (2019):

Quantum Advantage for the LOCAL Model in Distributed Computing

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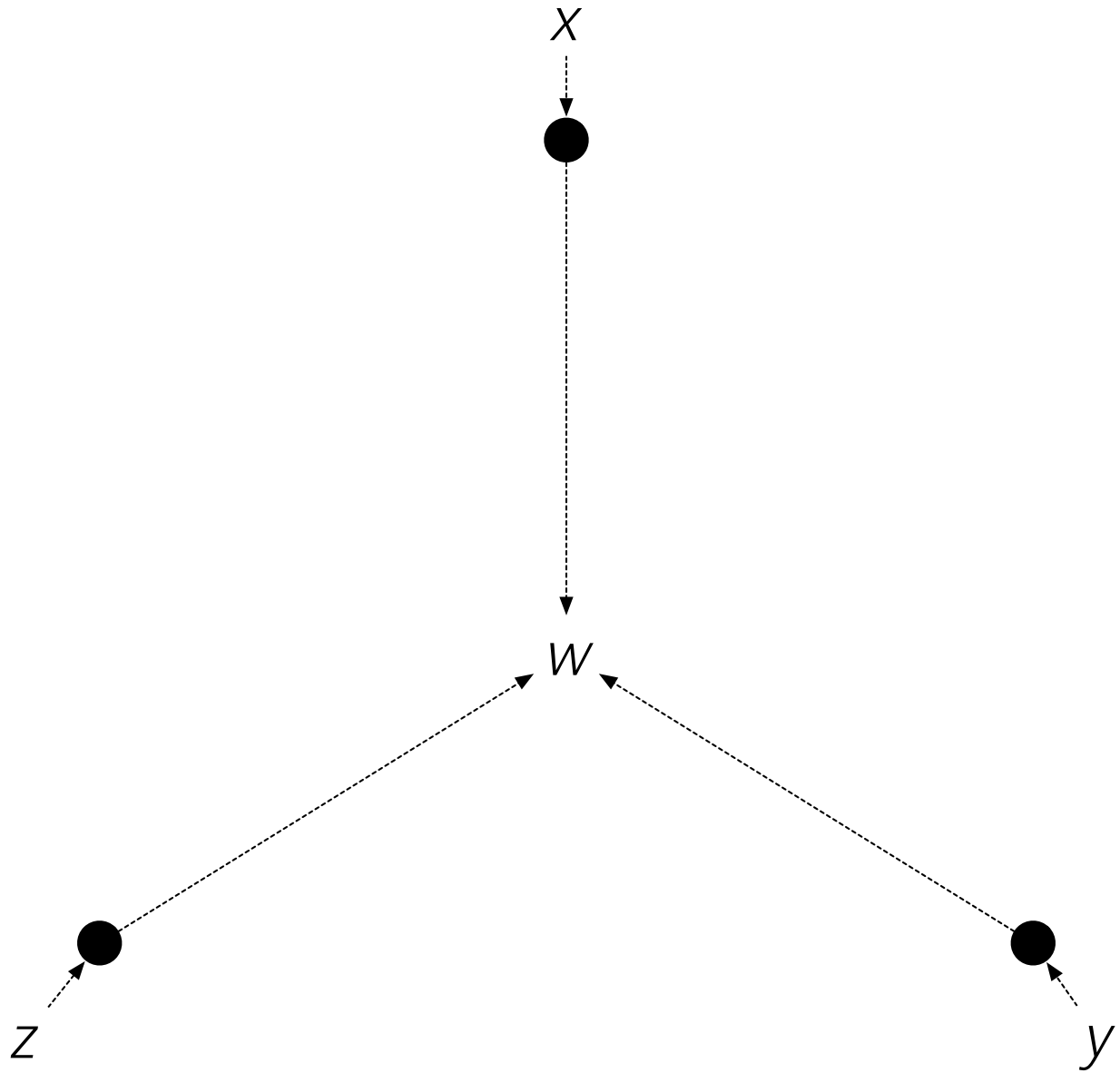

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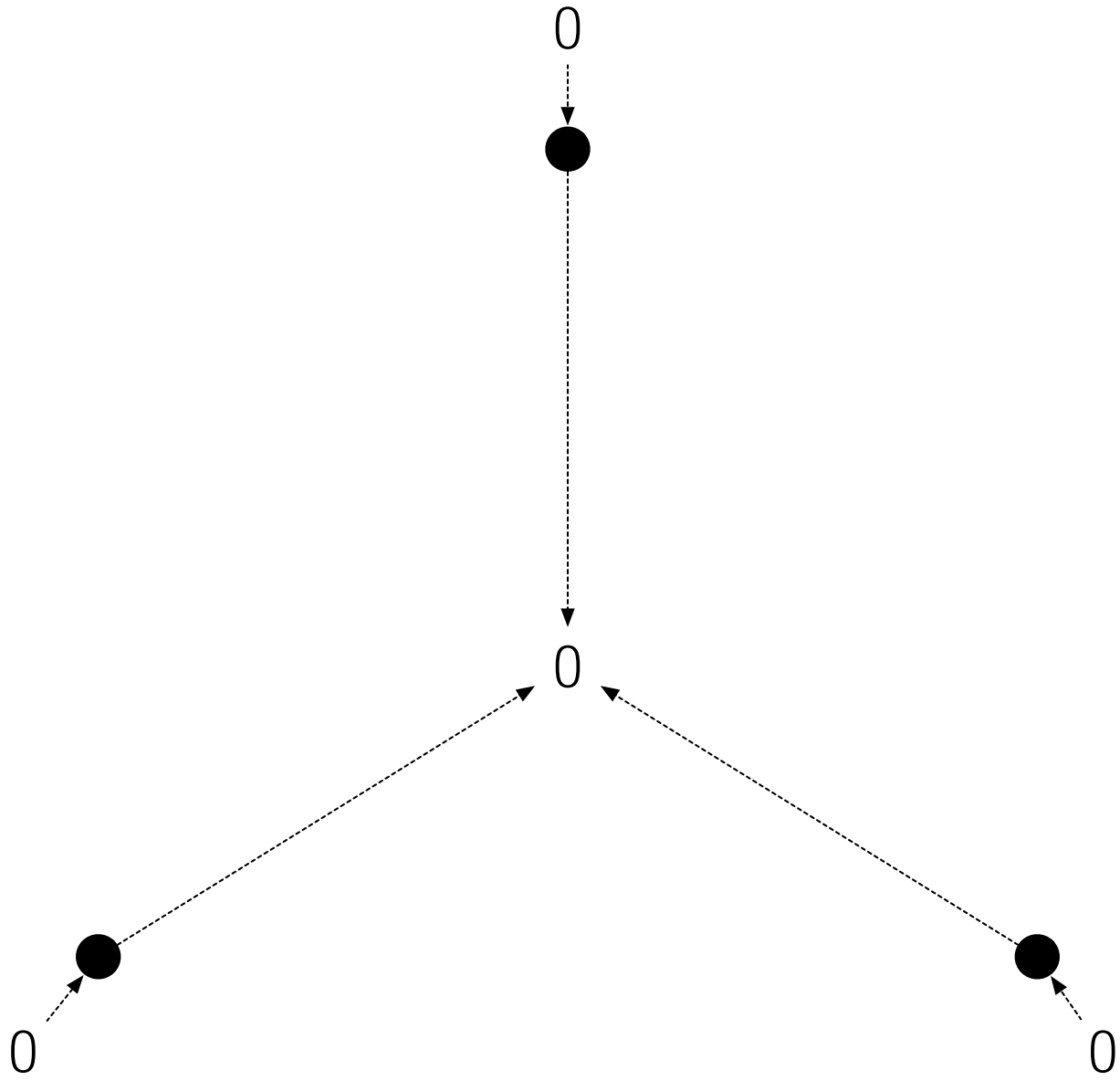

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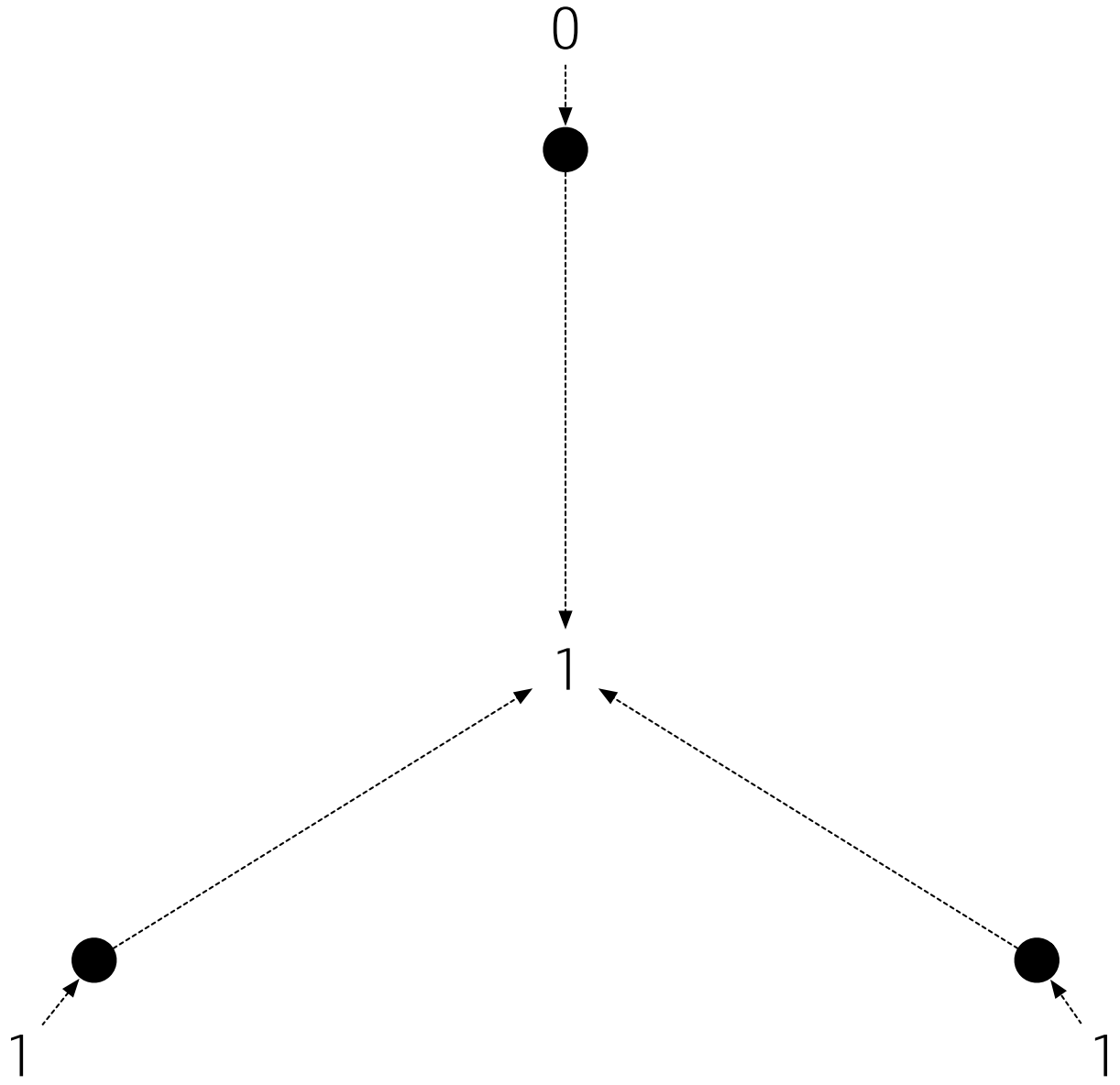

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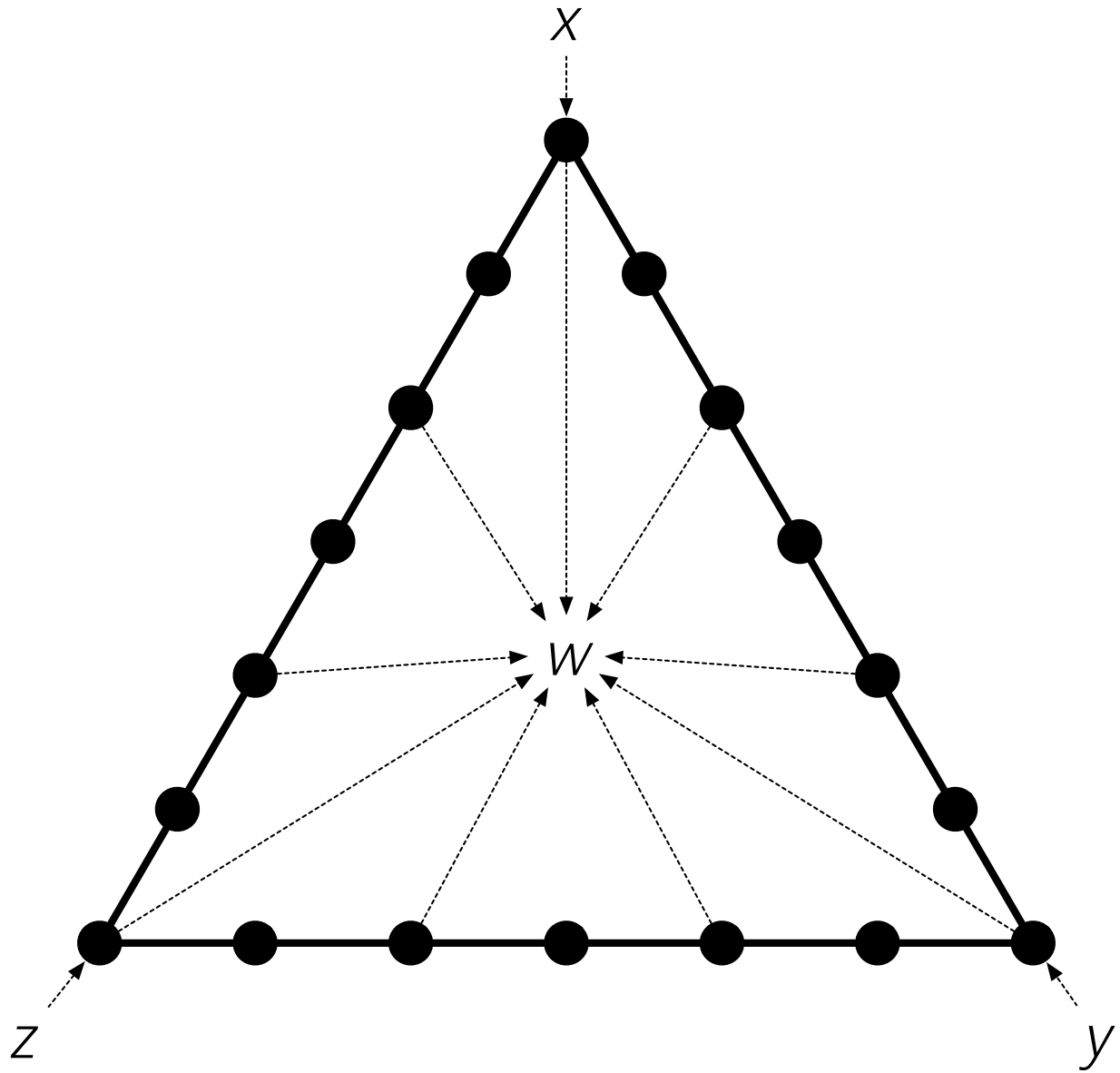

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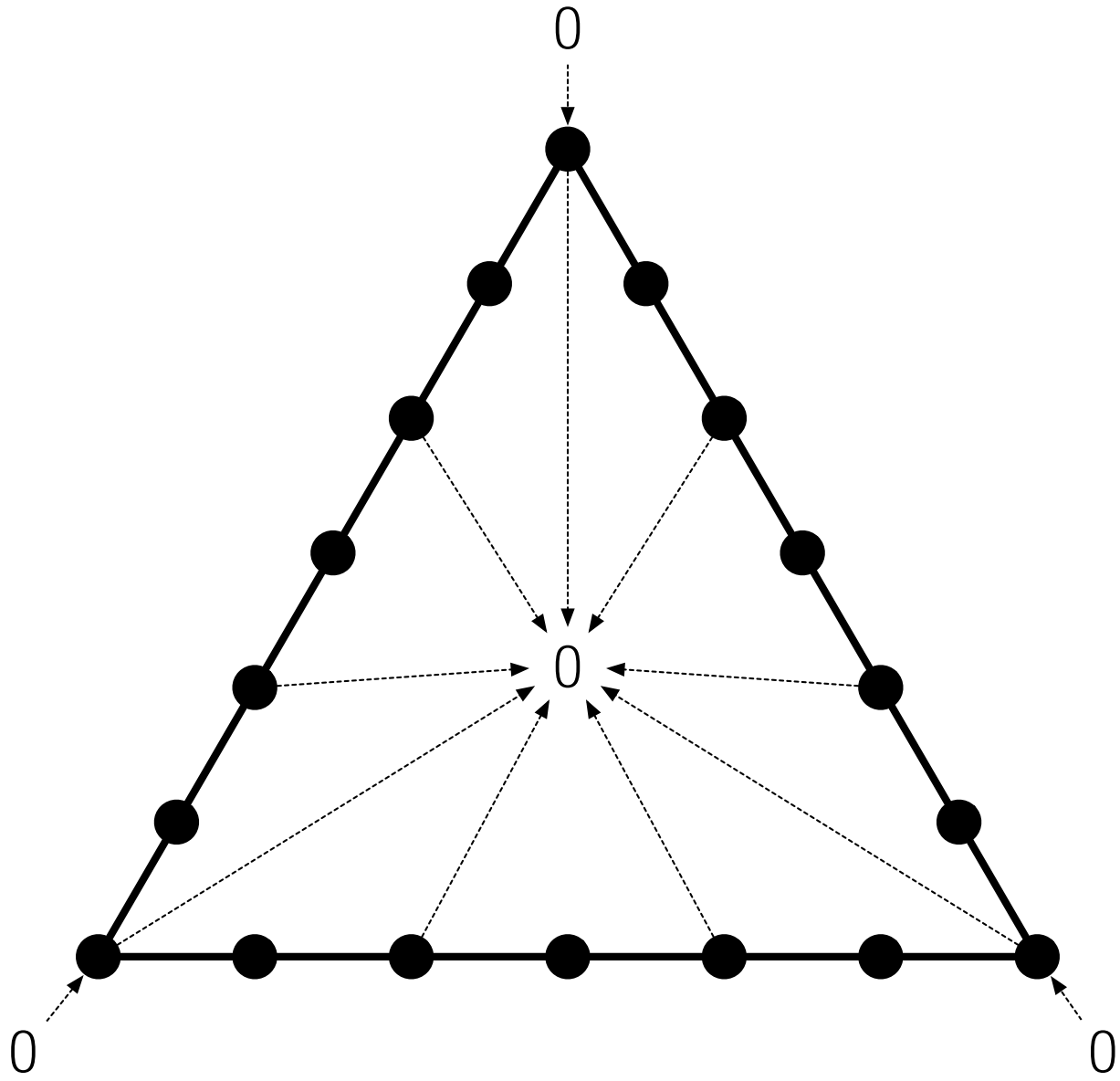

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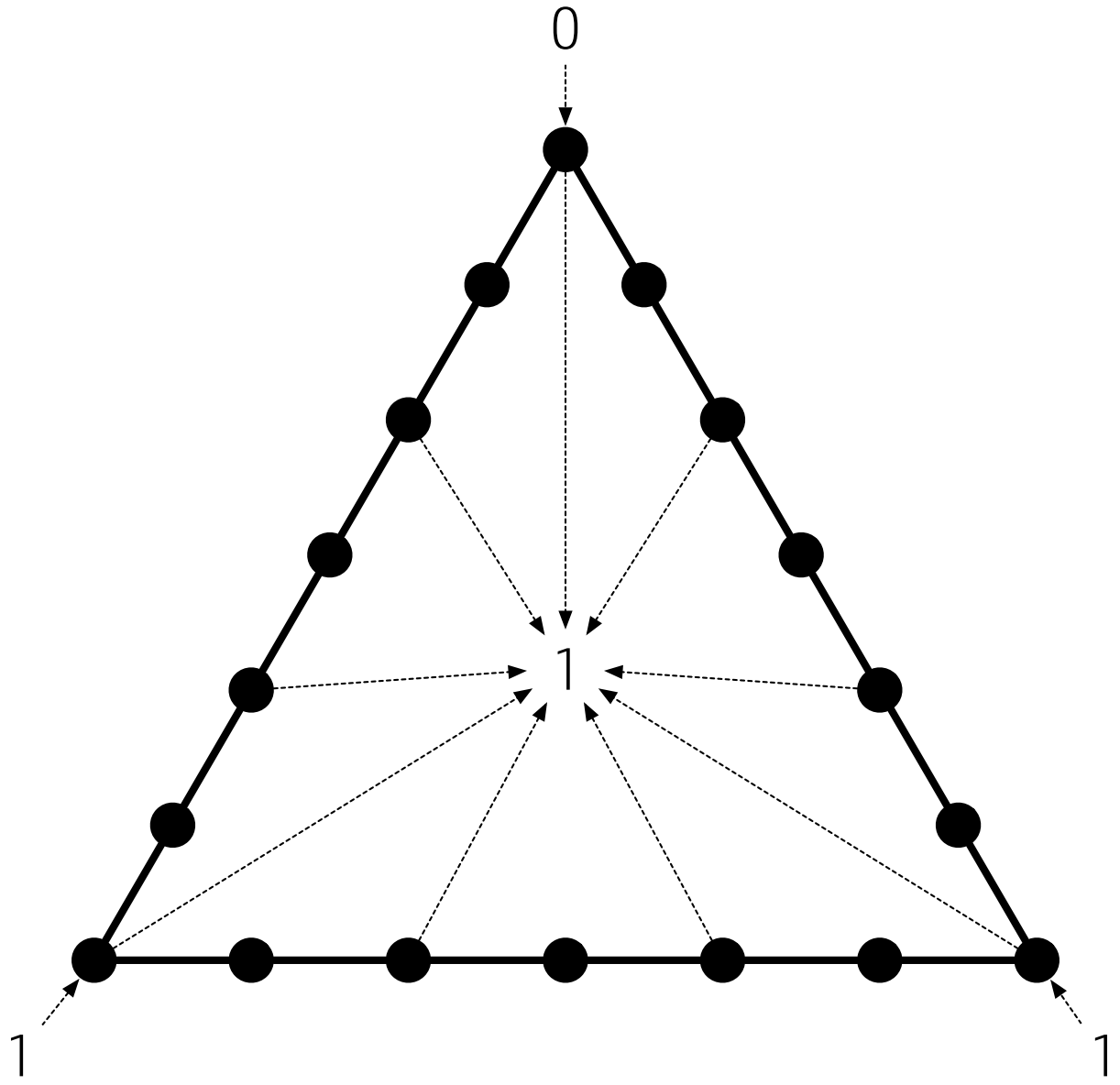

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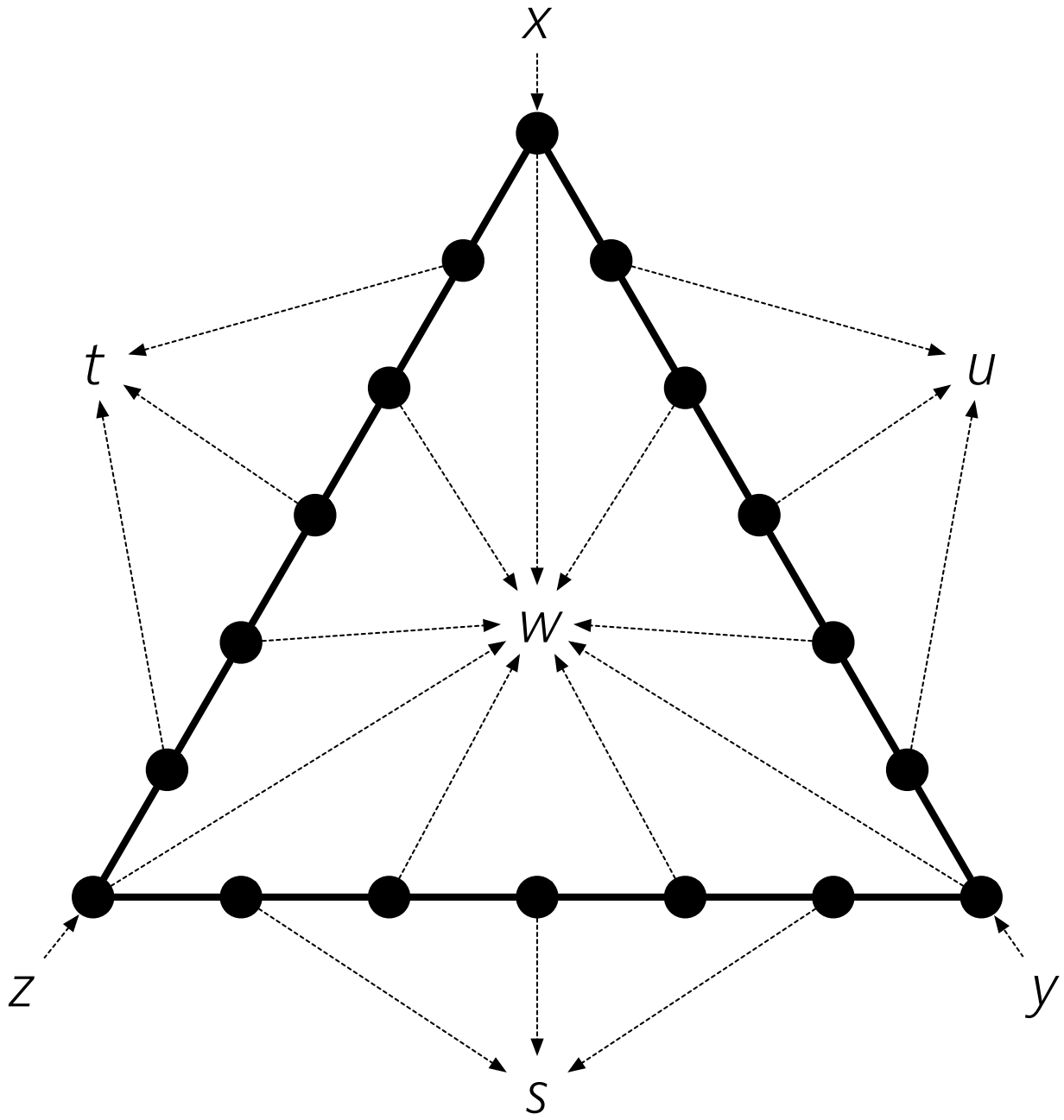

$s + t + u = 0 \bmod 2$

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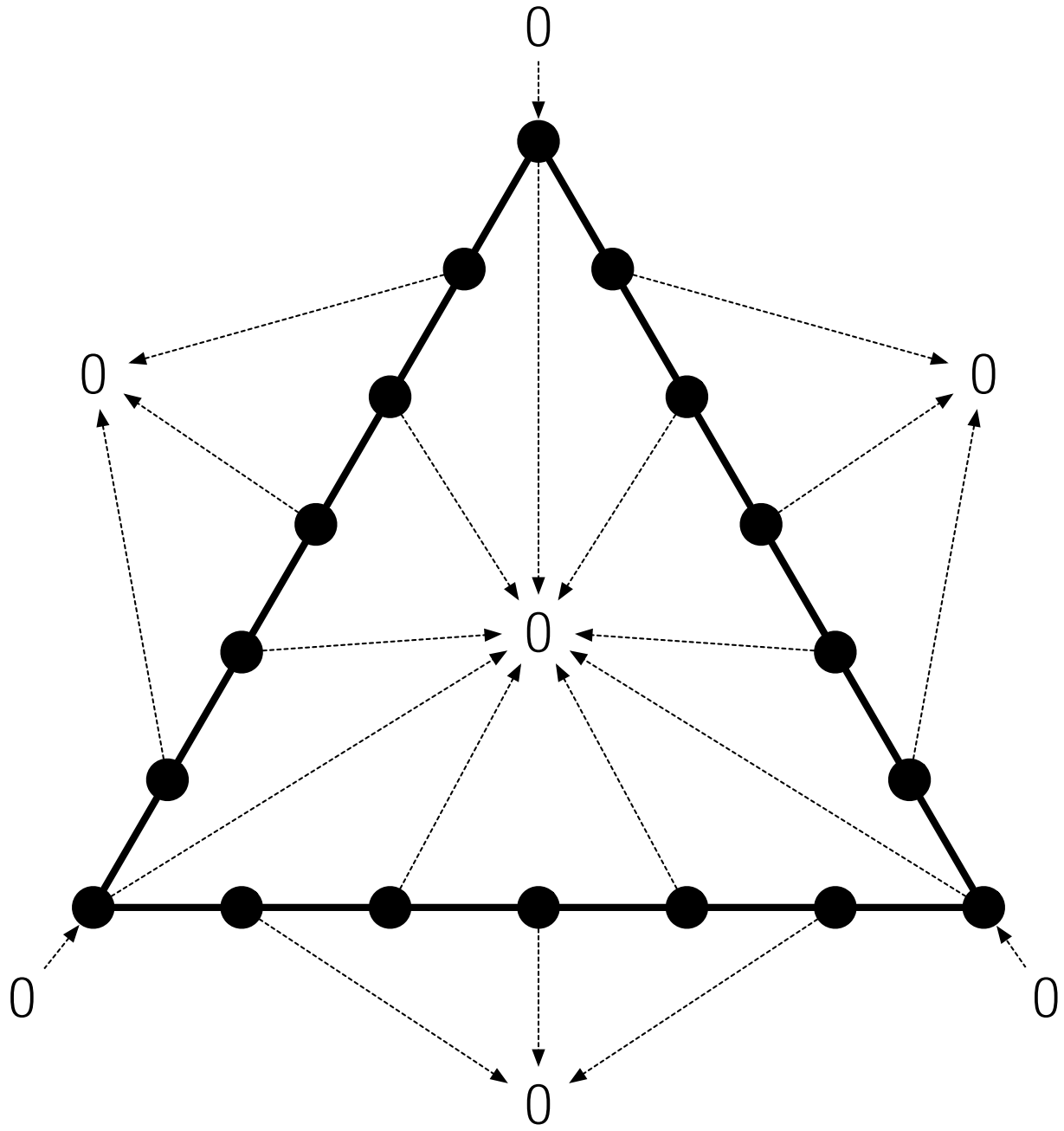

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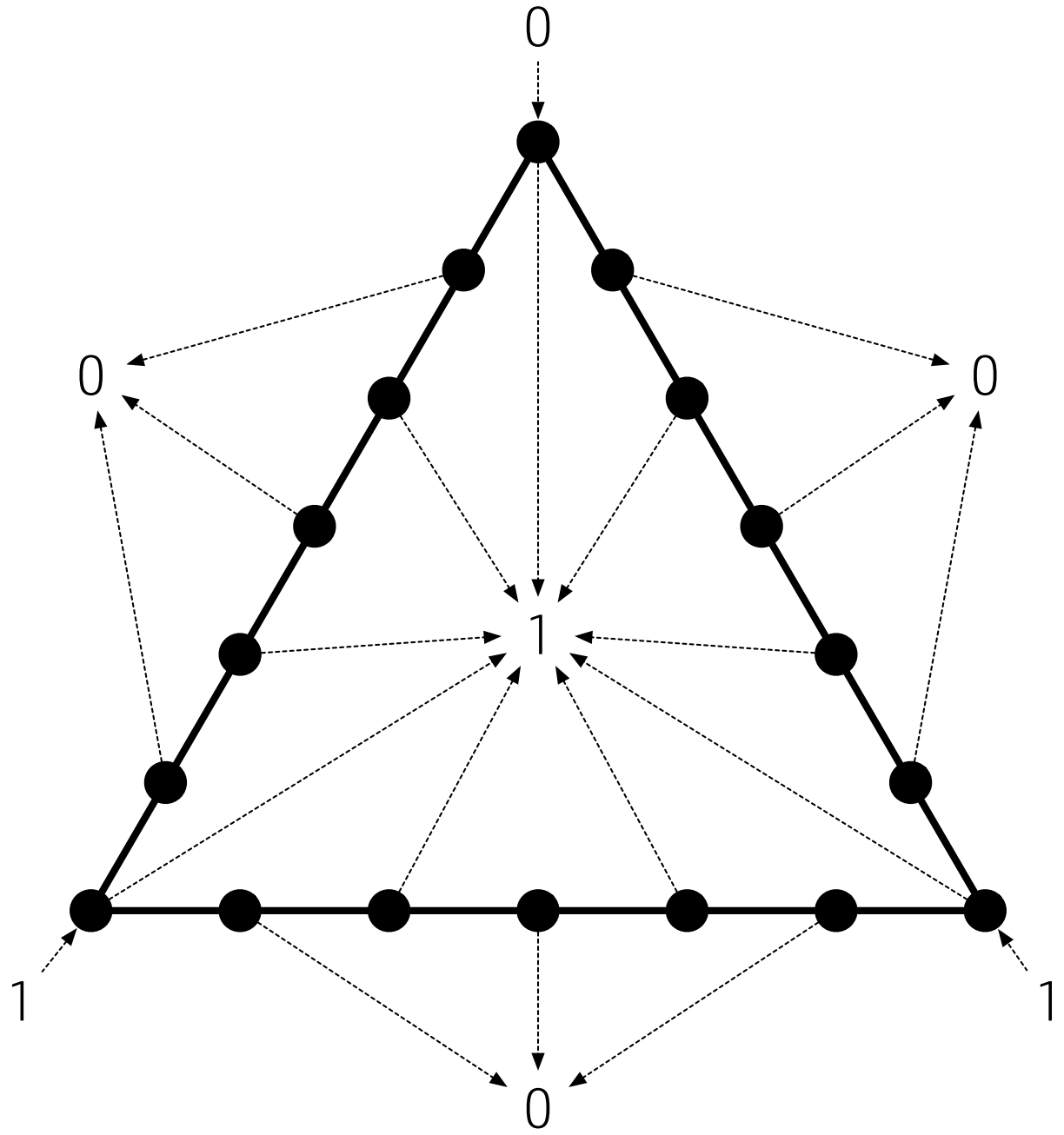

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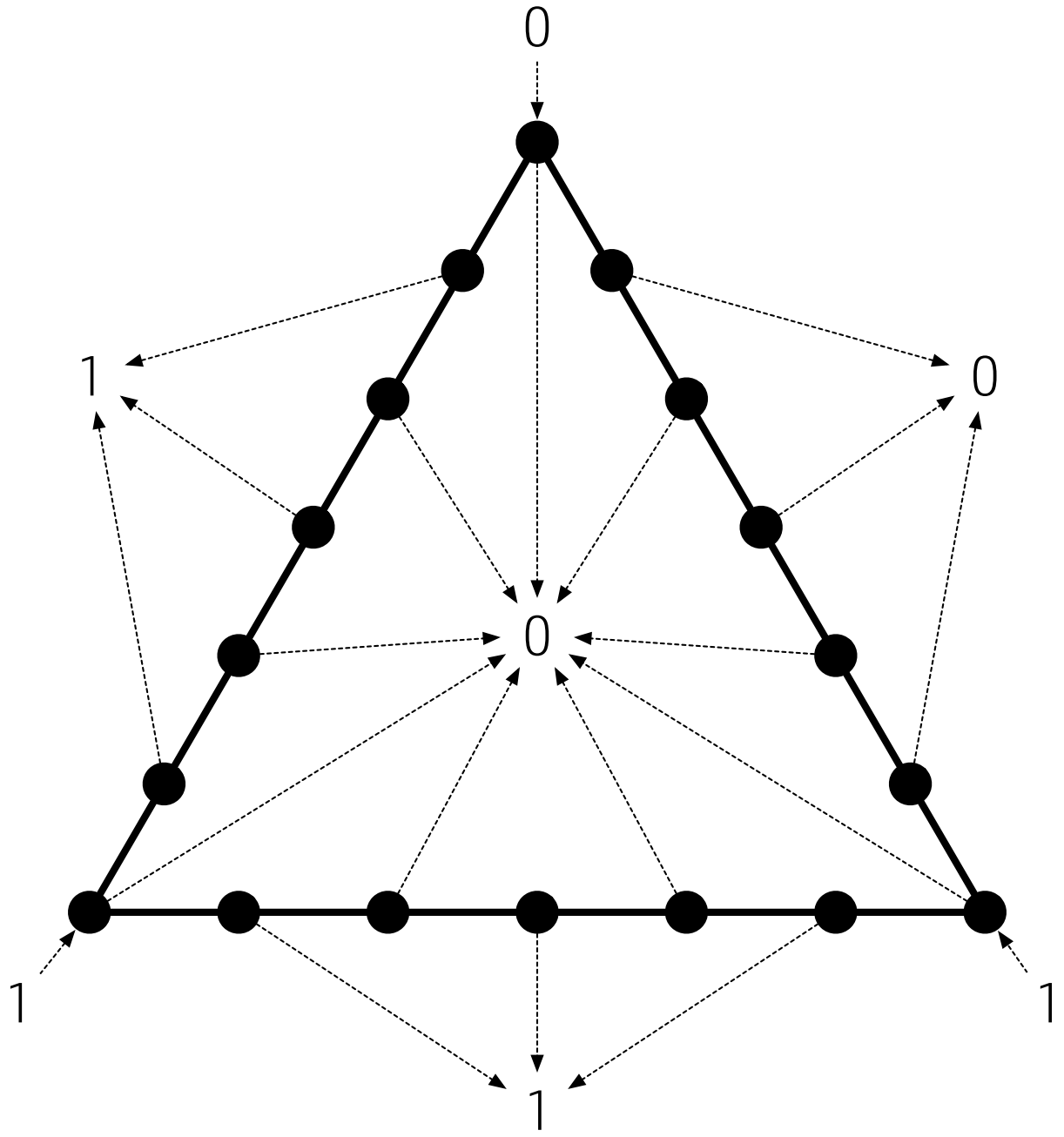

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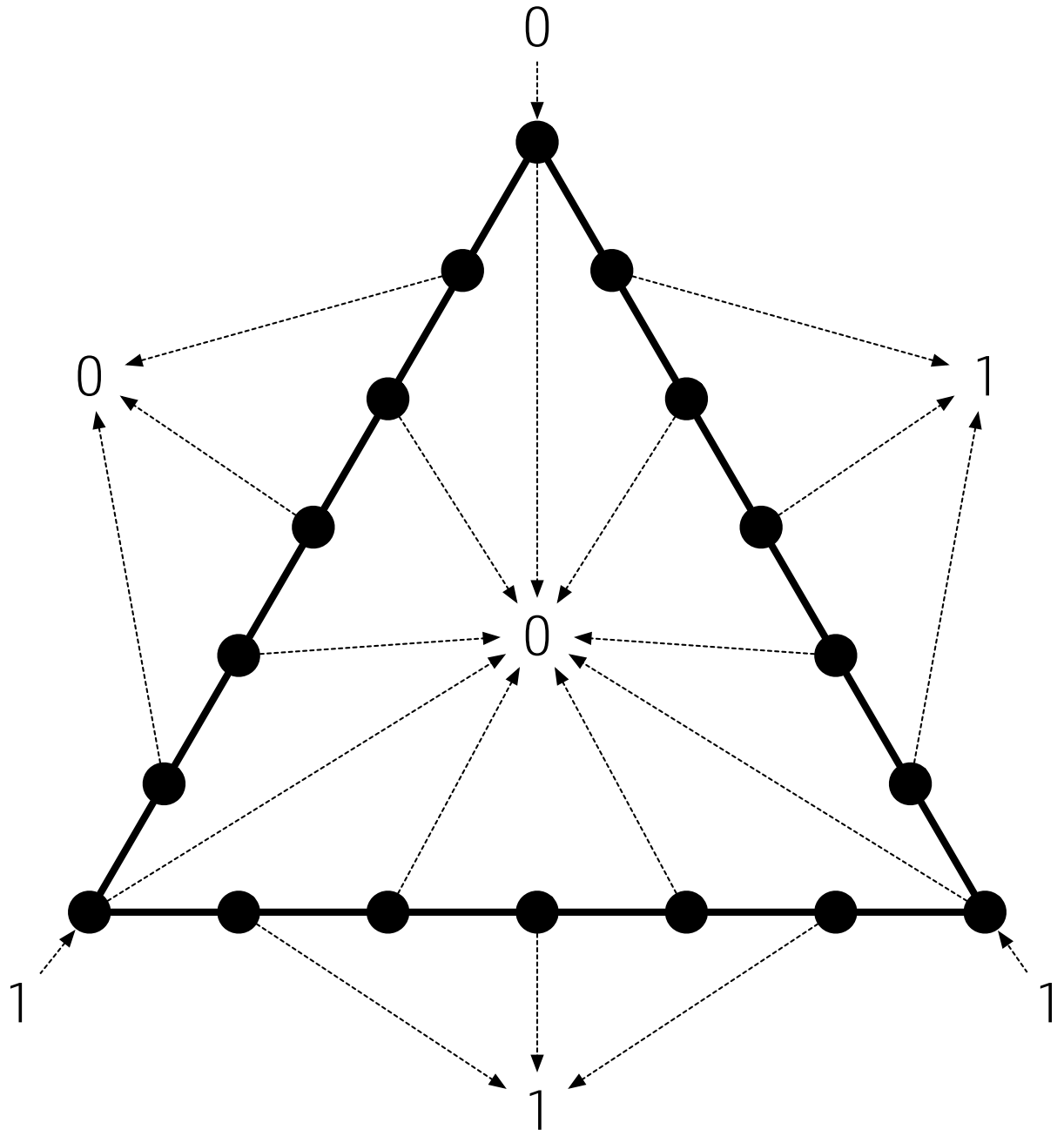

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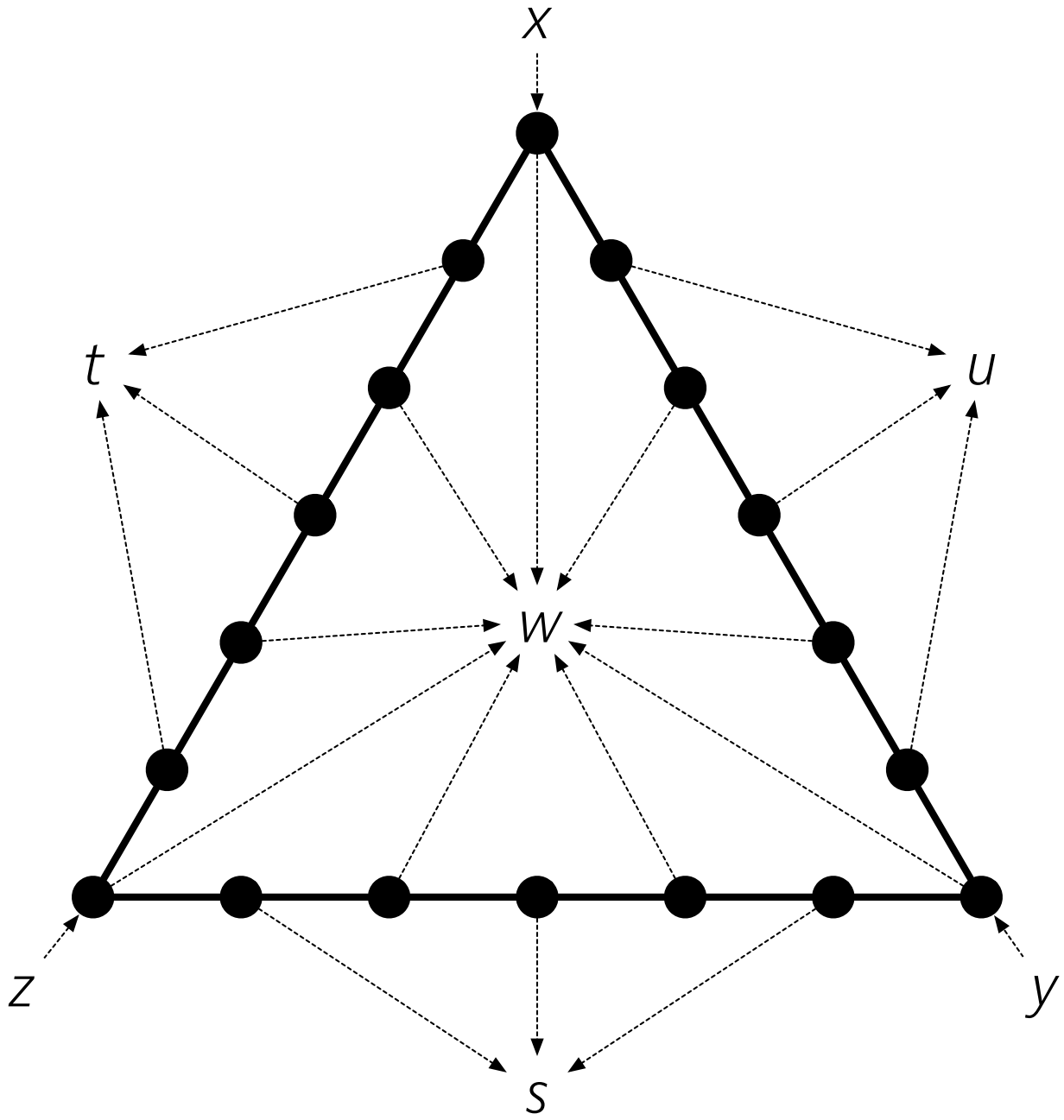

$s + t + u = 0 \bmod 2$

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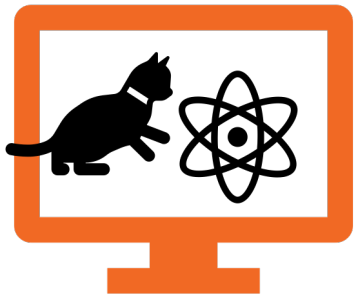
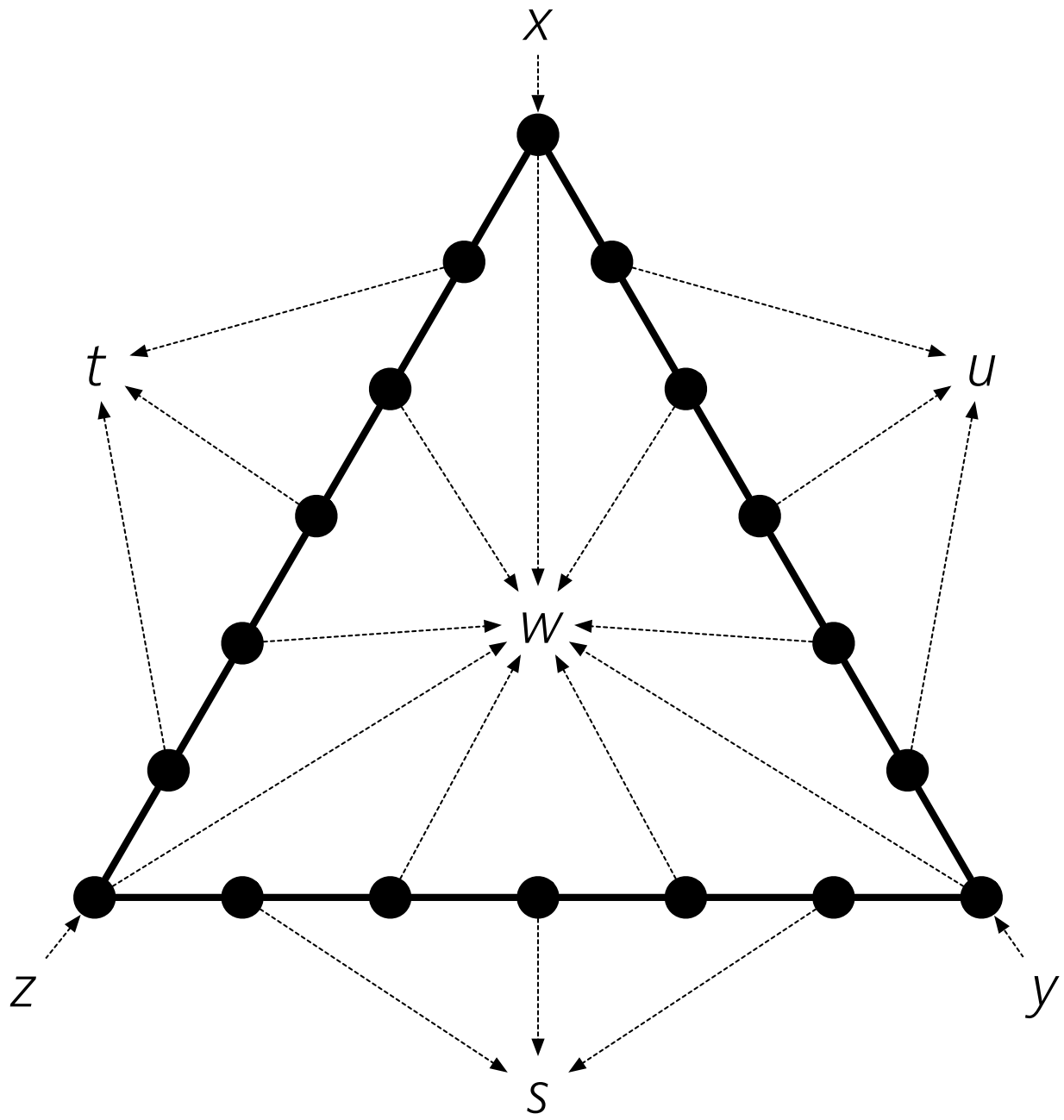
Quantum Advantage for the LOCAL Model in Distributed Computing

n/6 rounds



2 rounds



Balliu, Brandt, Coiteux-Roy, d'Amore, Equi, Le Gall, Lievonen, Modanese, Olivetti, Renou, S, Tendick, Veeren (2024):

Distributed Quantum Advantage for Local Problems

Balliu, Brandt, Coiteux-Roy, d'Amore, Equi, Le Gall, Lievonen, Modanese, Olivetti, Renou, S, Tendick, Veeren (2024):

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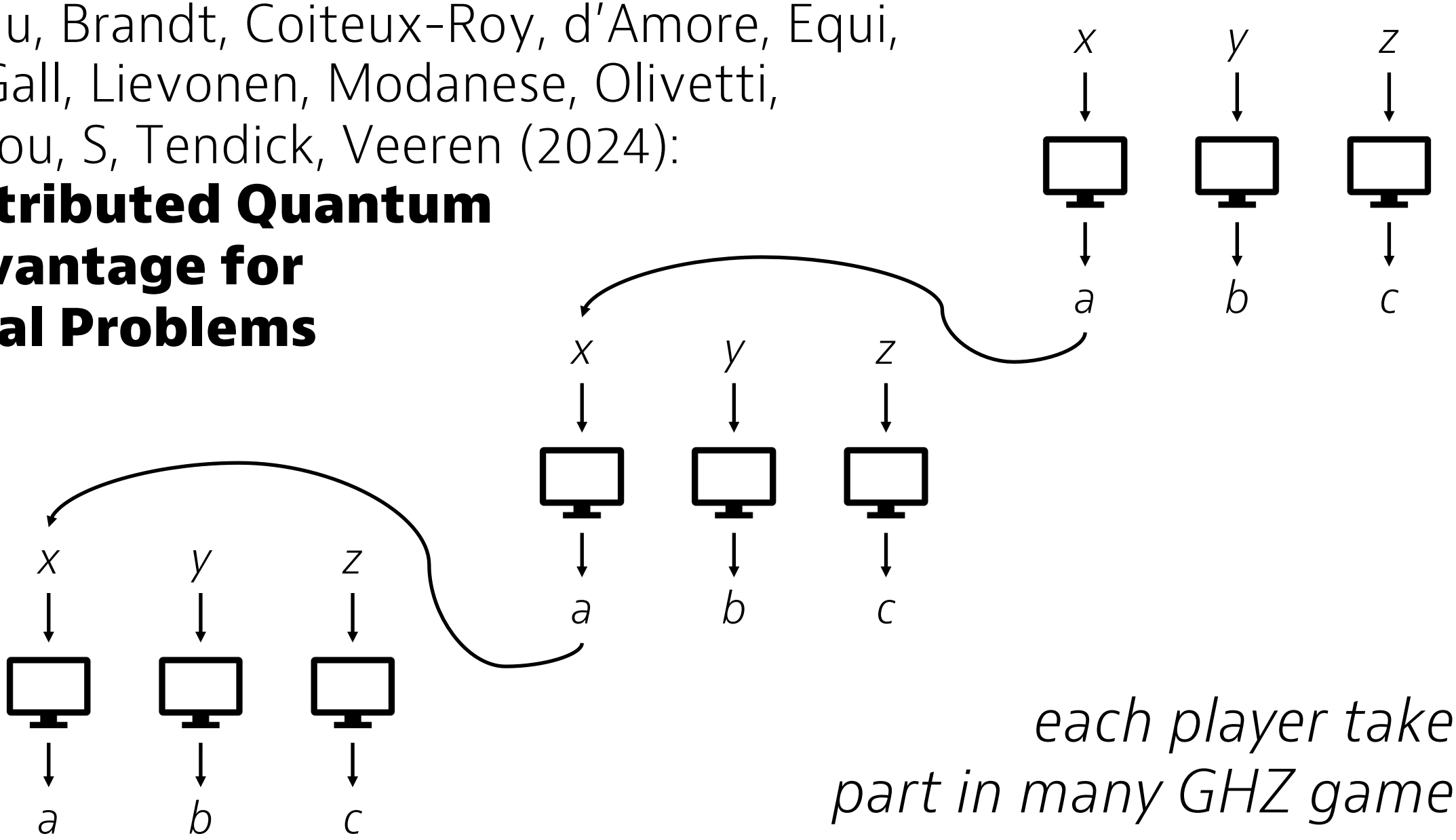


each player takes part in many GHZ games

Balliu, Brandt, Coiteux-Roy, d'Amore, Equi, Le Gall, Lievonen, Modanese, Olivetti, Renou, S, Tendick, Veeren (2024):

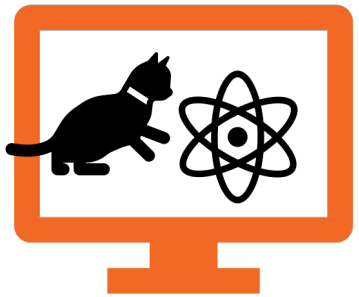
Distributed Quantum Advantage for Local Problems

Δ rounds

For each game:

1. look at your input
2. **talk to your neighbors**
3. compute your output

sequential!



1 round

For each game:

1. **talk to your neighbors**
2. look at your input
3. compute your output

parallelizes!

arXiv:2307.09444

No distributed quantum advantage for approximate graph coloring (*STOC 2024*)

arXiv:2403.01903

Online locality meets distributed quantum computing

arXiv:2411.03240

Distributed quantum advantage for local problems