Distributed Quantum Advantage for Local Problems

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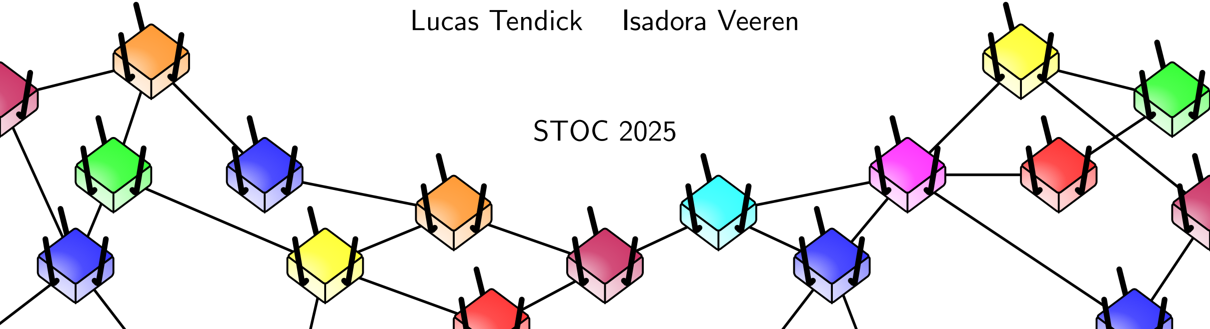
Dennis Olivetti Marc-Olivier Renou Jukka Suomela
Lucas Tendick Isadora Veeren

STOC 2025



Distributed Quantum Advantage for Local Problems

Distributed Quantum Advantage for Local Problems

LOCAL model

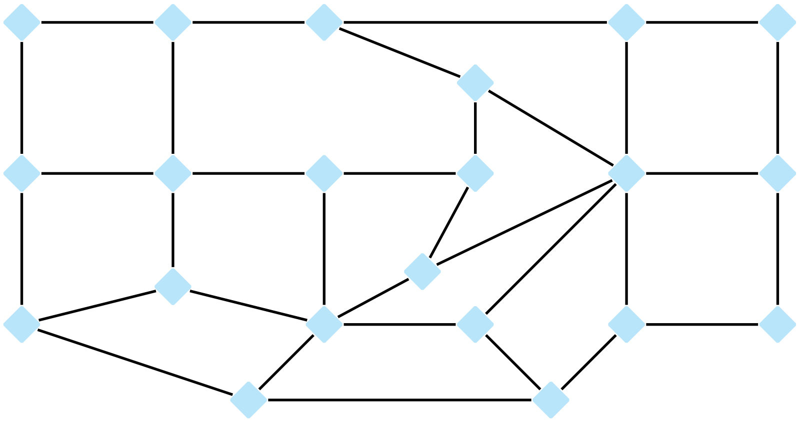
Local problems

Games

Networks of games

Summary

LOCAL model



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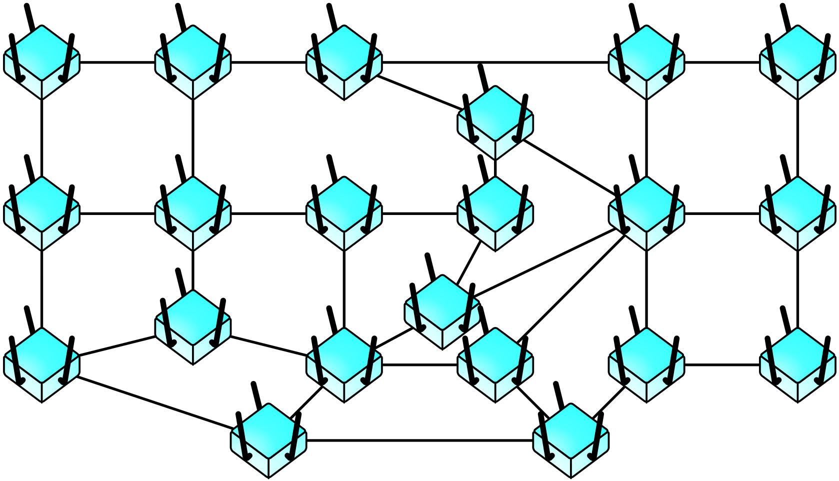

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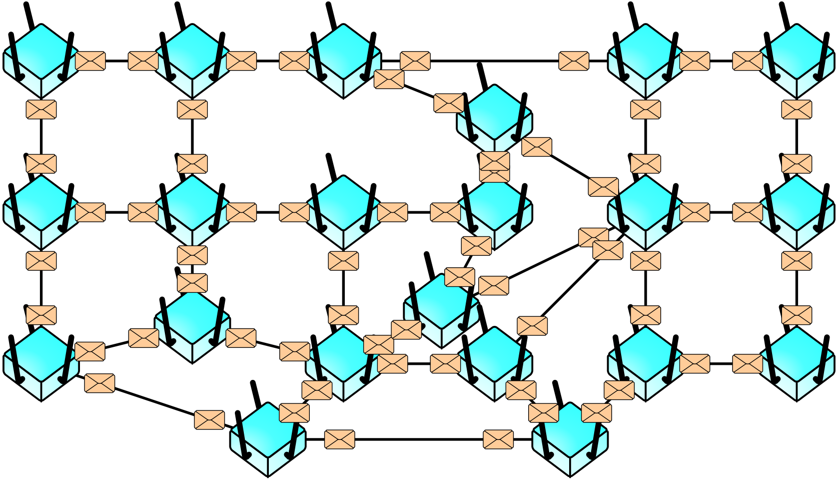

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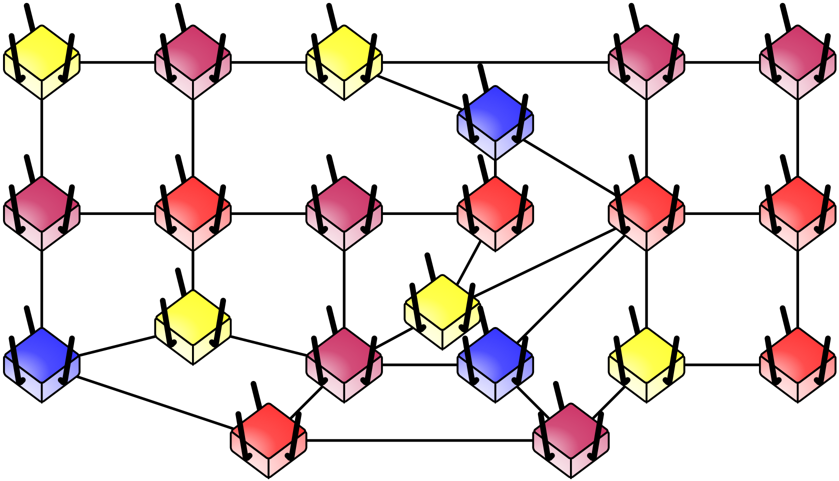

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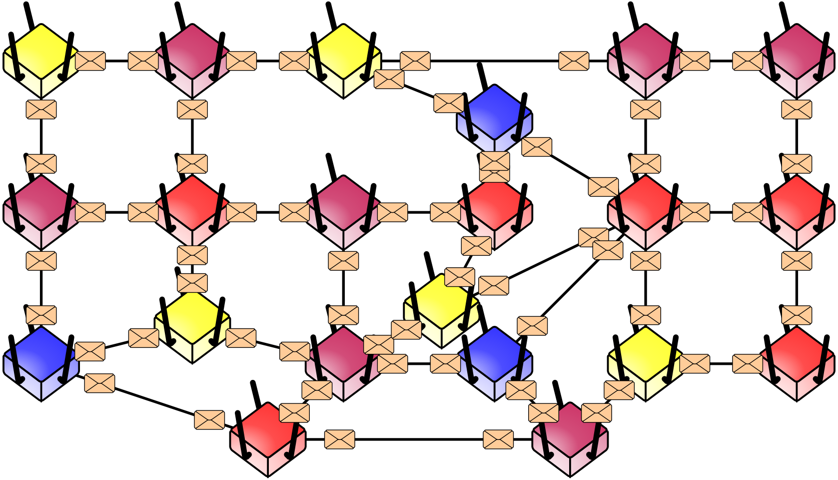

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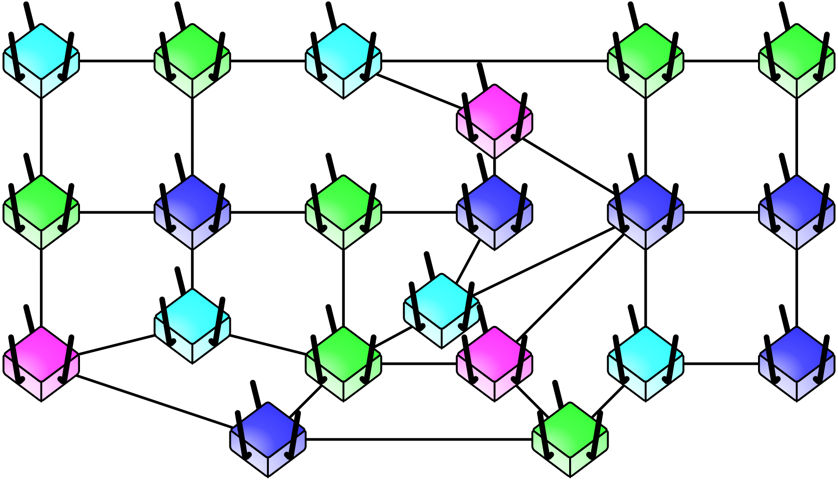

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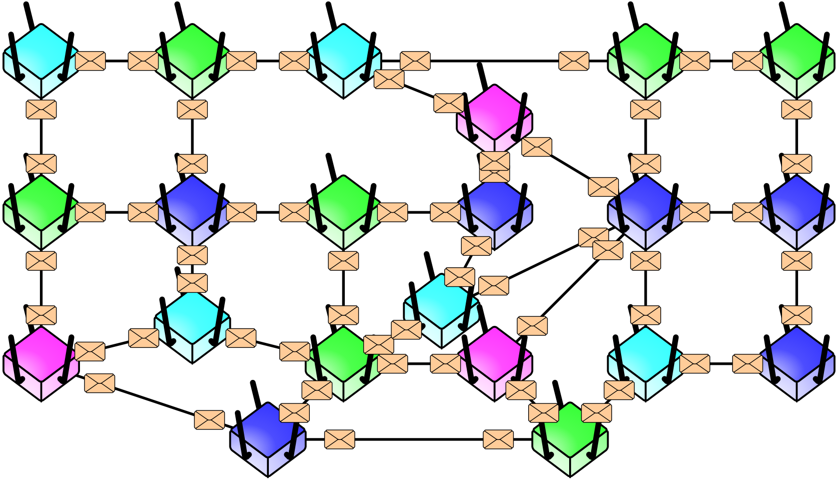

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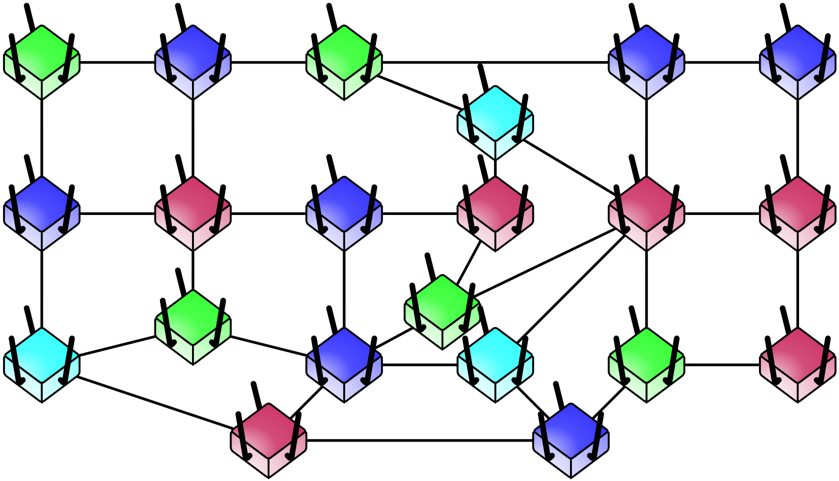

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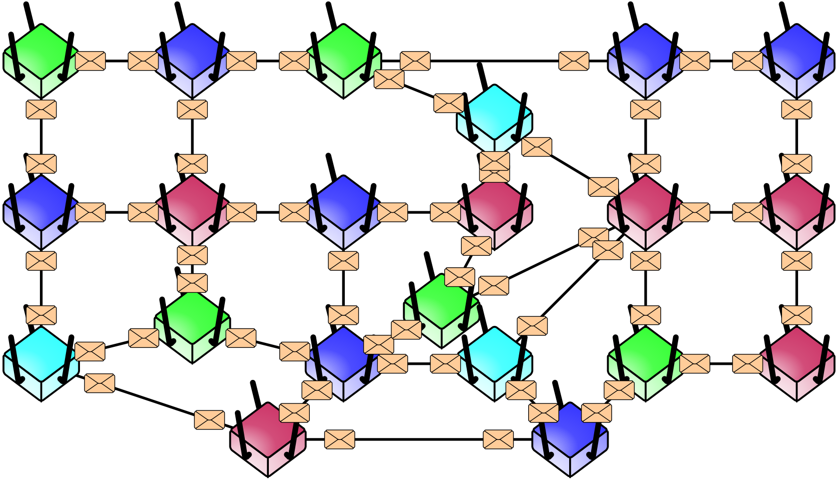

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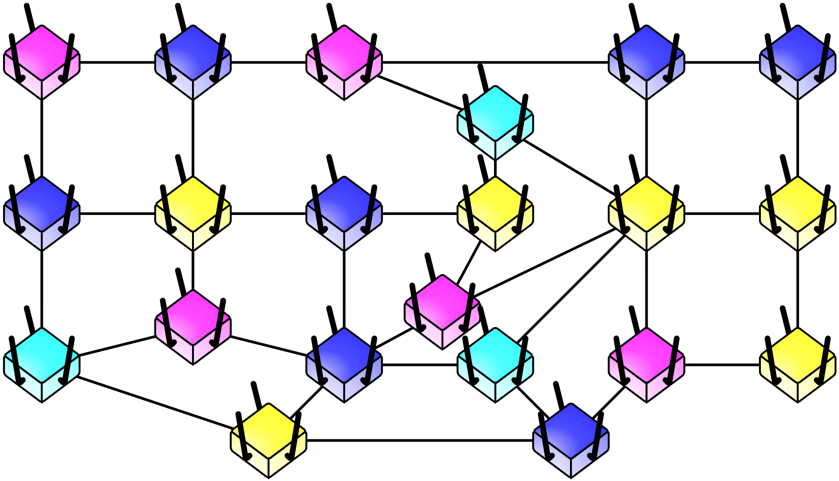
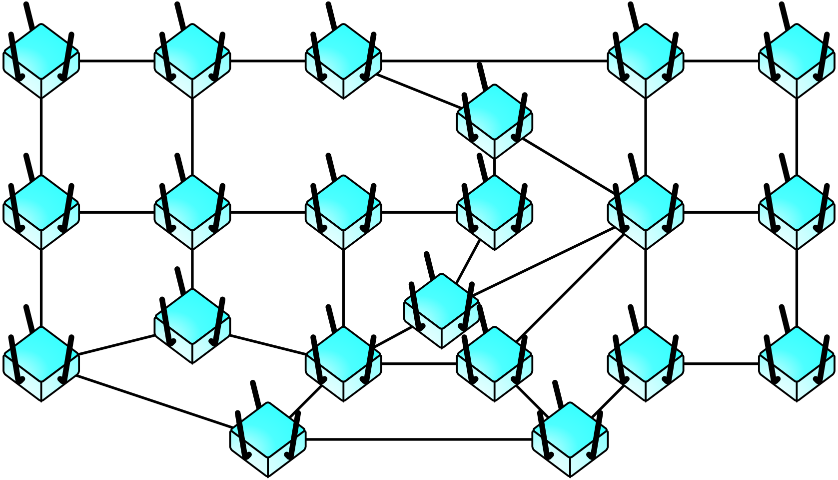


Quantum-LOCAL model



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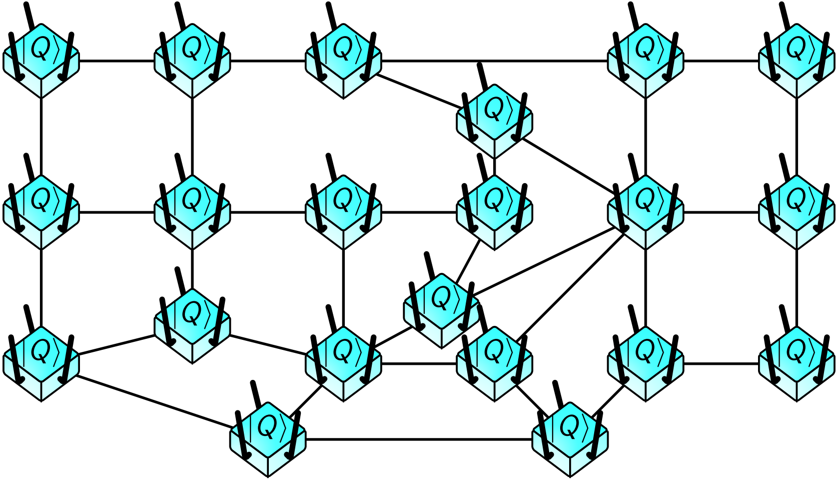

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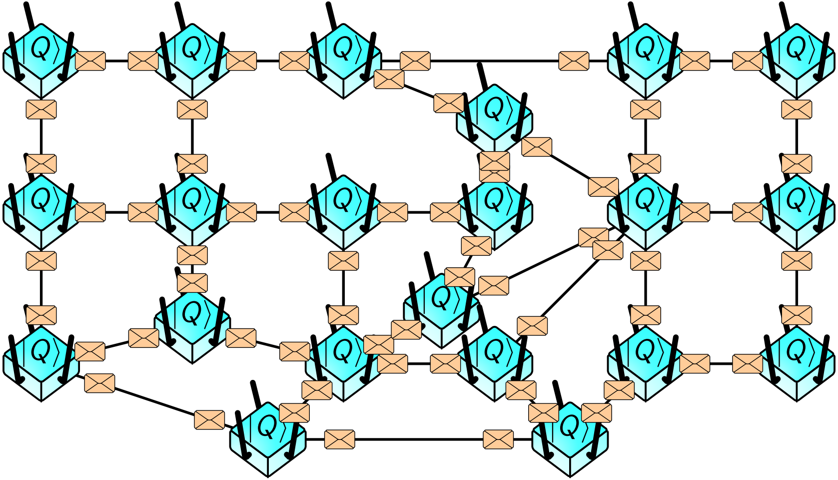

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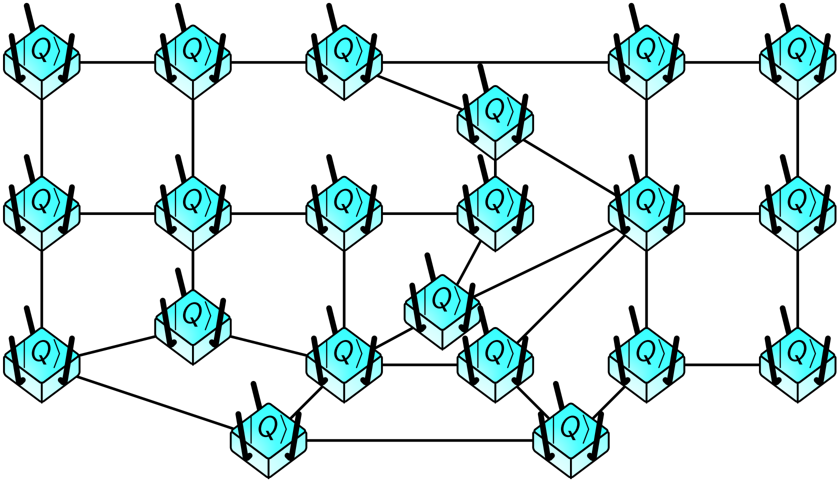


Previous work

Theorem (Le Gall, Nishimura, and Rosmanis 2019)

There exists a global computational problem that can be solved with 2 round in the quantum-LOCAL model, but requires $\Omega(n)$ *rounds in the classical LOCAL model.*

Previous work

Theorem (Le Gall, Nishimura, and Rosmanis 2019)

There exists a **global** *computational problem that can be solved with 2 round in the quantum-LOCAL model, but requires* $\Omega(n)$ *rounds in the classical LOCAL model.*

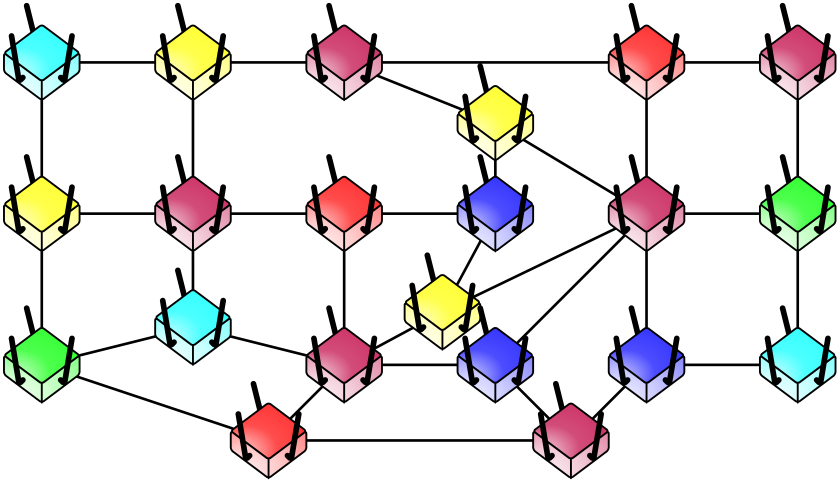
Summary

	Classical	Quantum	Local
Previous work[1]	$\Omega(n)$	$O(1)$	No
Our work	$\Theta(\Delta)$	$O(1)$	Yes

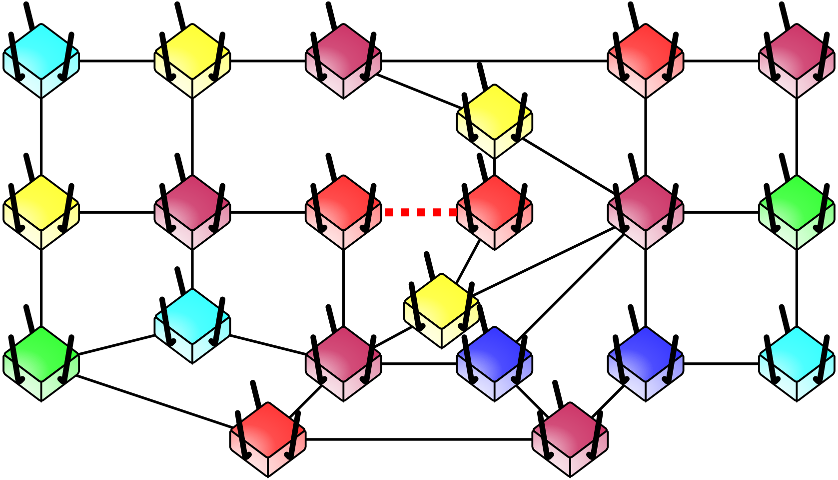
[1] Le Gall, Nishimura, and Rosmanis 2019

Distributed Quantum Advantage for Local Problems

Local problems



Local problems



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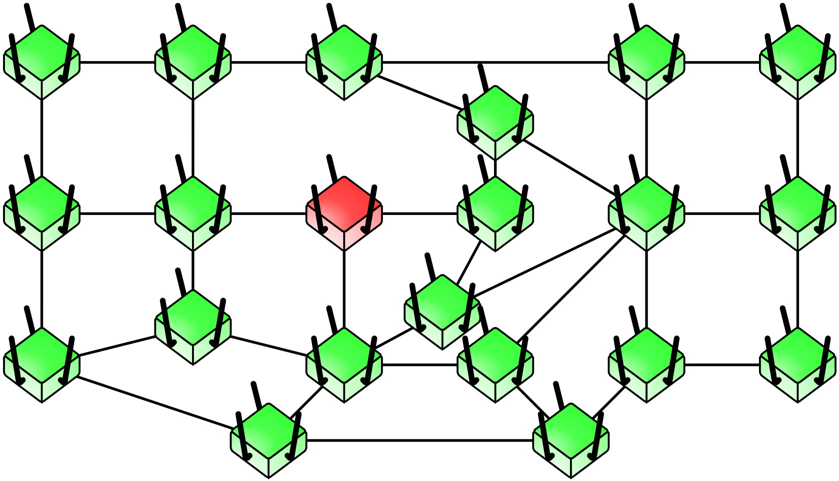

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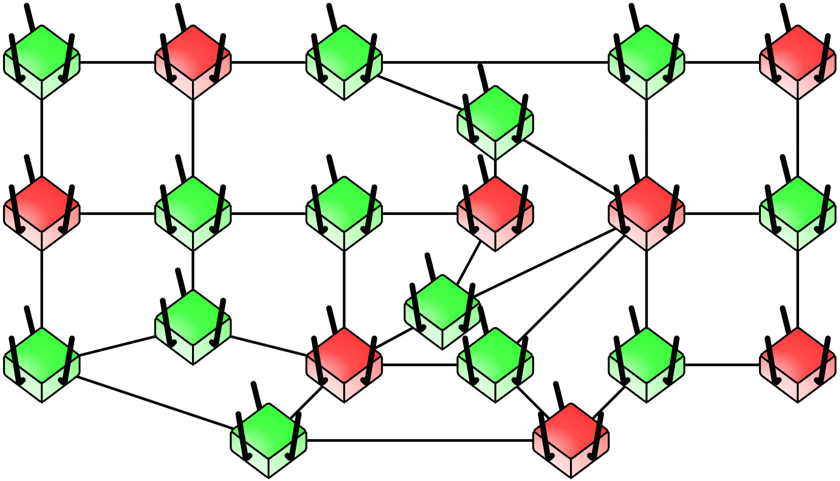

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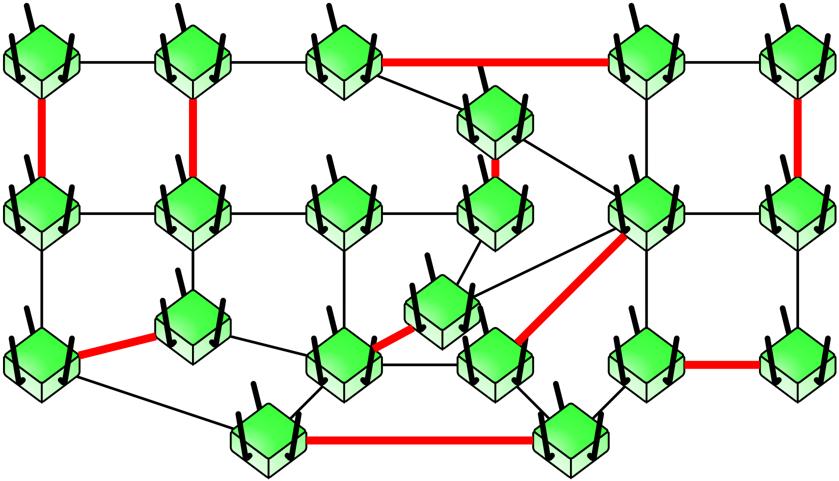

Distributed Quantum Advantage for Local Problems

Games

Relation R		
x	y	$a \oplus b$
0	0	0 mod 2
0	1	0 mod 2
1	0	0 mod 2
1	1	1 mod 2

Games

Alice

Bob

Relation R

x	y	$a \oplus b$
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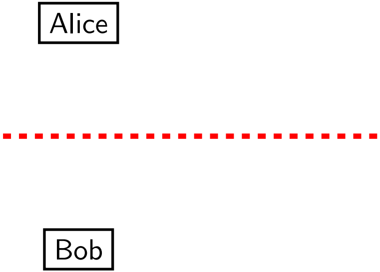

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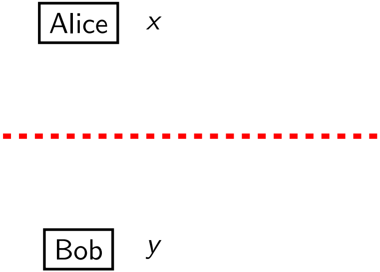

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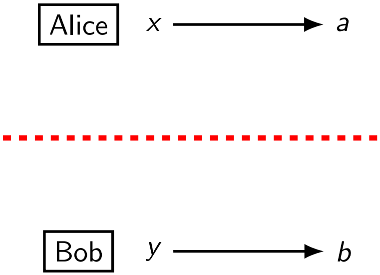

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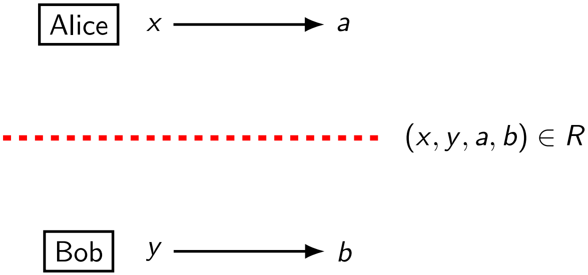

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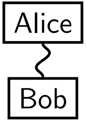
Quantum games



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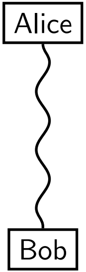
Quantum games



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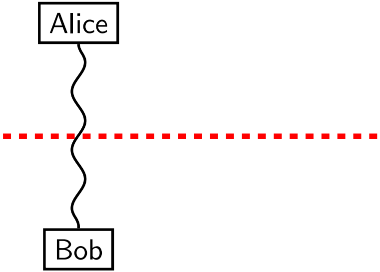

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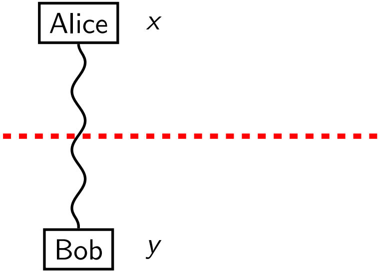

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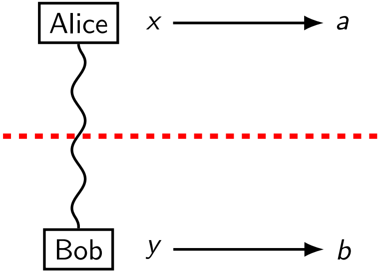
Quantum games



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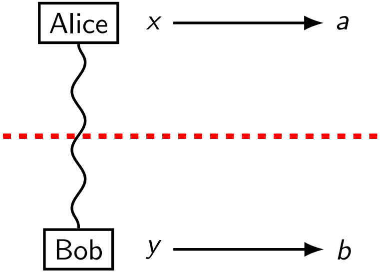

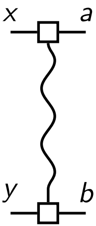

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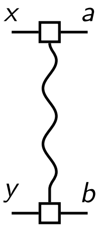

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CHSH[2] game

x	y	$a \oplus b$
0	0	$0 \mod 2$
0	1	$0 \mod 2$
1	0	$0 \mod 2$
1	1	$1 \mod 2$

[2] Clauser, Horne, Shimony, and Holt 1969

CHSH[2] game

x	y	$a \oplus b$
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Winning probability:

Classical
75%

[2] Clauser, Horne, Shimony, and Holt 1969

CHSH[2] game

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Winning probability:

Classical	Quantum
75%	$\cos^2\left(\frac{\pi}{8}\right) \approx 85\%$

[2] Clauser, Horne, Shimony, and Holt 1969

CHSH[2] game

x	y	$a \oplus b$
0	0	$0 \mod 2$
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Winning probability:

Classical	Quantum	Non-Signaling
75%	$\cos^2\left(\frac{\pi}{8}\right) \approx 85\%$	100%

[2] Clauser, Horne, Shimony, and Holt 1969

CHSH[2] game

x	y	$a \oplus b$
0	0	$0 \mod 2$
0	1	$0 \mod 2$
1	0	$0 \mod 2$
1	1	$1 \mod 2$

Winning probability:

Classical	Quantum	~~Non-Signaling~~ Super-Quantum
75%	$\cos^2\left(\frac{\pi}{8}\right) \approx 85\%$	100%

[2] Clauser, Horne, Shimony, and Holt 1969

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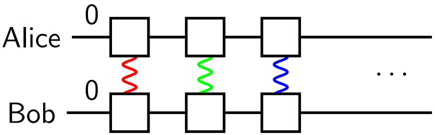

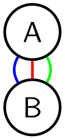

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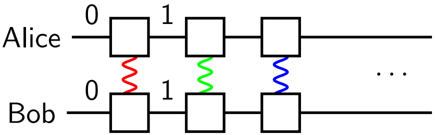

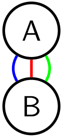

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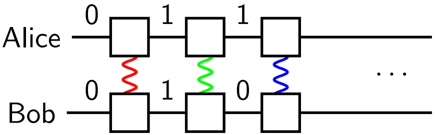

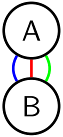

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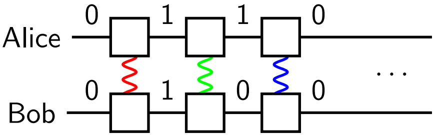

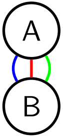

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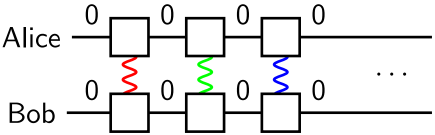

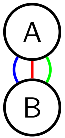

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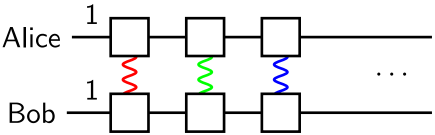

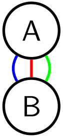

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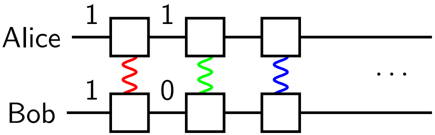

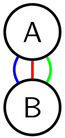

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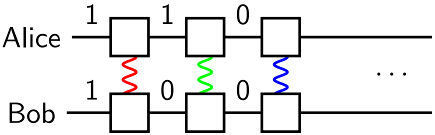

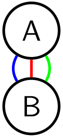

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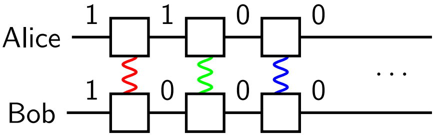

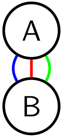

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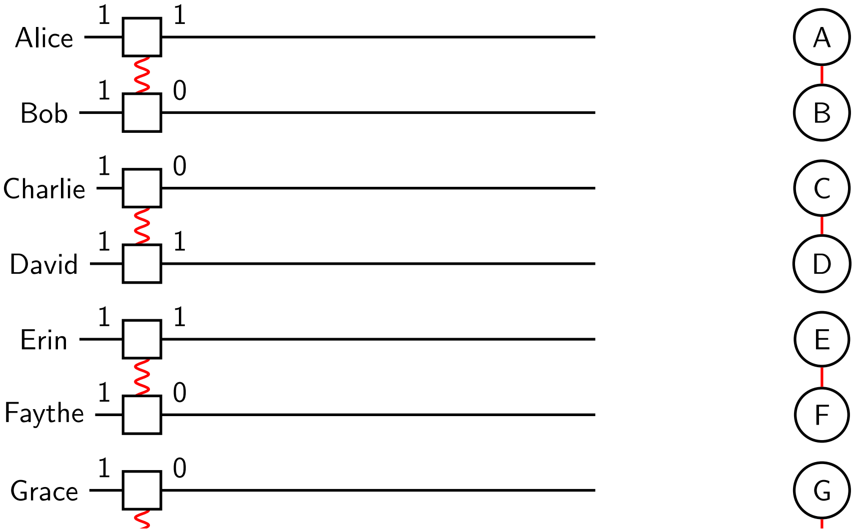

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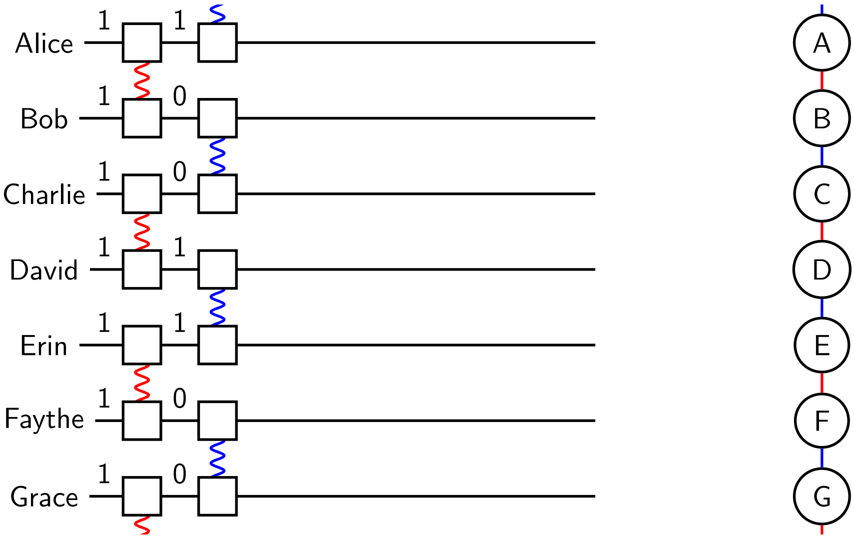

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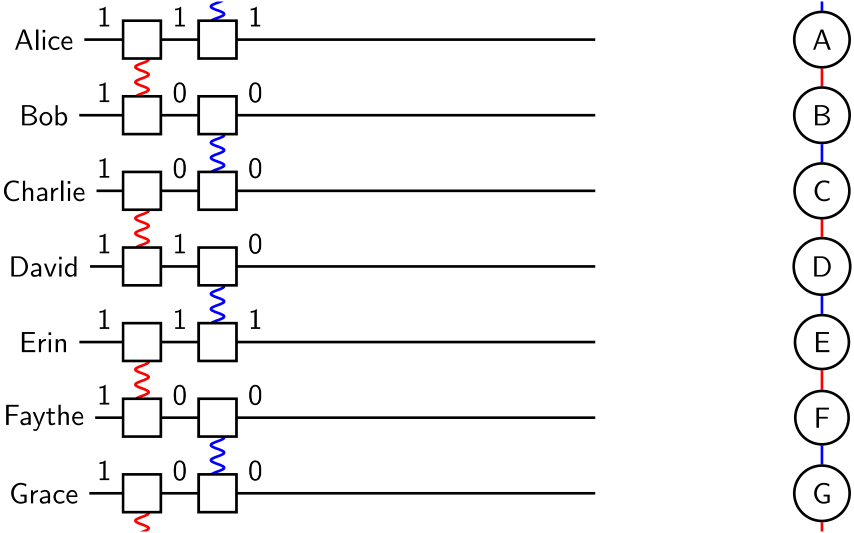

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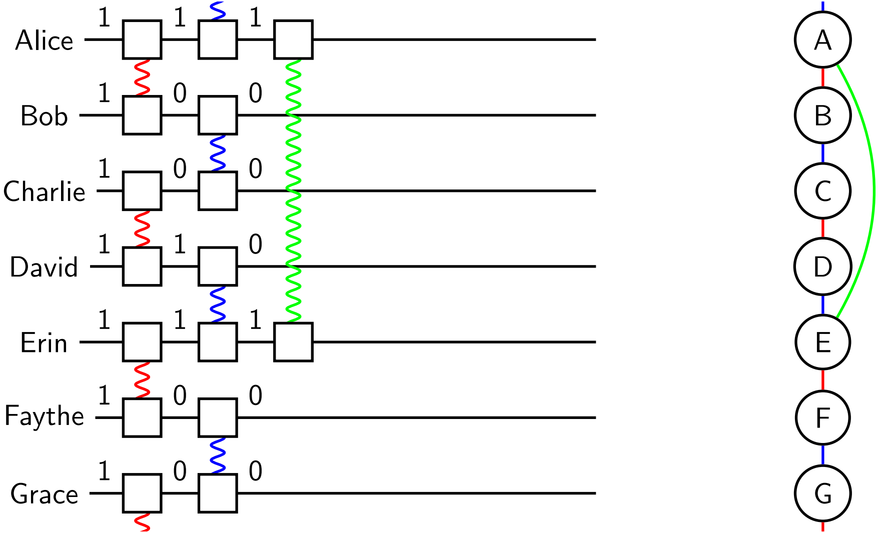

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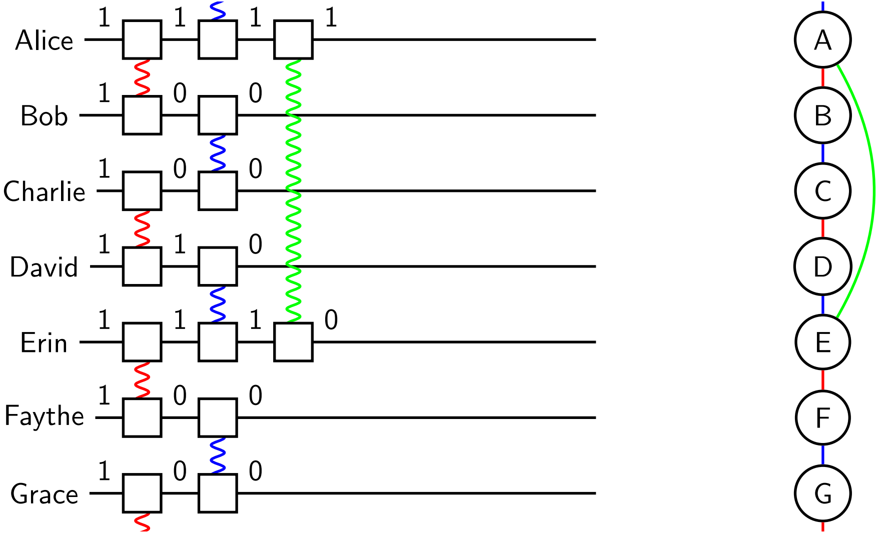

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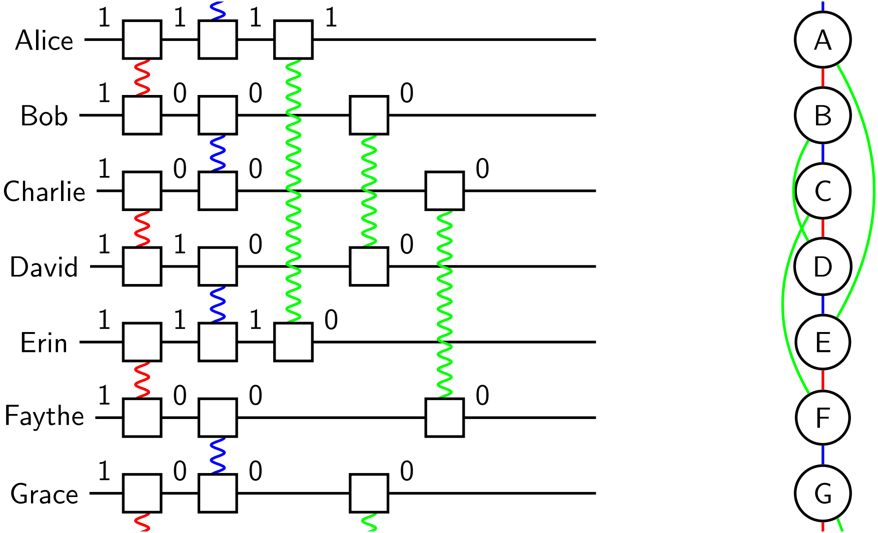

Summary

	Classical	Super-Quantum	Local
Previous work[3]	$\Omega(n)$	$O(1)$	No
Our work	$\Theta(\Delta)$	$O(1)$	Yes

[3] Le Gall, Nishimura, and Rosmanis 2019

GHZ[4] game

x	y	z	$a \oplus b \oplus c$
0	0	0	$0 \mod 2$
0	1	1	$1 \mod 2$
1	0	1	$1 \mod 2$
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[4] Greenberger, Horne, and Zeilinger 1989

GHZ[4] game

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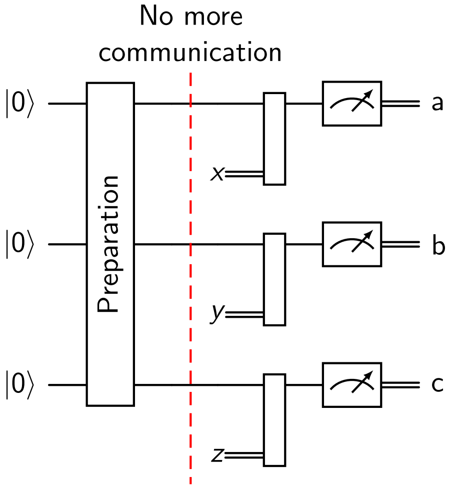
1	1	0	1 mod 2



[4]Greenberger, Horne, and Zeilinger 1989

Distributed Quantum Advantage for Local Problems

Summary

	Classical	Quantum	Local
Previous work[5]	$\Omega(n)$	$O(1)$	No
Our work	$\Theta(\Delta)$	$O(1)$	Yes

[5] Le Gall, Nishimura, and Rosmanis 2019

Summary

	Classical	Quantum	Local	Constant Δ
Previous work[5]	$\Omega(n)$	$O(1)$	No	Yes
Our work	$\Theta(\Delta)$	$O(1)$	Yes	No
Future work	$\Omega(\log n \cdot \frac{\log\log n}{\log\log\log n})$	$O(\log n)$	Yes	Yes

[5] Le Gall, Nishimura, and Rosmanis 2019

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