New Limits on Distributed Quantum Advantage: Dequantizing Linear Programs

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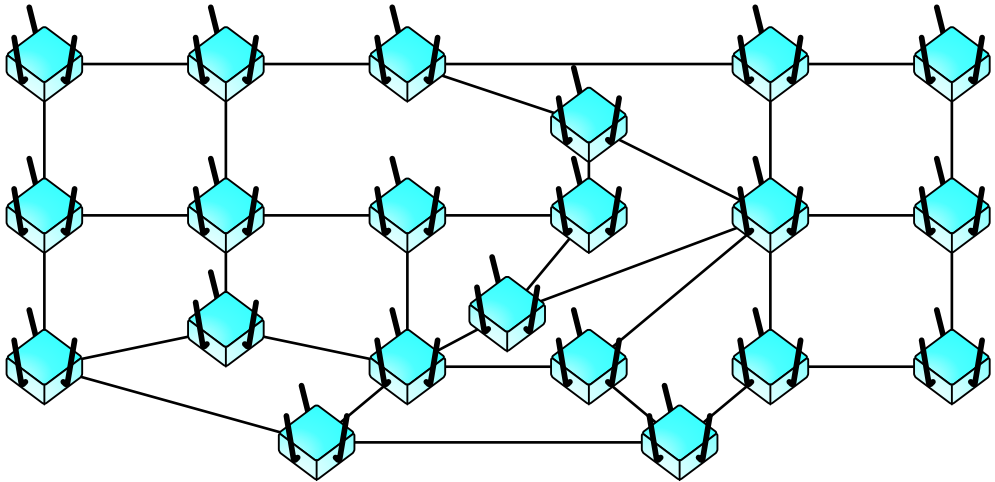
LOCAL and Quantum-LOCAL Models

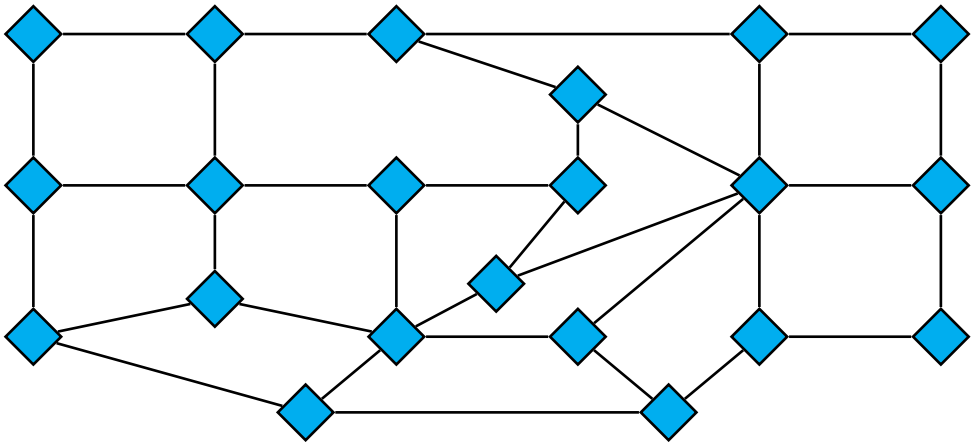
Contribution 1: Quantum Doesn't Help

Contribution 2: Sequentiality Does Help

LOCAL Model [Lin92]



LOCAL Model [Lin92]



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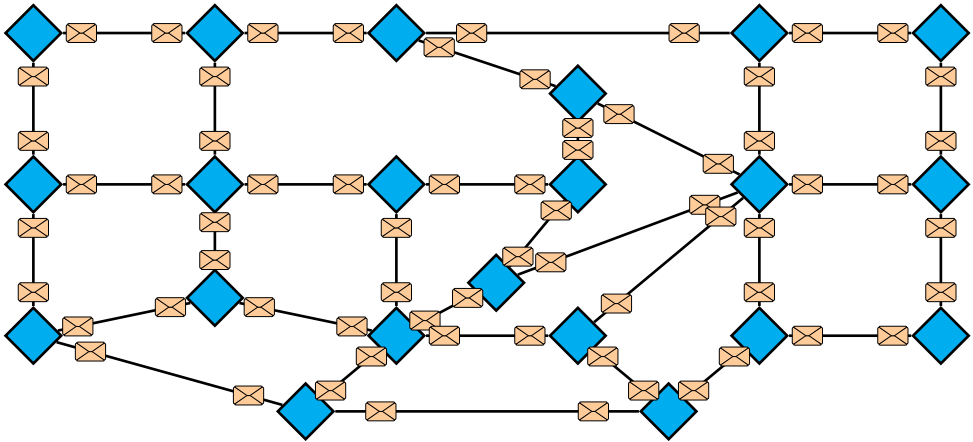

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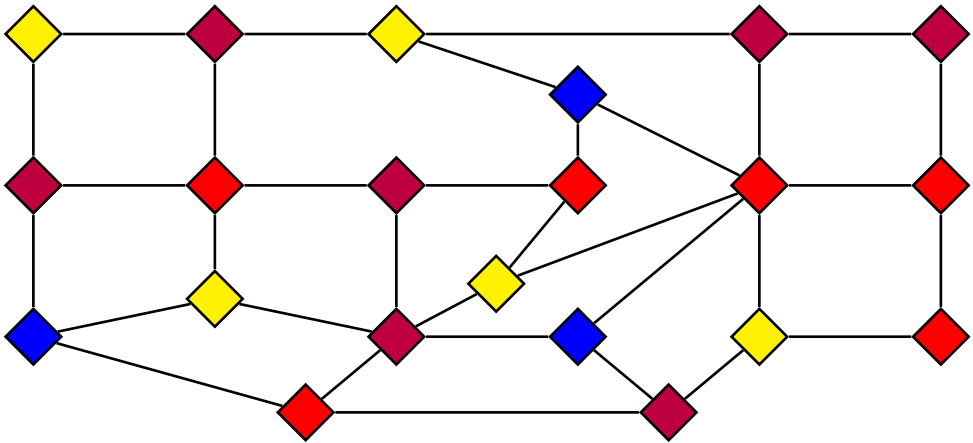

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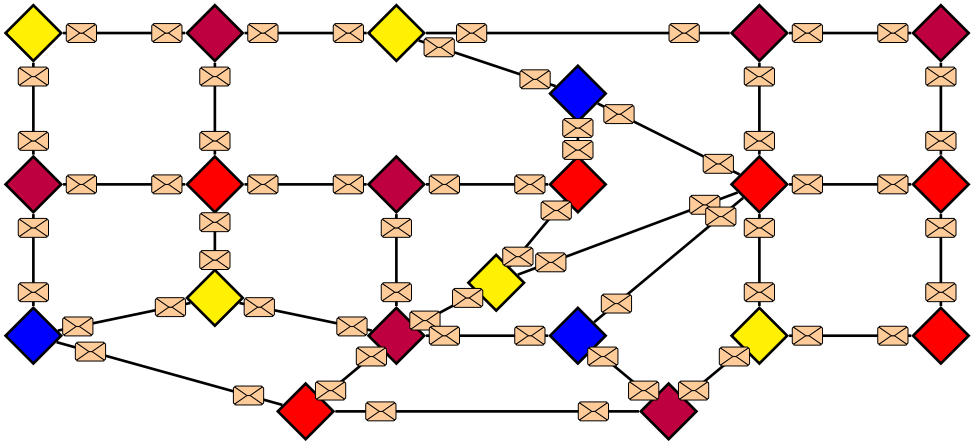

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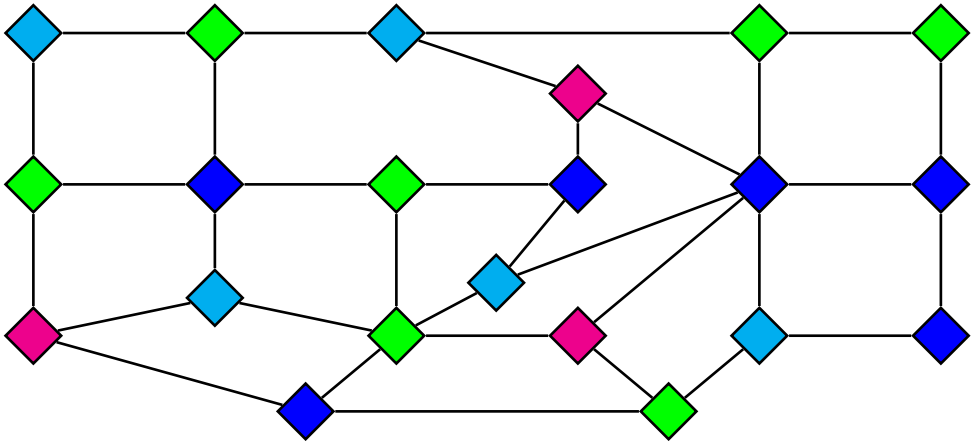

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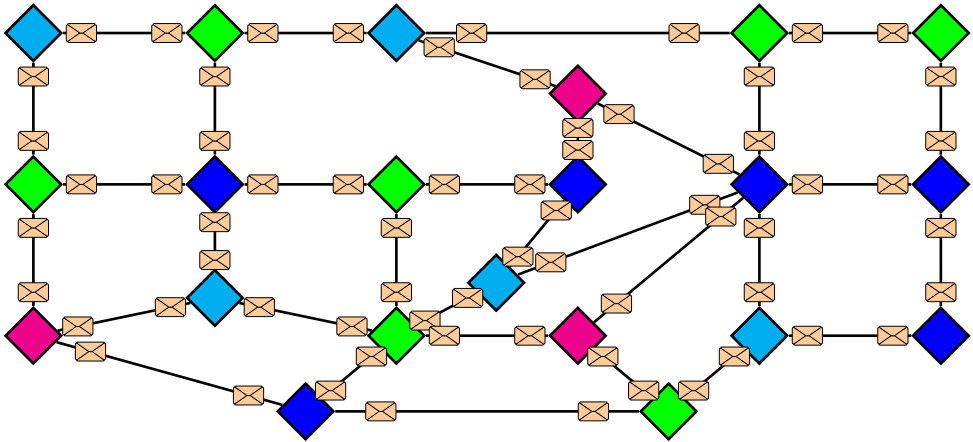

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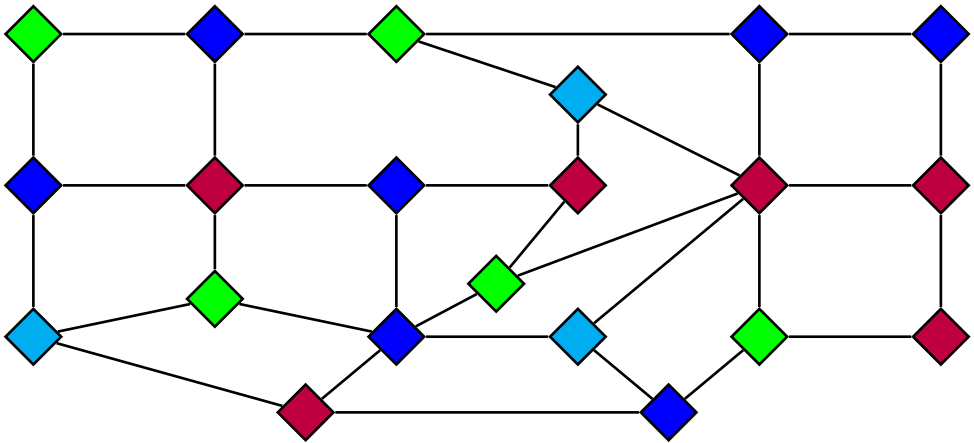

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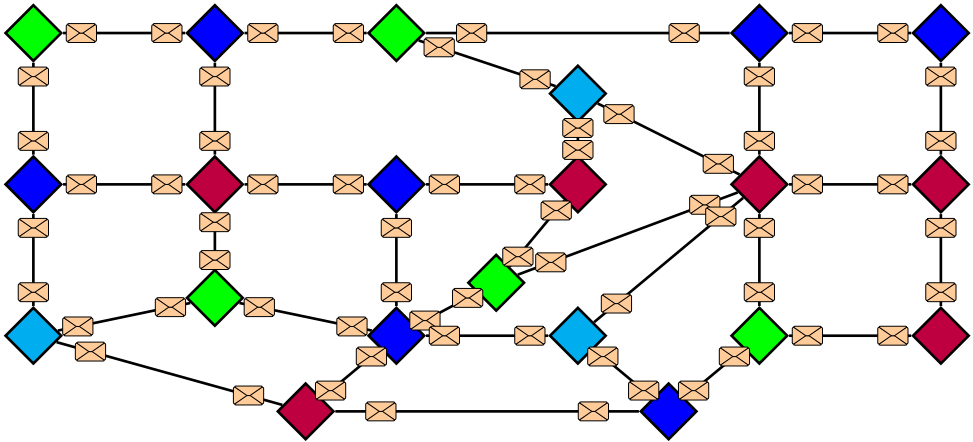

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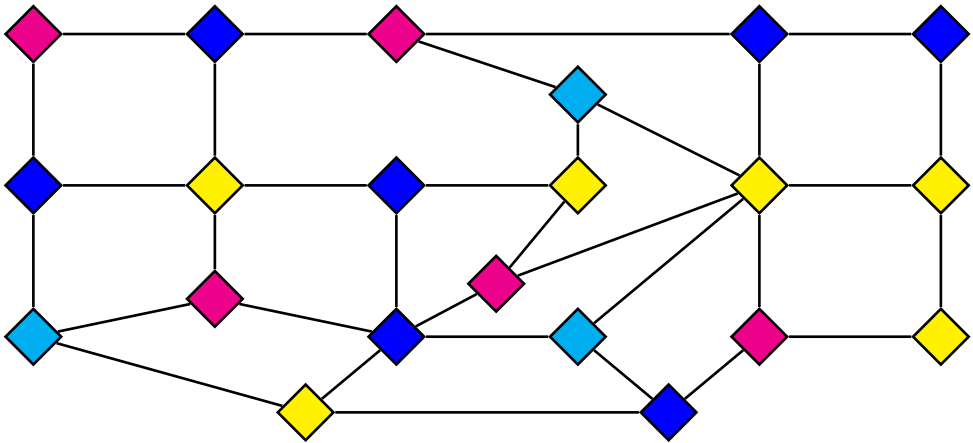
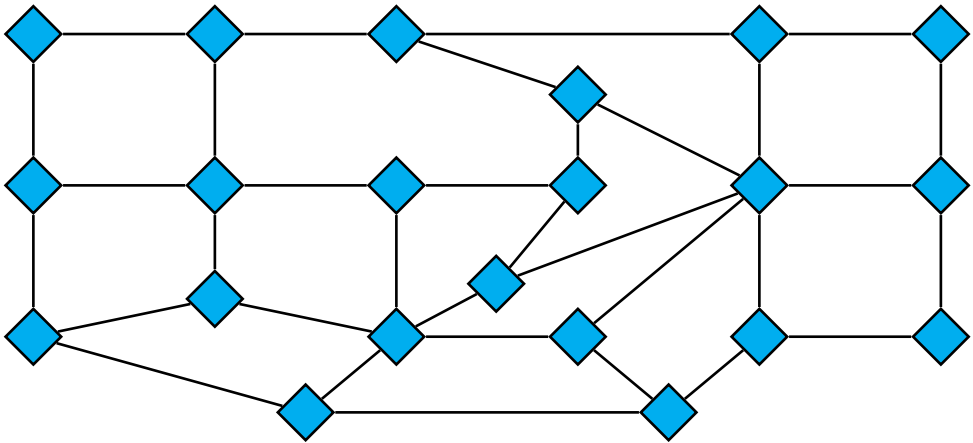
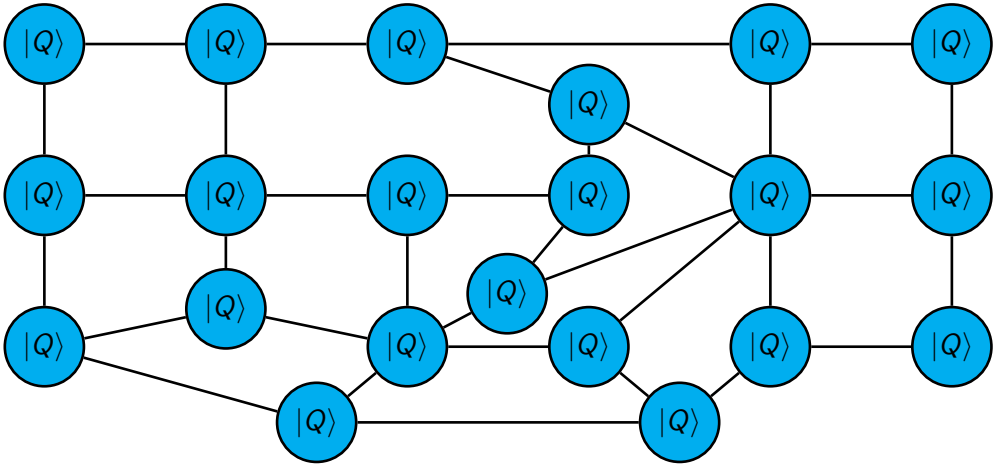


Quantum-LOCAL model



Quantum-LOCAL model



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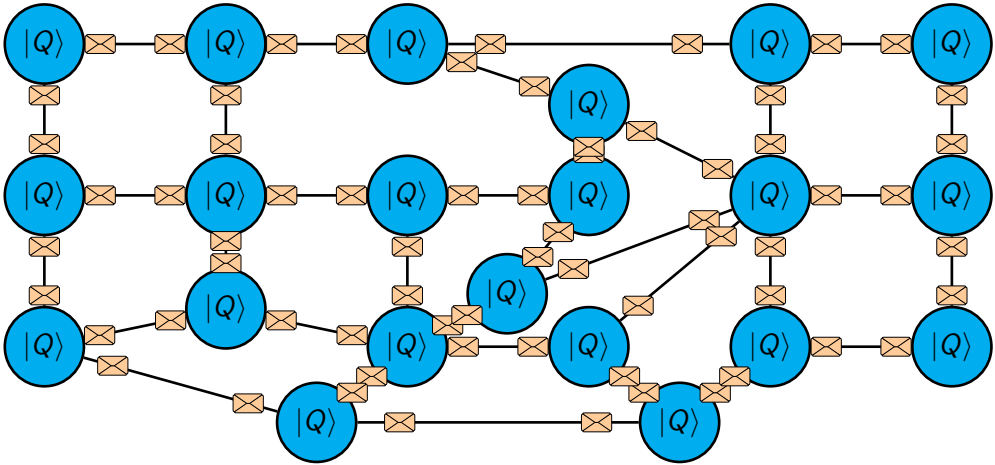

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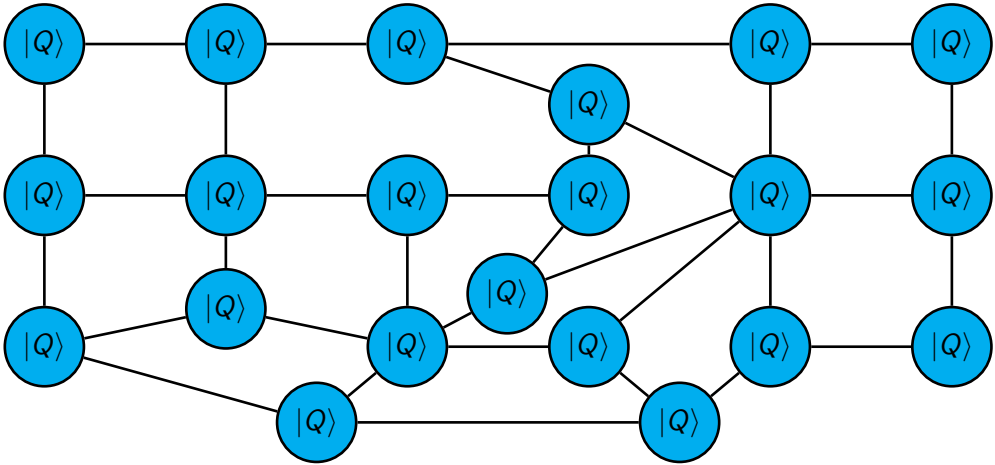
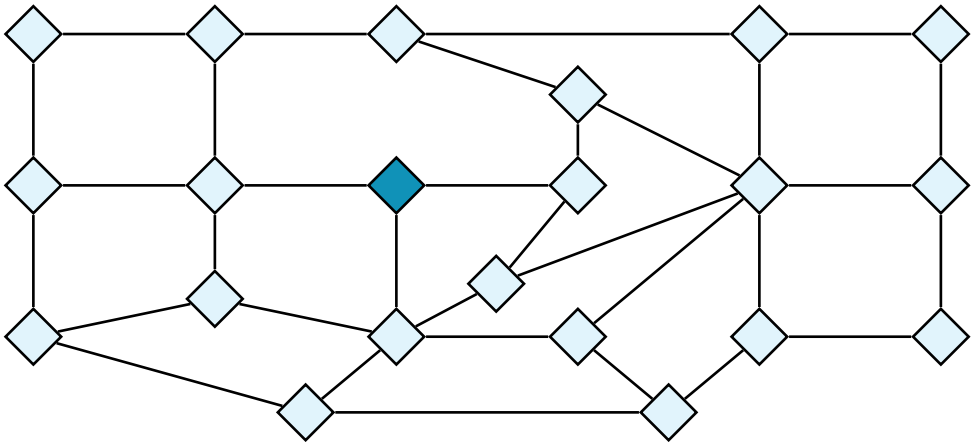


LOCAL Revisited



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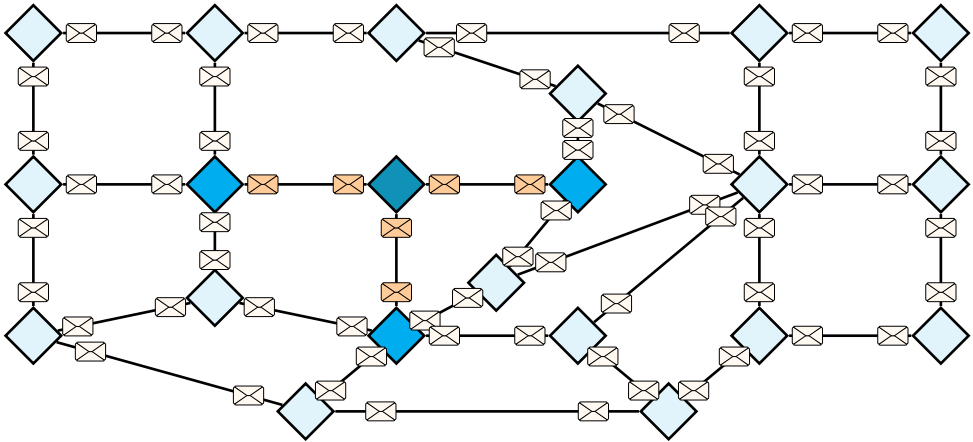

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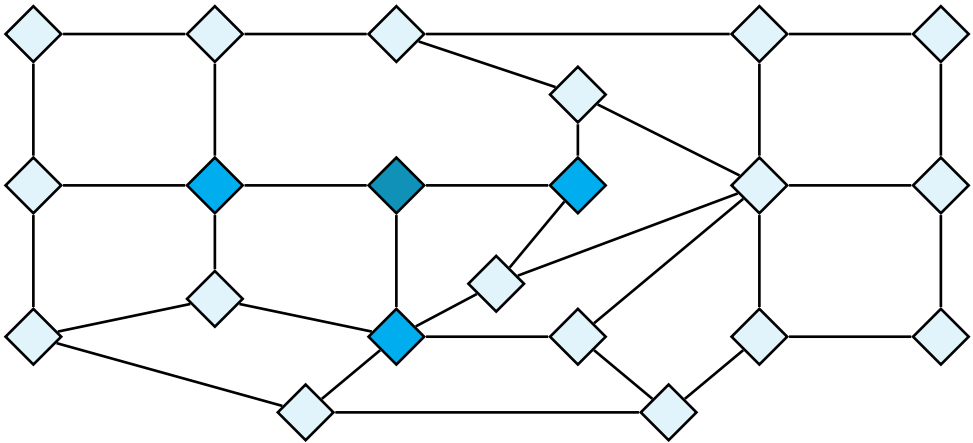

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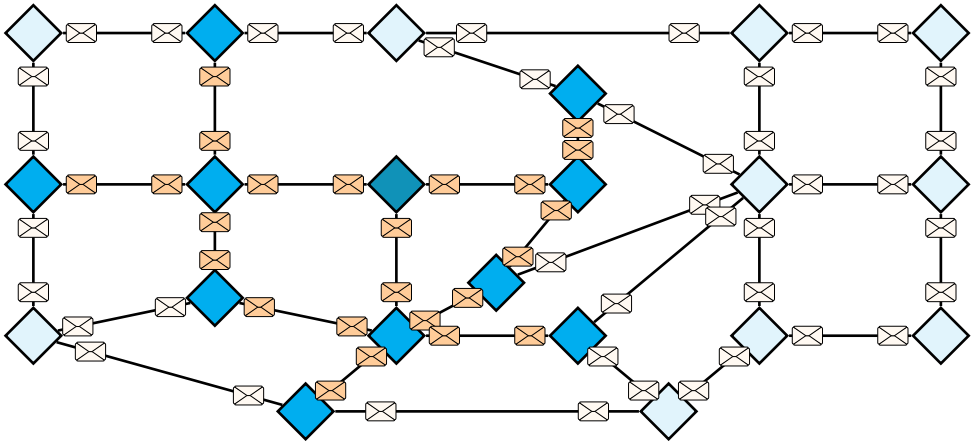

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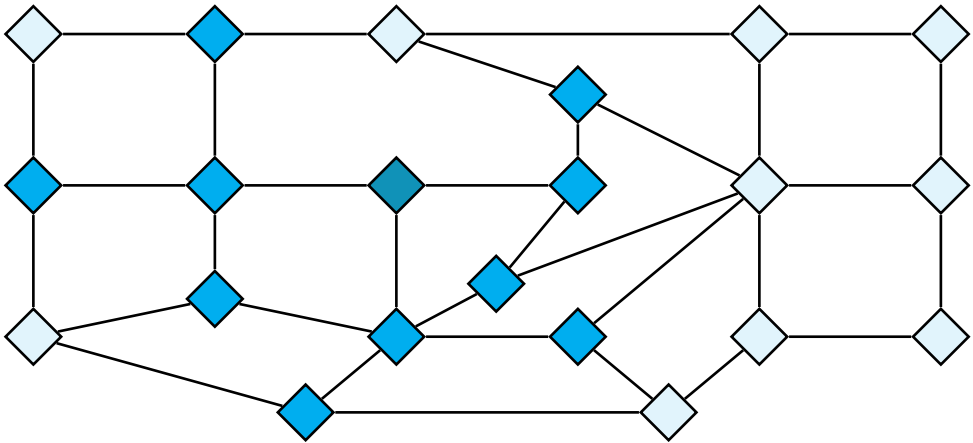

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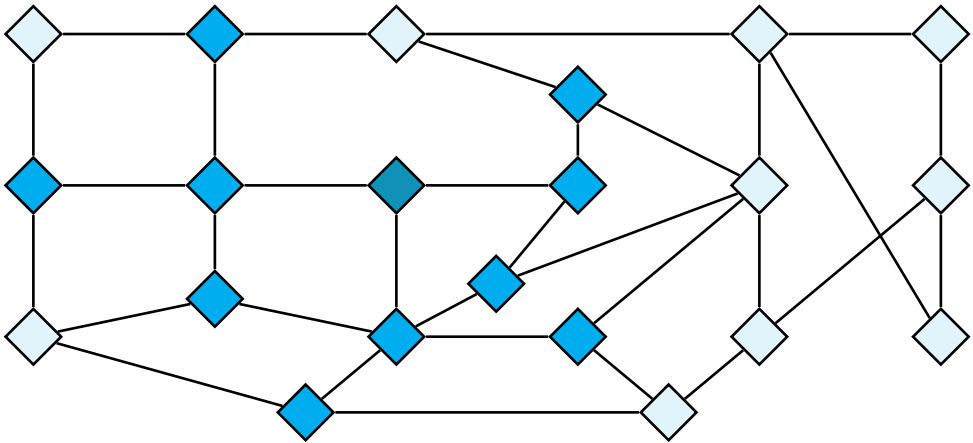
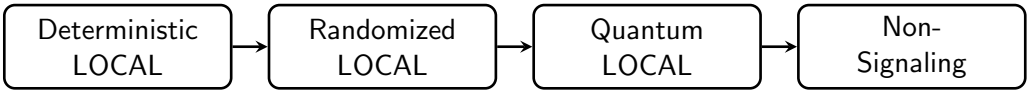
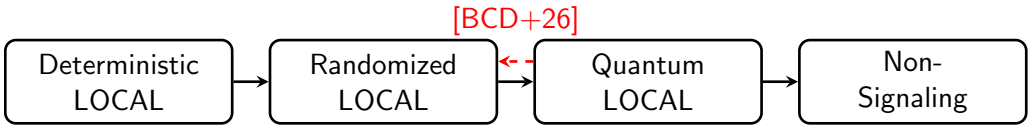


Landscape



⟶ Stronger

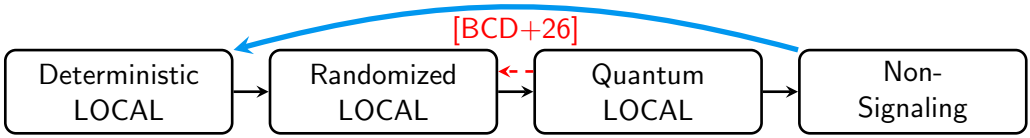
Landscape



Stronger

LCL Separation

Landscape



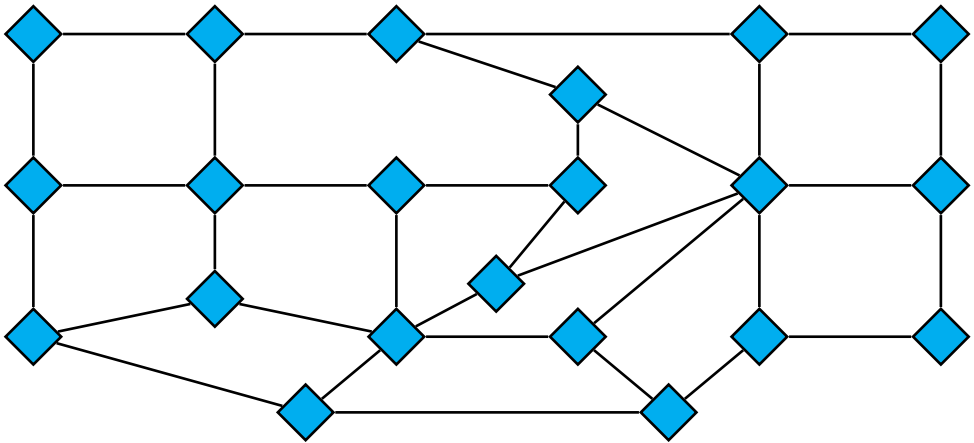
Stronger LCL Separation Linear Programs

Contribution 1

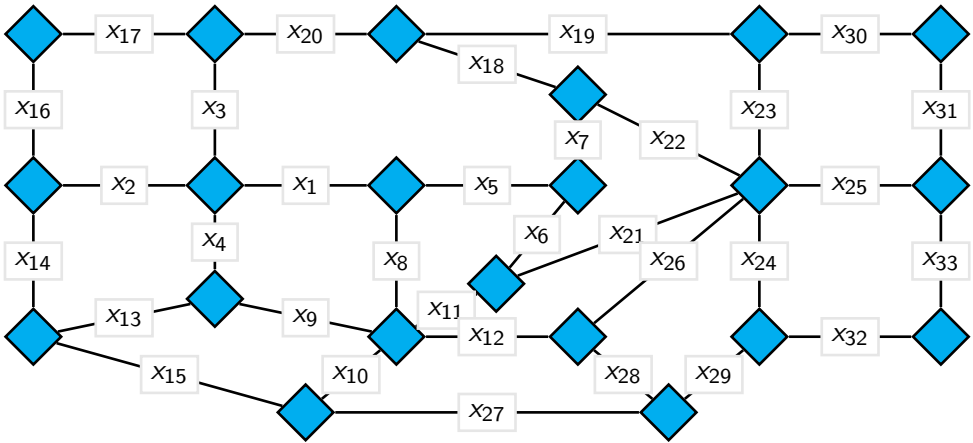
Theorem

If there exists a **non-signaling distribution** *that finds an α-approximation for some linear optimization problem Π with locality T, then there exists a* **classical LOCAL algorithm** *that finds an α-approximation for Π with locality T.*

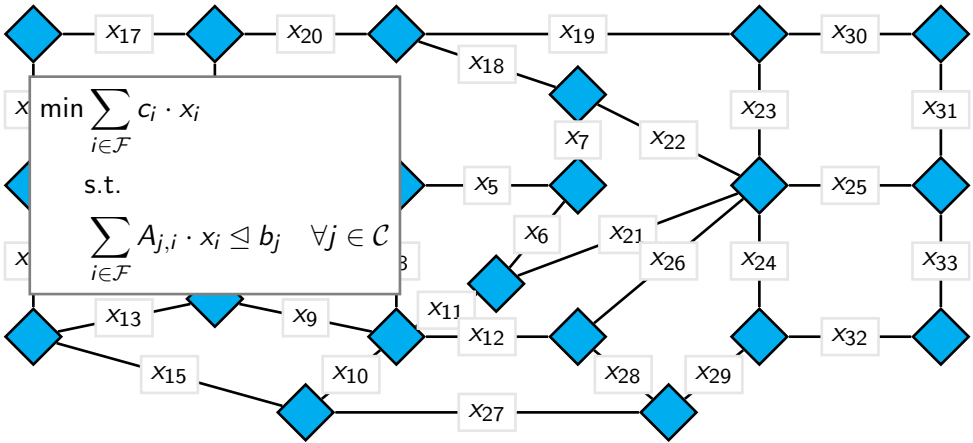
Linear Programs on Graphs



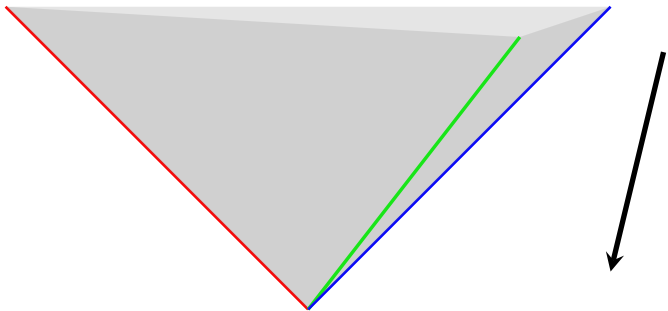
Linear Programs on Graphs



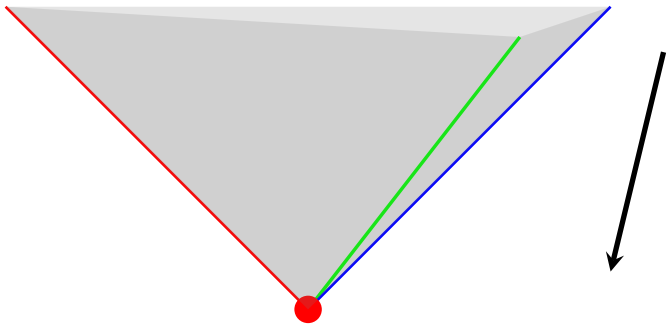
Linear Programs on Graphs



Contribution 1: Details



Contribution 1: Details



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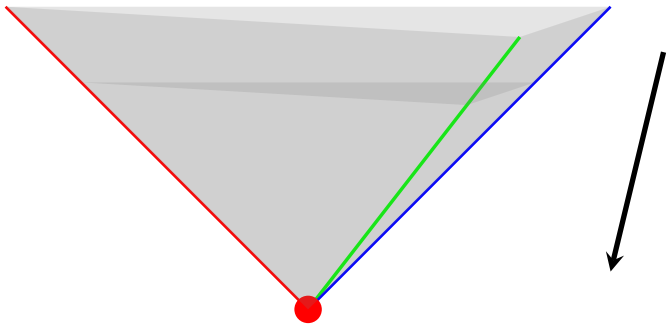

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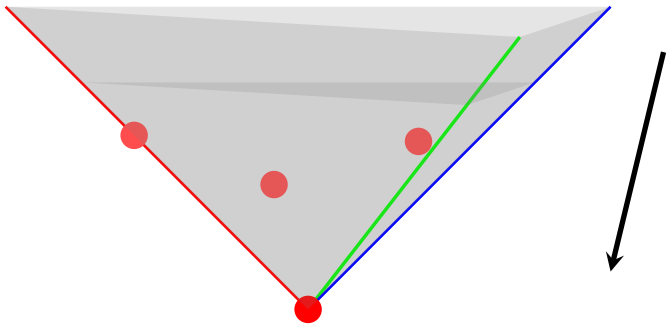

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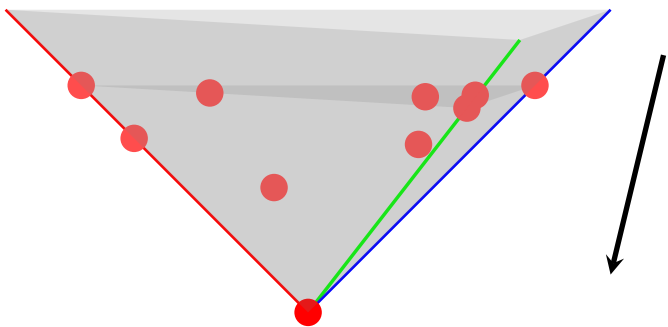

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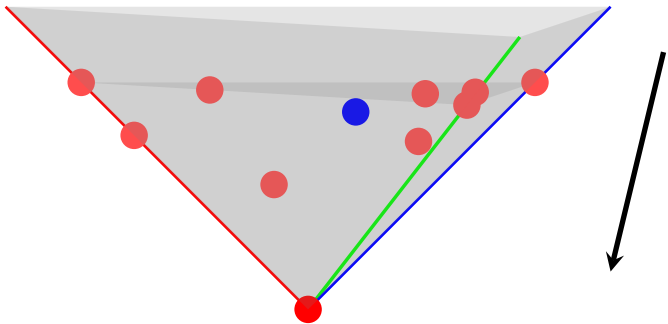
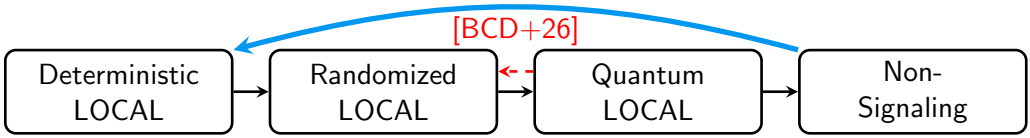


Landscape



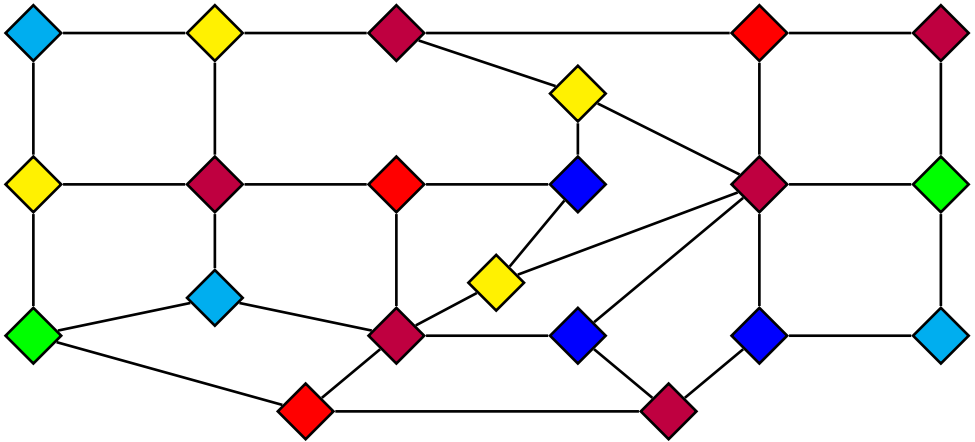
Stronger LCL Separation Linear Programs

Contribution 2

Theorem

There exists an LCL problem Π *that can be solved with locality* $O(\log n)$ *in* **SLOCAL model**, *but requires locality* $\omega(\log^{1.49} n)$ *locality* **quantum-LOCAL model** *and* **non-signaling model**.

Locally Checkable Labeling Problems [NS95]



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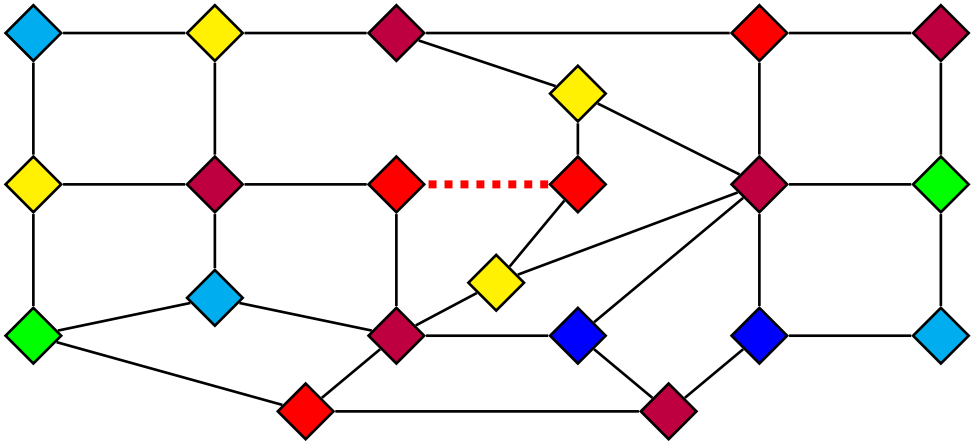

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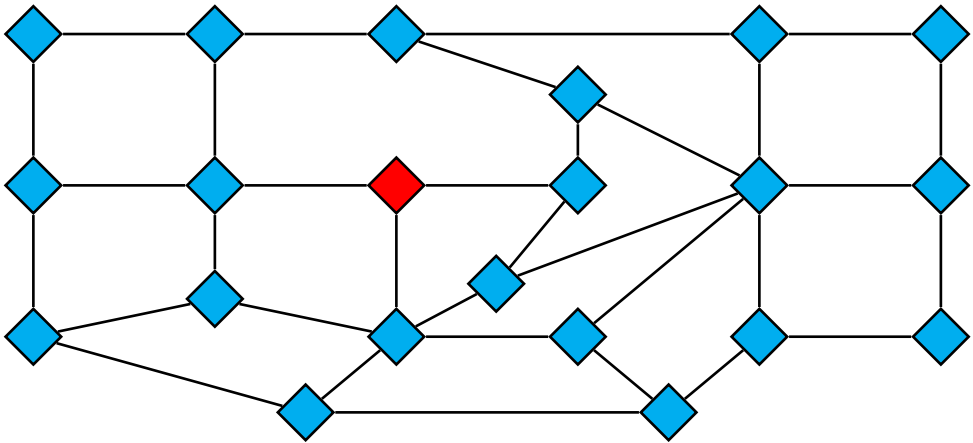

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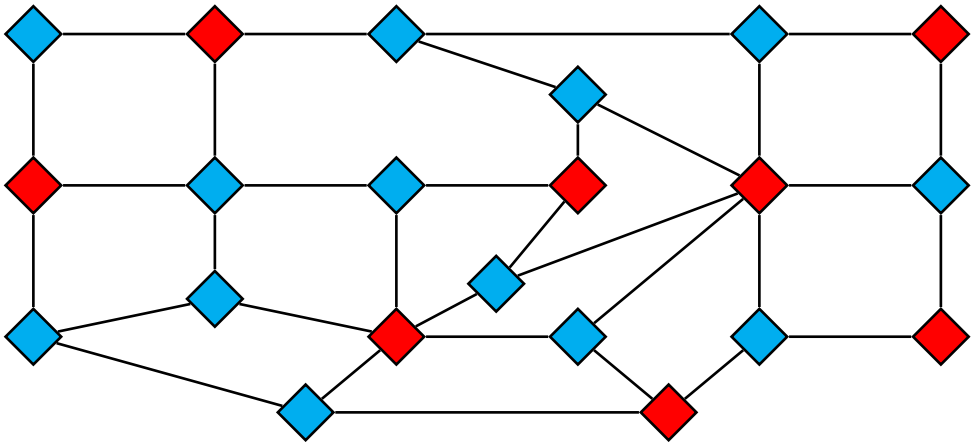

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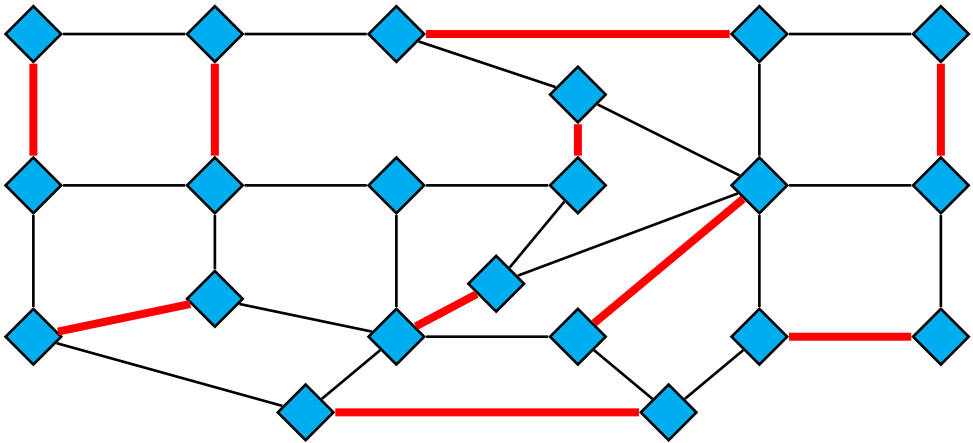
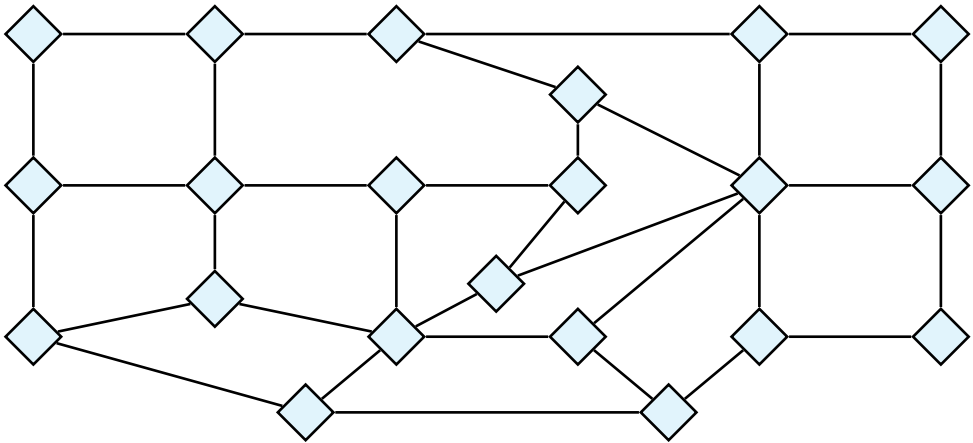


Sequential-LOCAL (SLOCAL) Model [GKM17]



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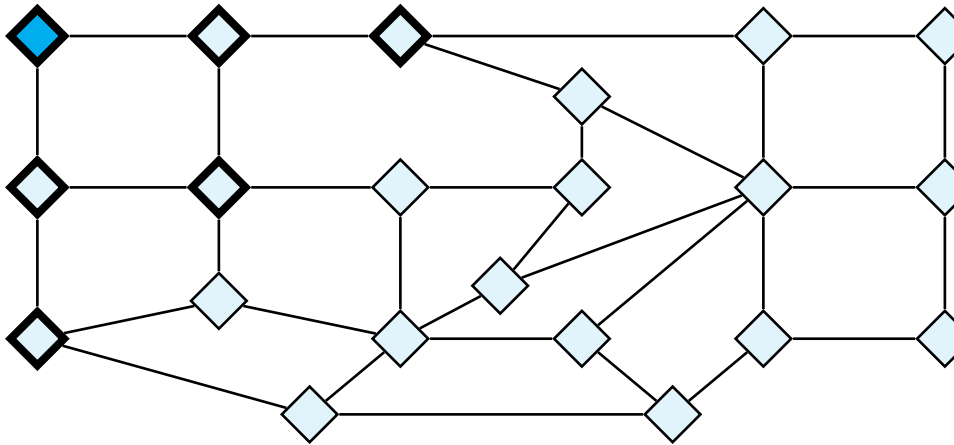

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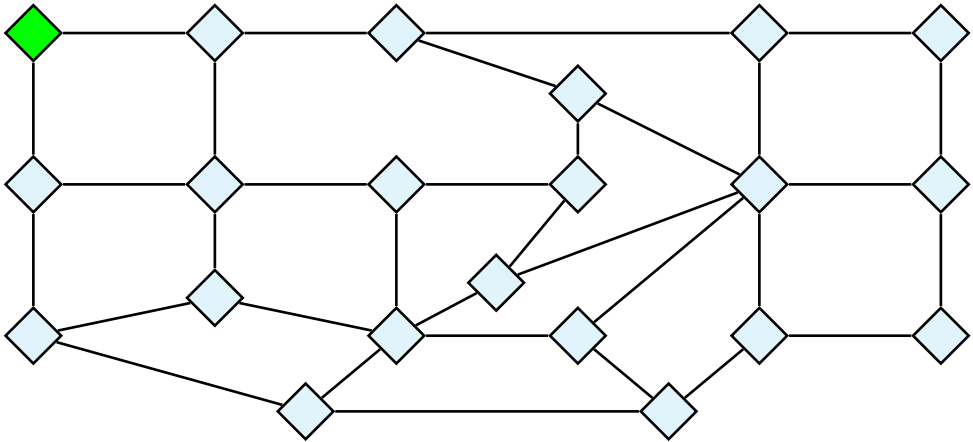

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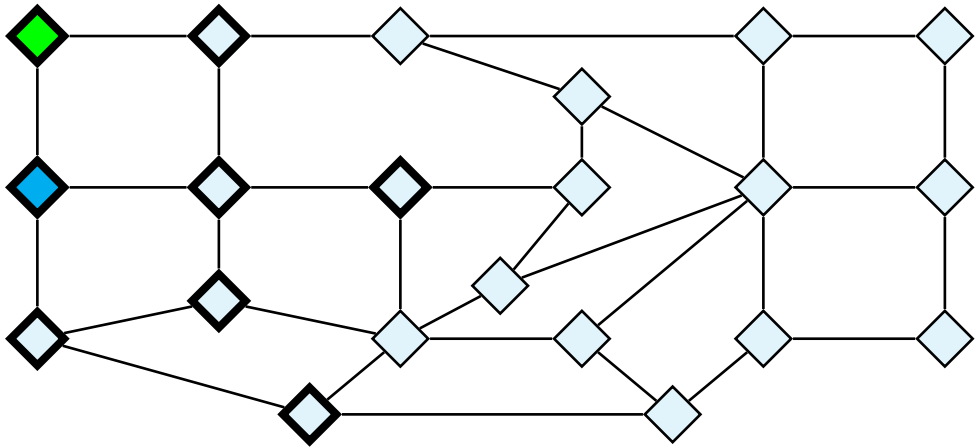

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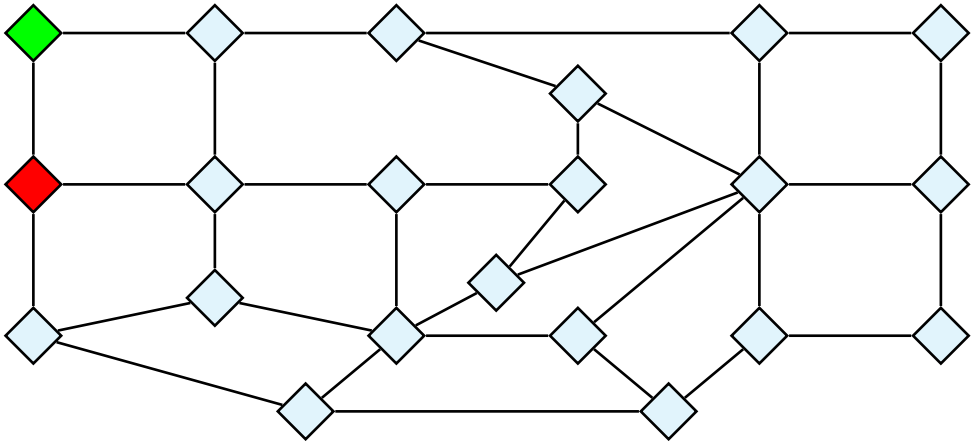

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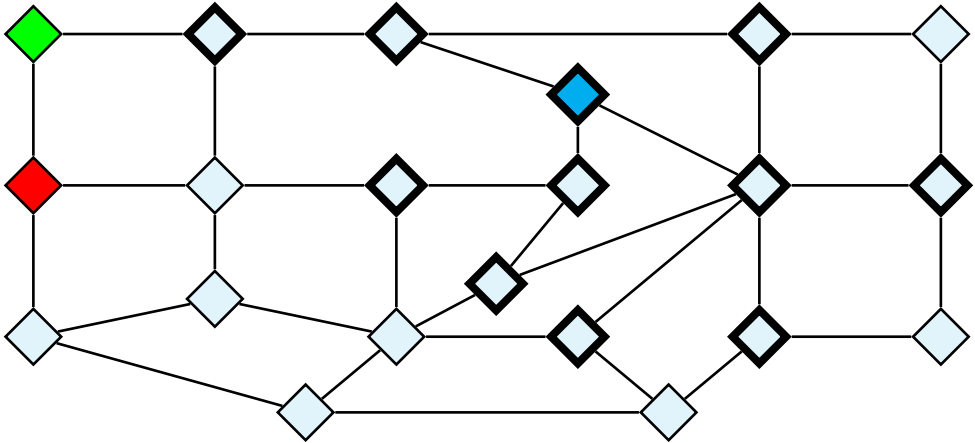

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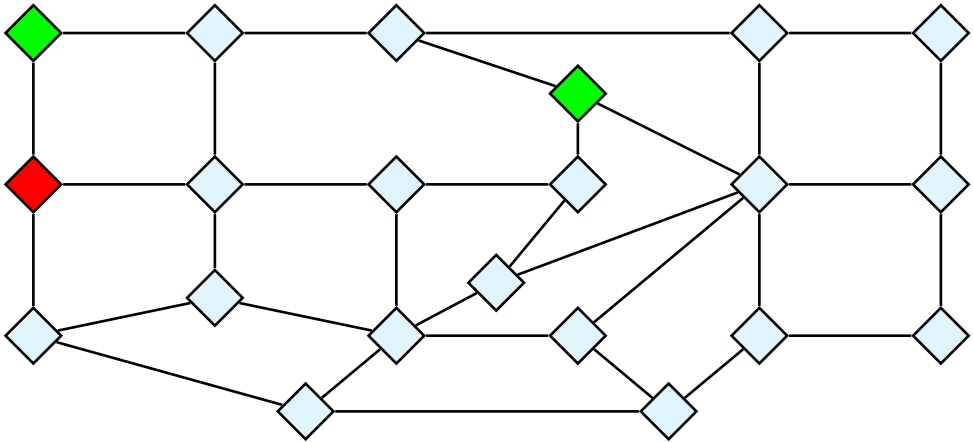
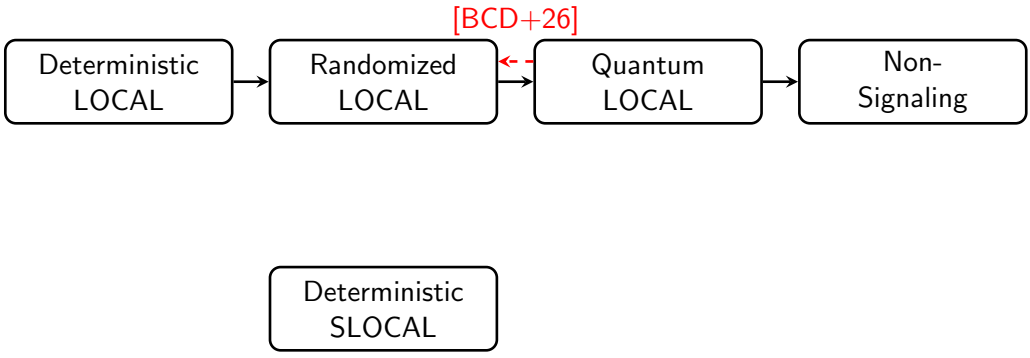


Landscape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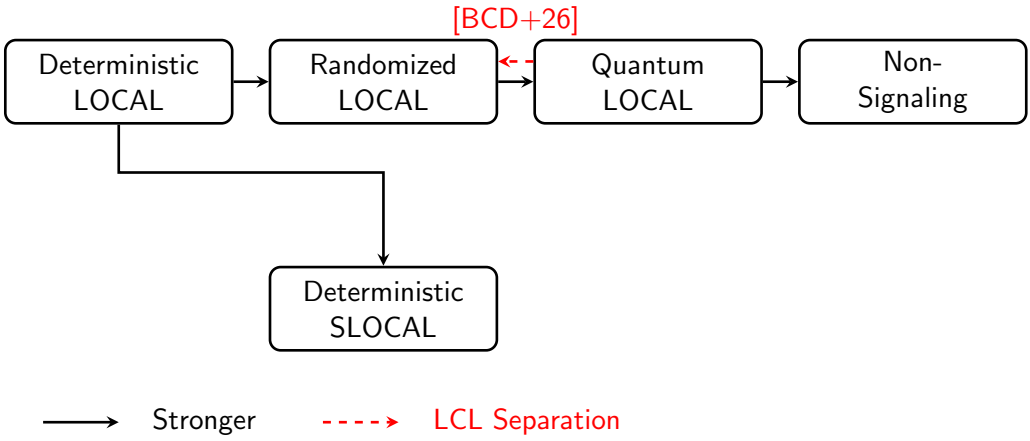
Deterministic LOCAL
Randomized LOCAL
Quantum LOCAL
Non-Signaling
Deterministic SLOCAL
Stronger
LCL Separation

Landscape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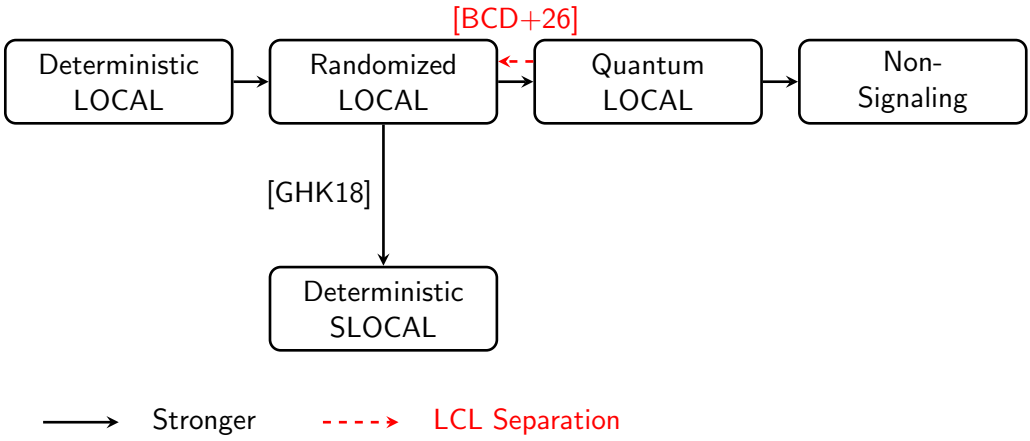
[BCD+26]
Deterministic LOCAL
Randomized LOCAL
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Non-Signaling
[GHK18]
Deterministic SLOCAL
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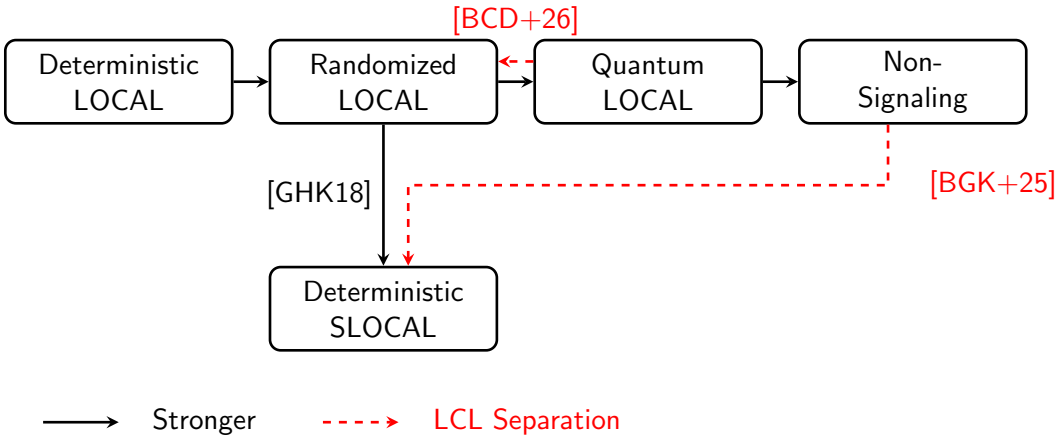
Landscape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Deterministic LOCAL
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Deterministic SLOCAL
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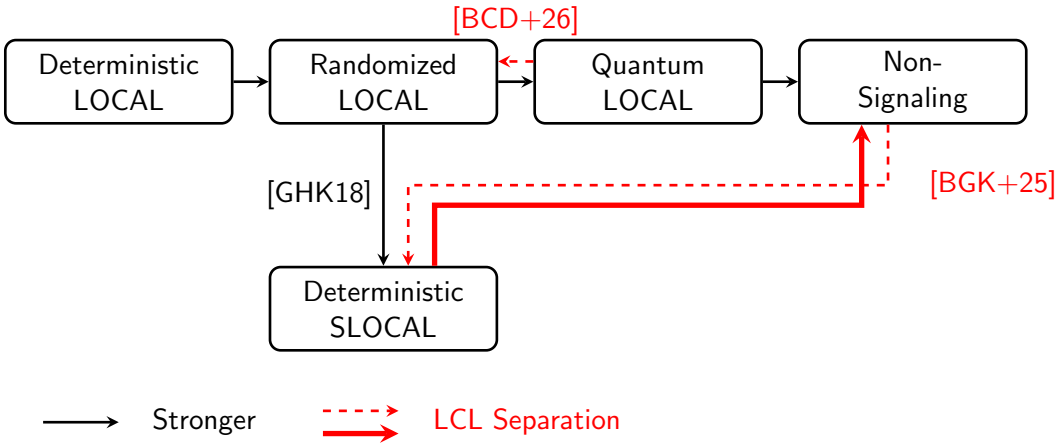
Landscape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Deterministic LOCAL
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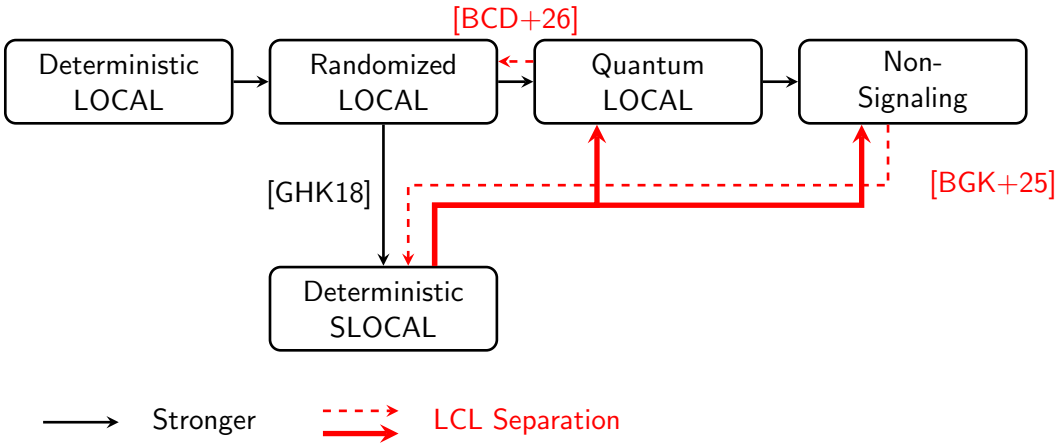
Landscape


[BCD+26]
Deterministic LOCAL
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[BGK+25]
Deterministic SLOCAL
Stronger
LCL Separation

KMW Bound [KMW16]

Theorem (Kuhn, Moscibroda, Wattenhofer, Simplified)

There does not exist a LOCAL algorithm providing a 3-approximation of fractional maximum matching with locality $o(\log^{0.49} n)$.

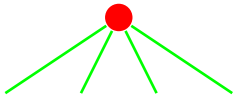
Contribution 2: Details

Problem	LOCAL	SLOCAL
Maximal matching	$\Omega(\log^{0.49} n)$	$O(1)$
$\Downarrow$		
2-approximate maximum matching	$\Omega(\log^{0.49} n)$	$O(1)$
$\Downarrow$		
3-approximate fractional maximum matching	$\Omega(\log^{0.49} n)$	$O(1)$

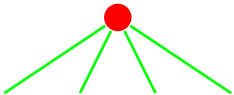
Contribution 2: Details

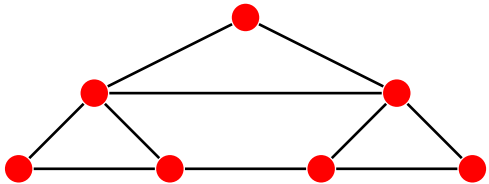
Problem	Non-Signaling	SLOCAL
Maximal matching	$\Omega(\log^{0.49} n)$	$O(1)$
$\Downarrow$		
2-approximate maximum matching	$\Omega(\log^{0.49} n)$	$O(1)$
$\Downarrow$		
3-approximate fractional maximum matching	$\Omega(\log^{0.49} n)$	$O(1)$

Contribution 2: Details

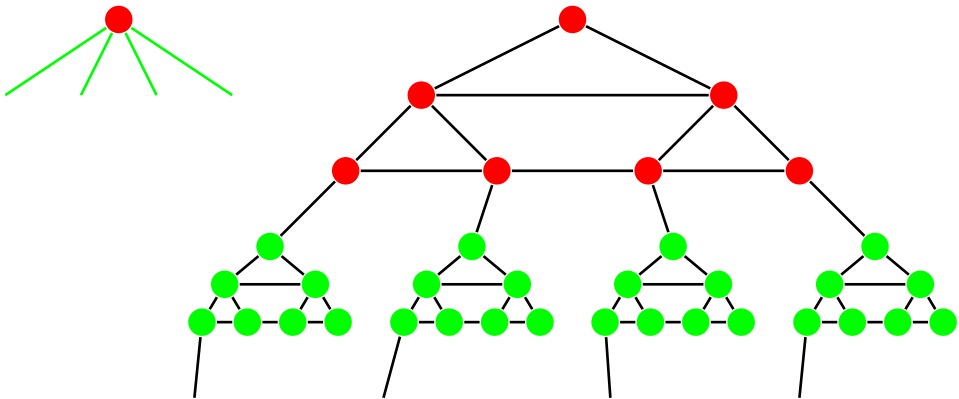


Contribution 2: Details





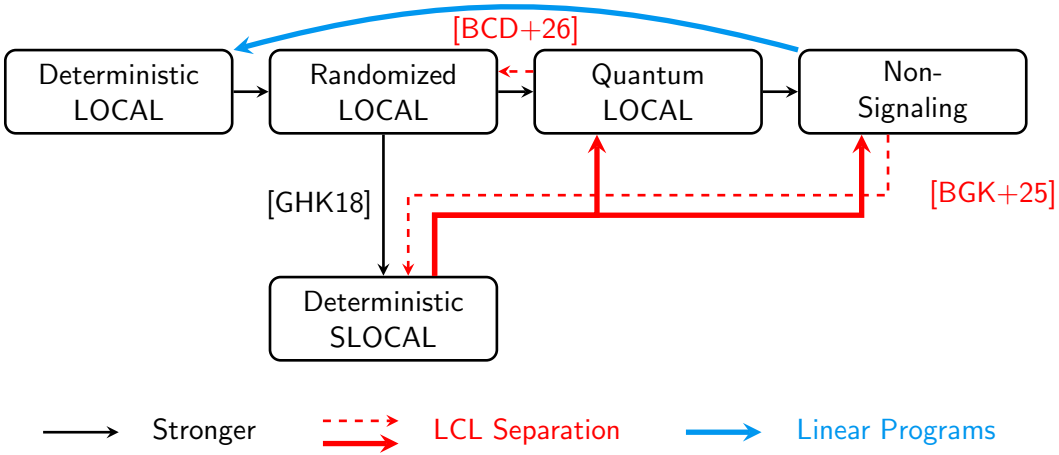
Contribution 2: Details



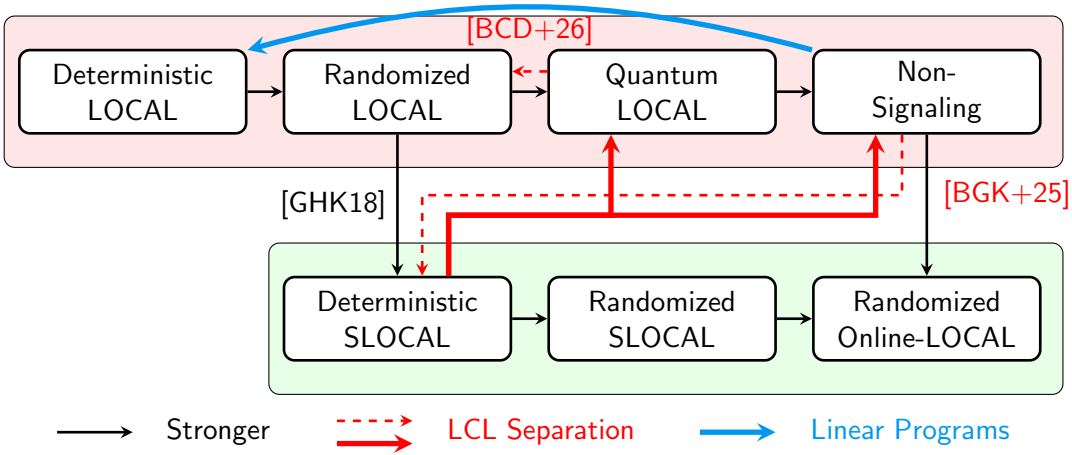
Contribution 2: Details

Problem	Quantum-LOCAL / Non-Signaling	SLOCAL	LCL
Maximal matching	$\omega(\log^{0.49} n)$	$O(1)$	No
Lifted maximal matching	$\omega(\log^{1.49} n)$	$O(\log n)$	Yes

Landscape


[BCD+26]
Deterministic LOCAL
Randomized LOCAL
Quantum LOCAL
Non-Signaling
[GHK18]
[BGK+25]
Deterministic SLOCAL
Stronger
LCL Separation
Linear Programs

Landscape


[BCD+26]
Deterministic LOCAL
Randomized LOCAL
Quantum LOCAL
Non-Signaling
[GHK18]
[BGK+25]
Deterministic SLOCAL
Randomized SLOCAL
Randomized Online-LOCAL
Stronger
LCL Separation
Linear Programs

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