Optimal Oblivious Reconfigurable Networks

STOC 2022

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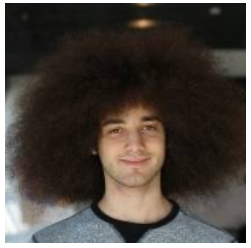
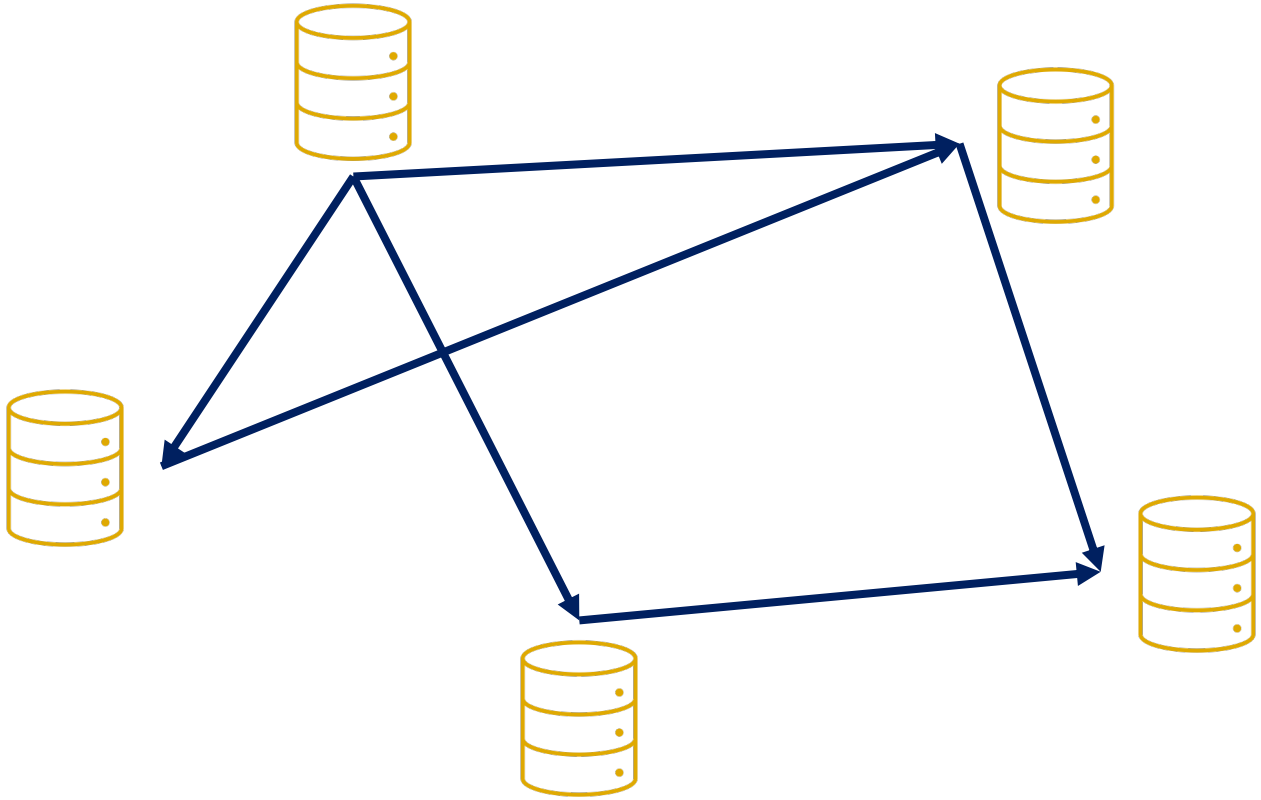
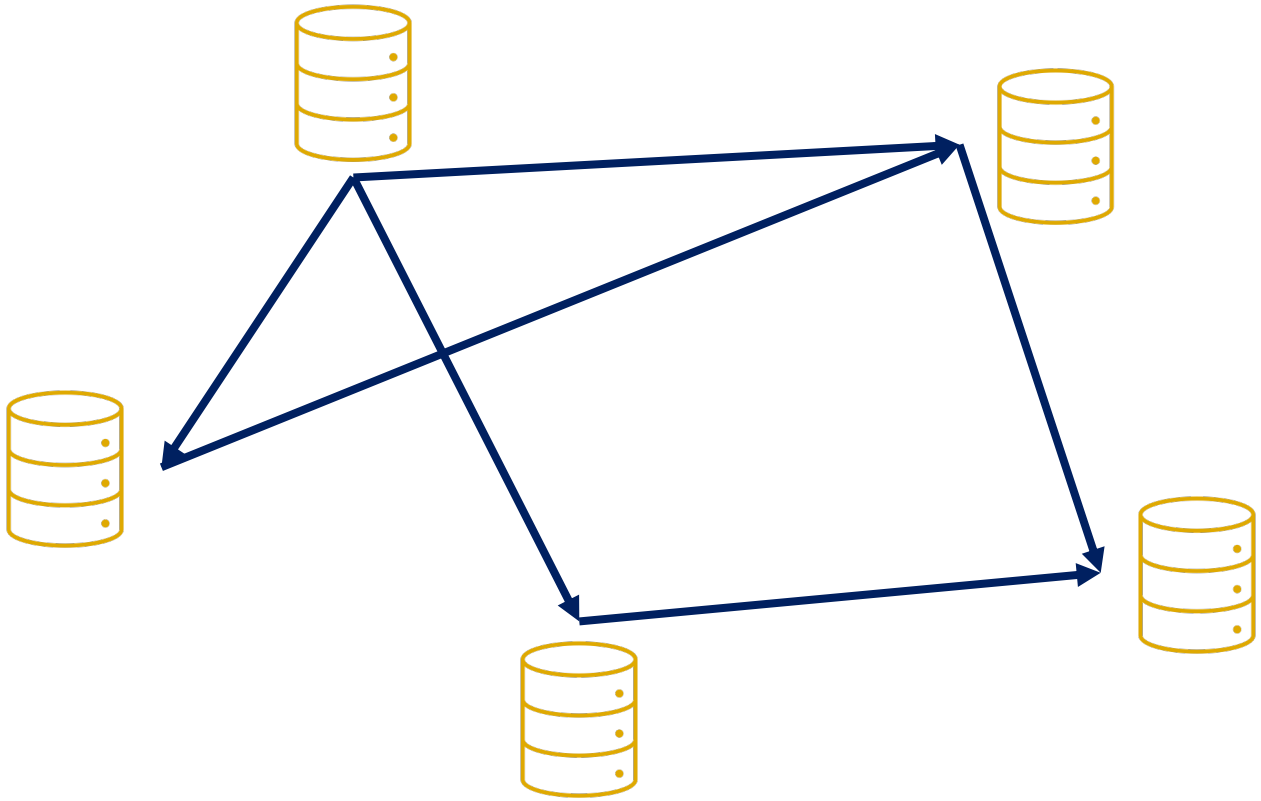
[1]Cornell University [2]Purdue University

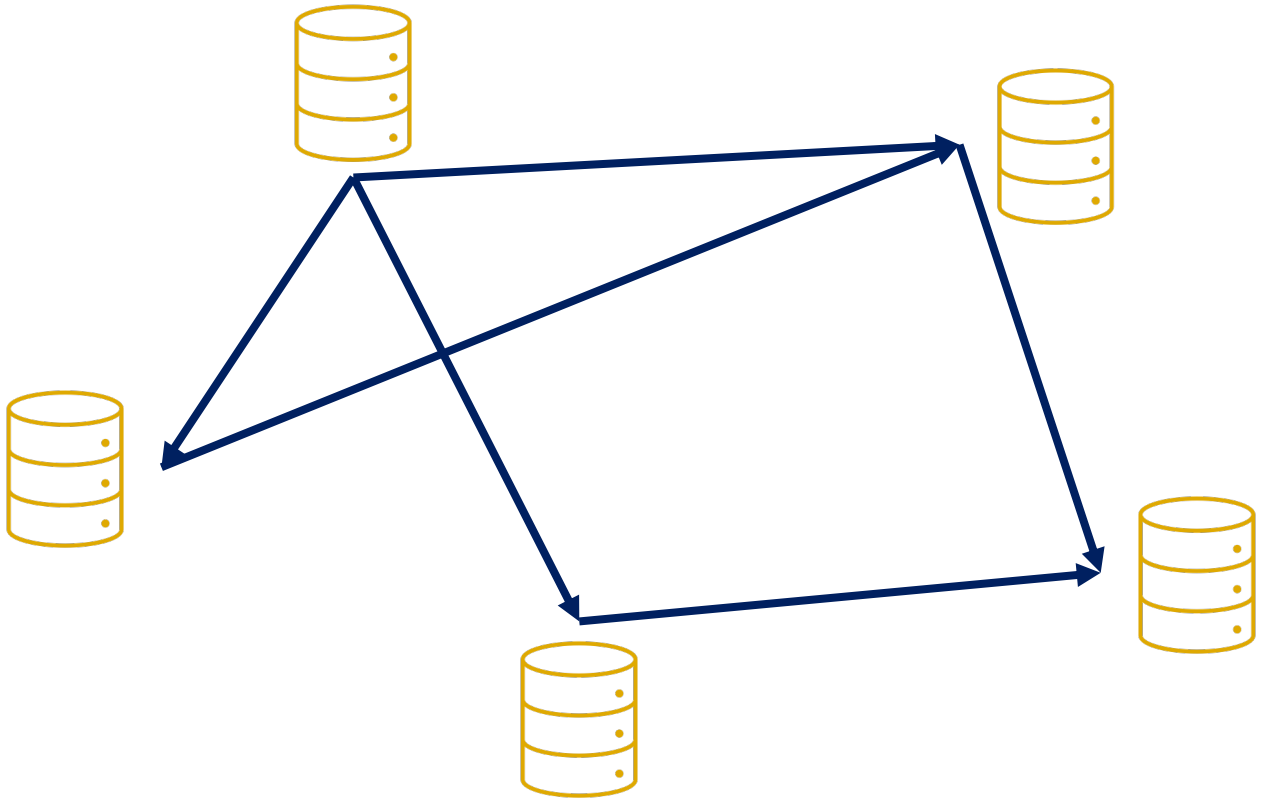






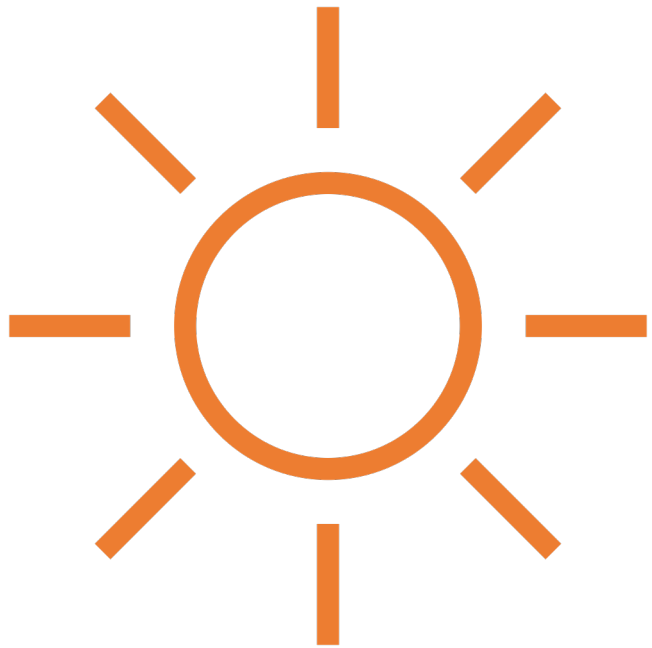


How do we connect servers so they can communicate?



How do we connect servers so they can communicate?

How do we route messages along those connections?



Oblivious Reconfigurable Networks (ORNs)

- Set of N nodes

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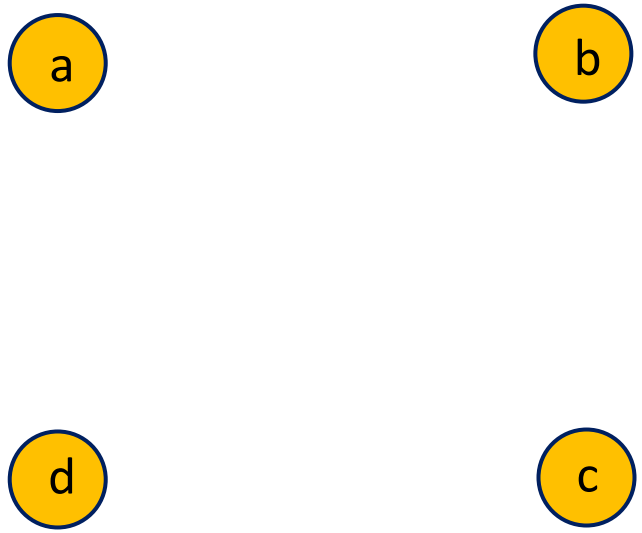
- 1-regular directed networks for this talk
  - Results extend to d-regular for any constant d

Oblivious Reconfigurable Networks



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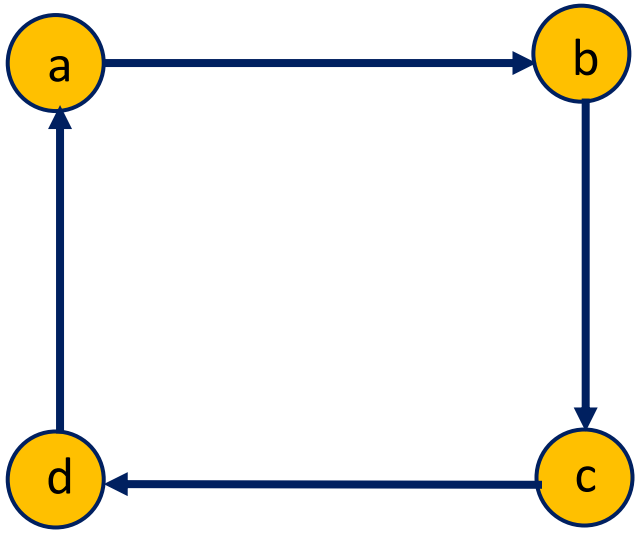

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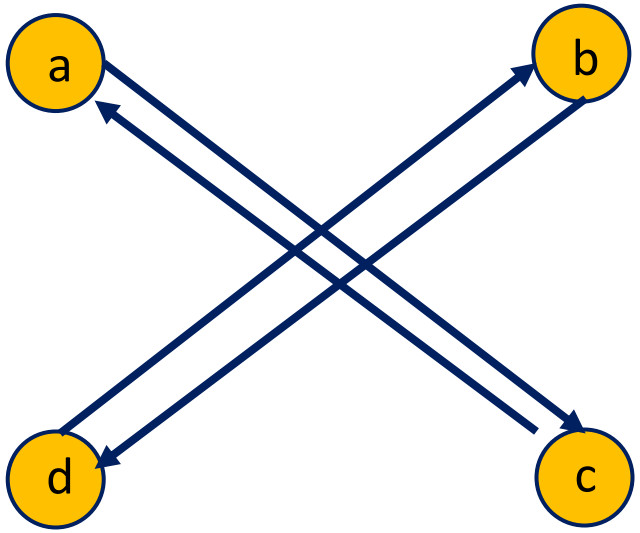

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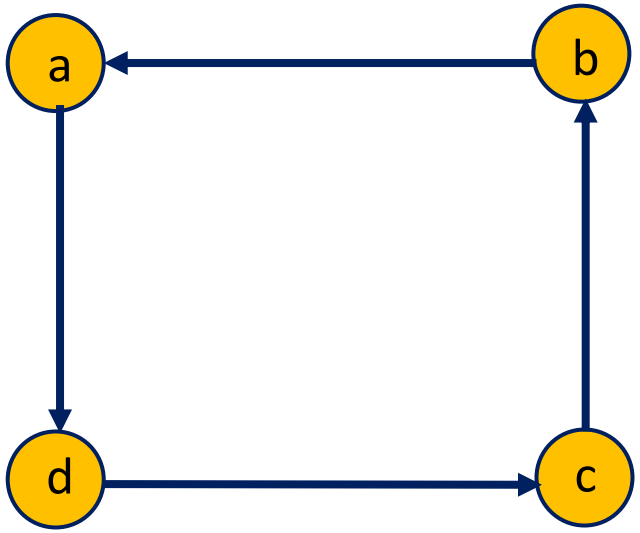

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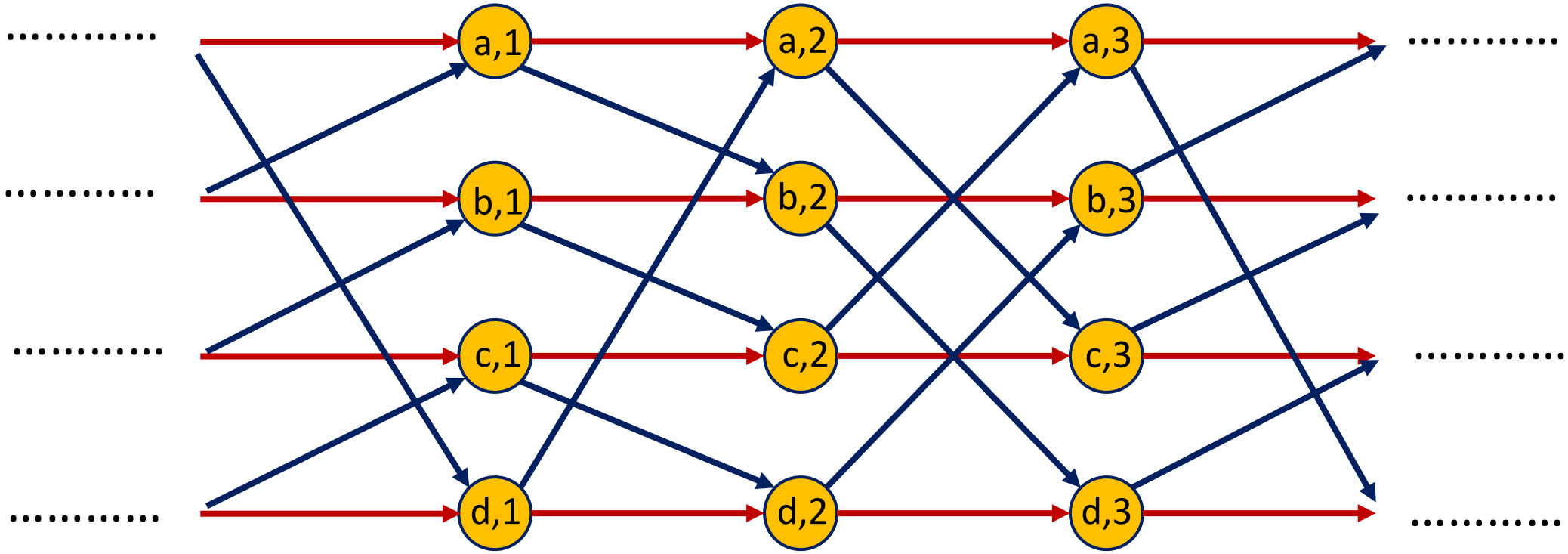
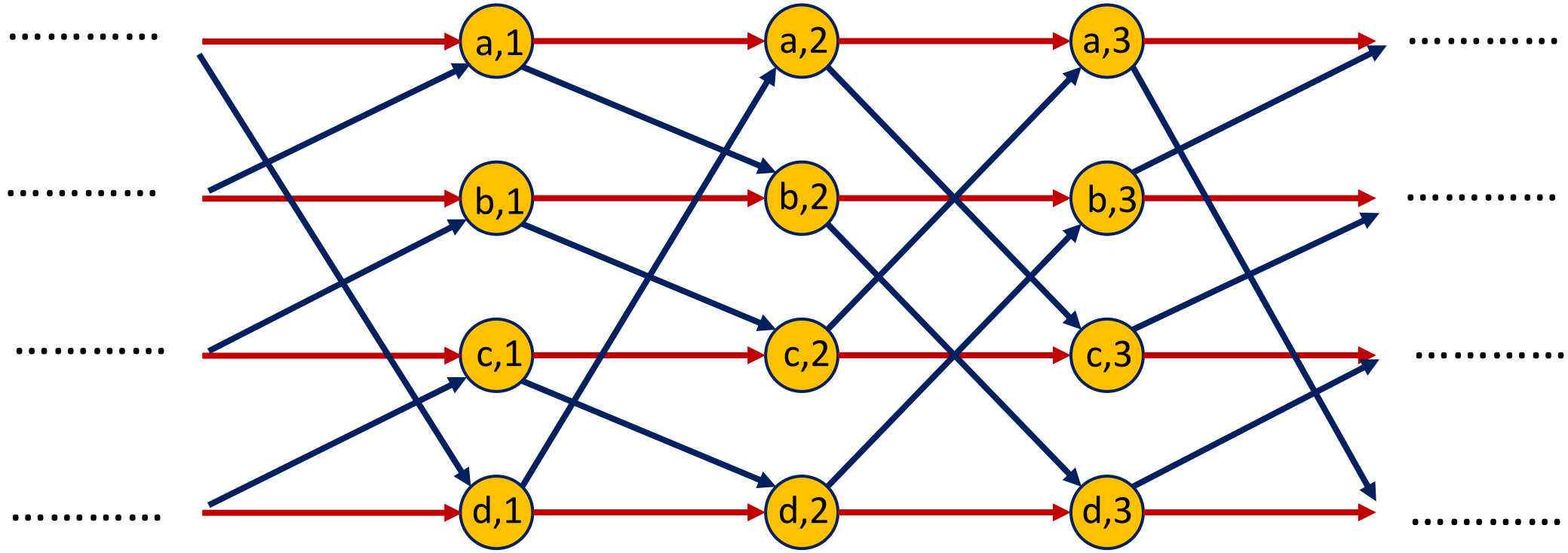


Oblivious Reconfigurable Networks

Virtual Topology



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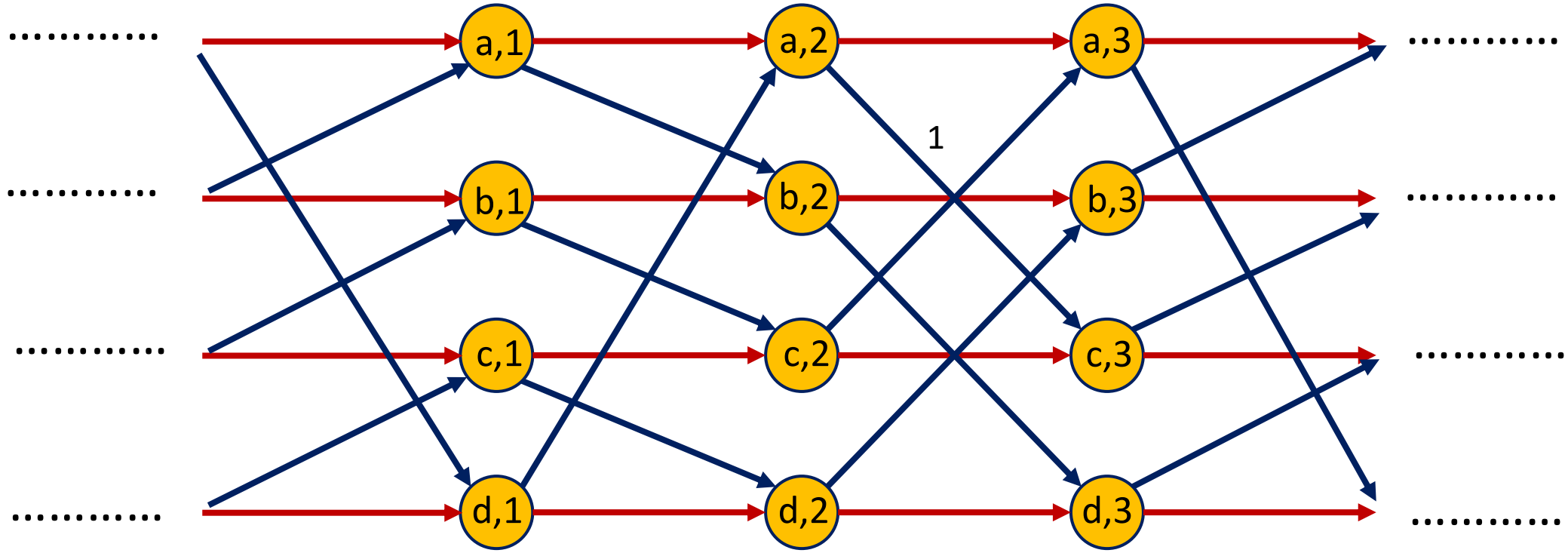

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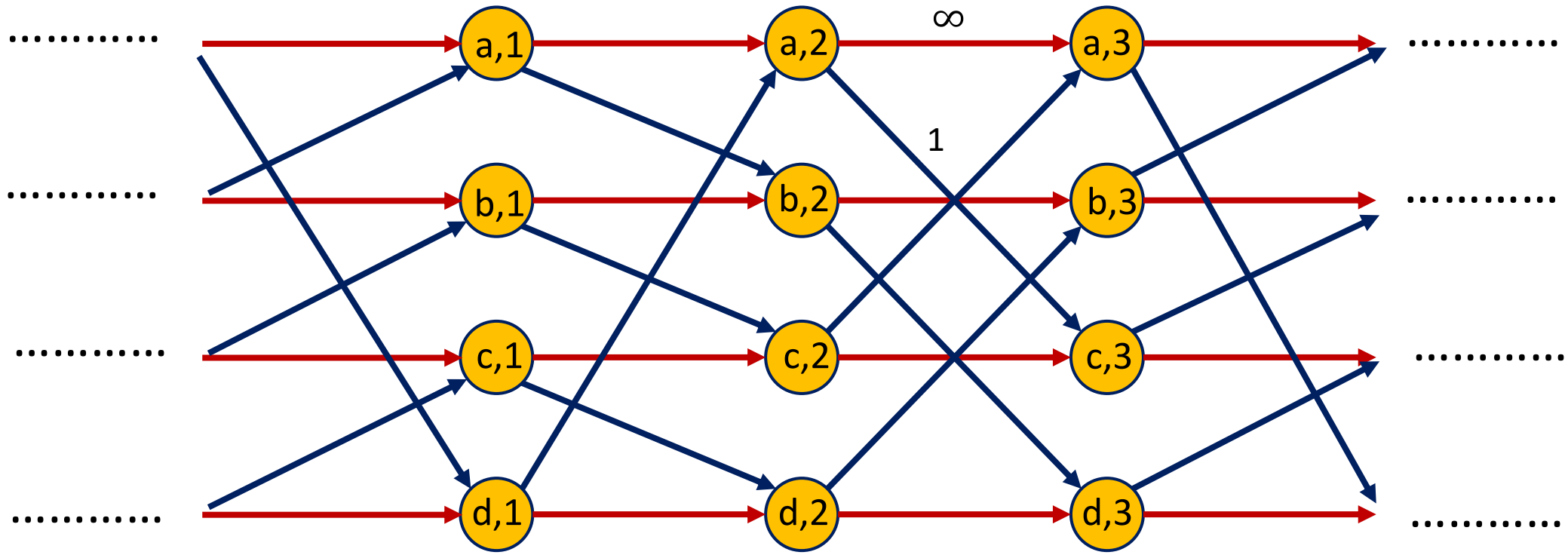

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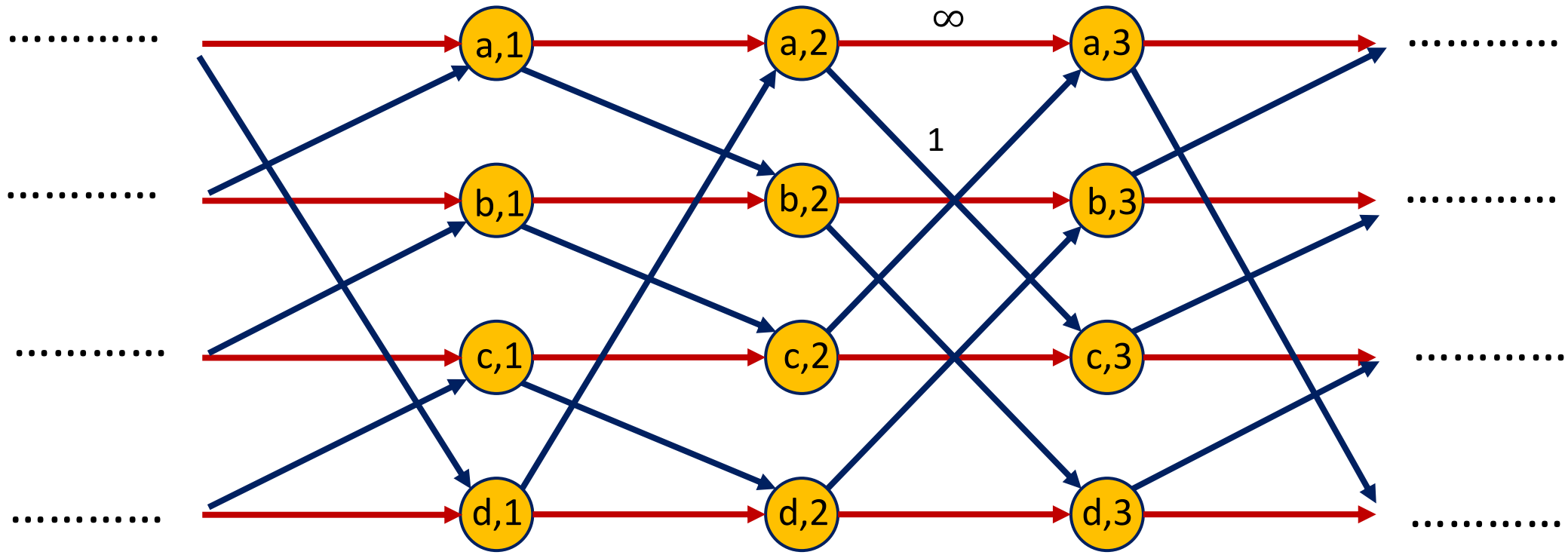

Route $a \rightarrow c$ starting at $t = 1$

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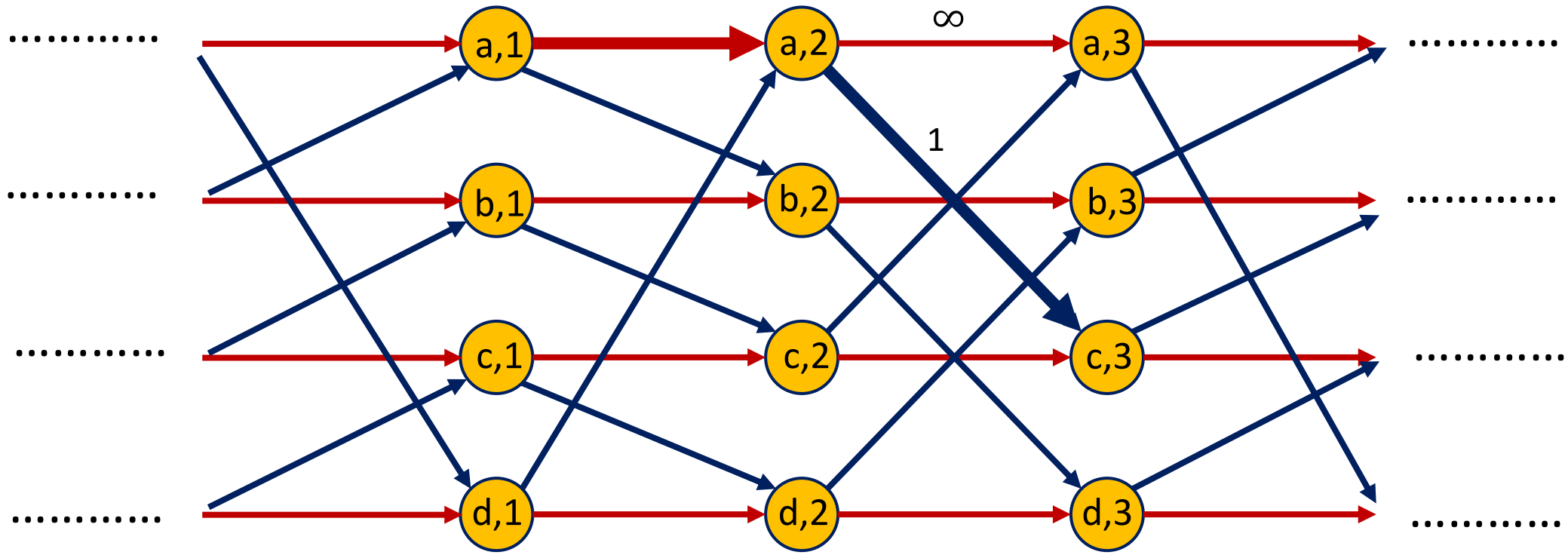

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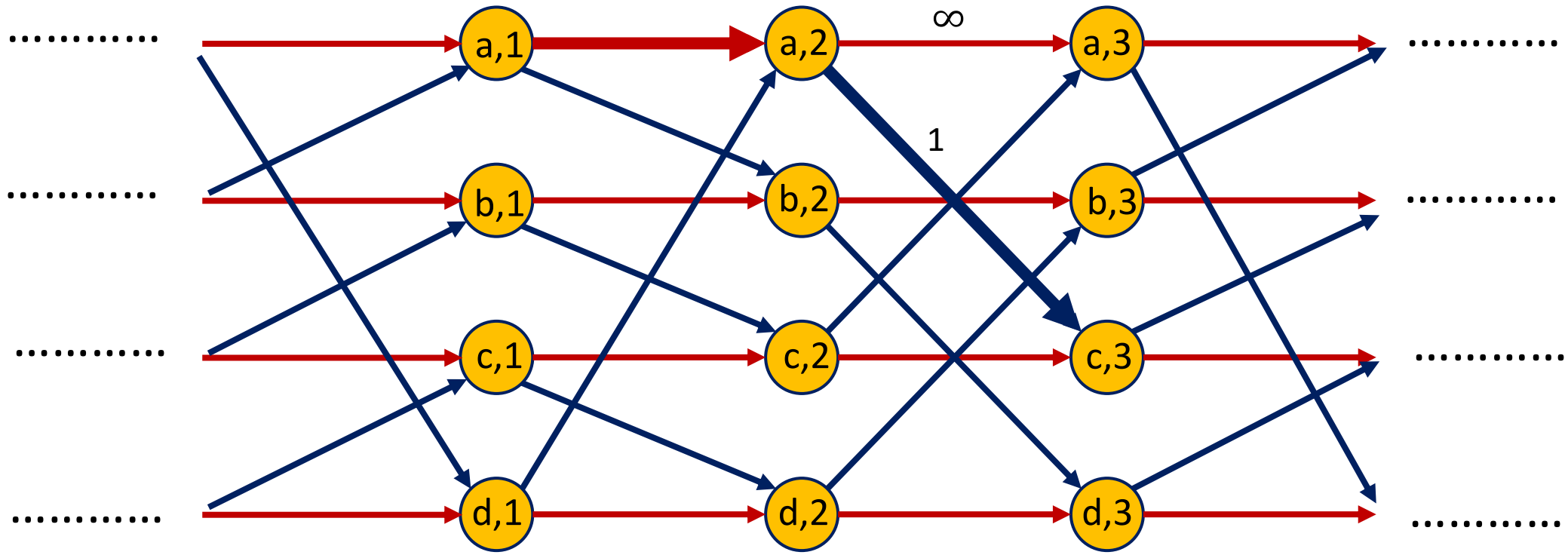

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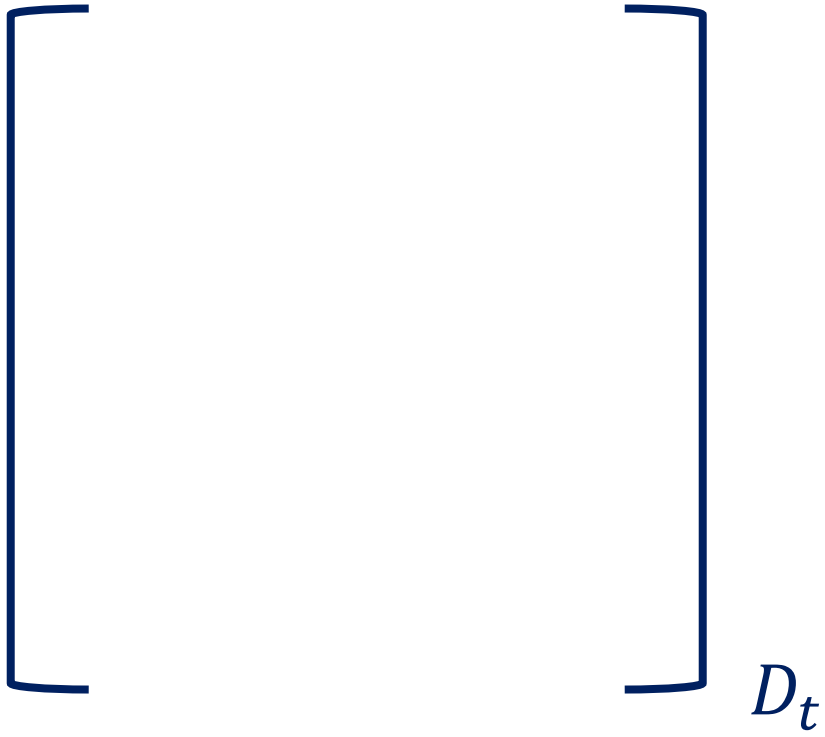
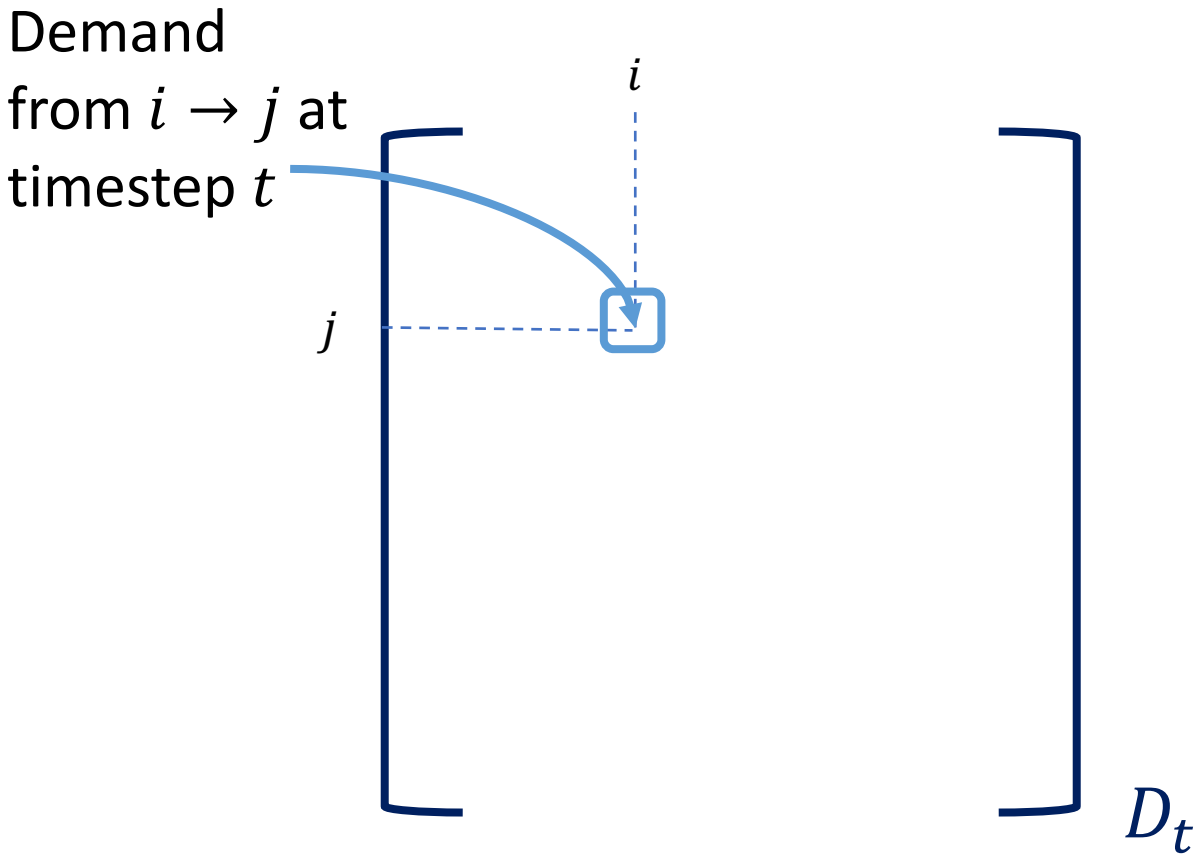
Path has latency $L = 2$

Throughput

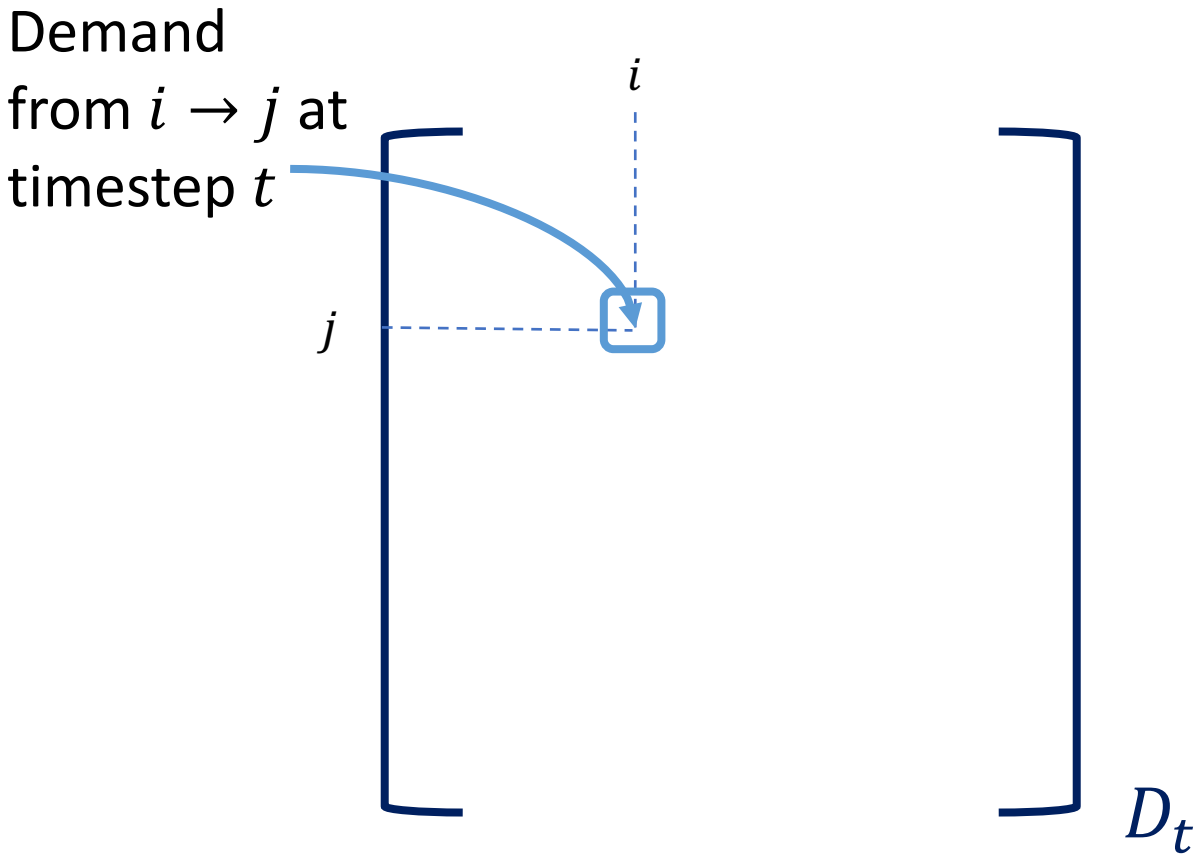


Throughput



Throughput

- A matrix requests throughput r if…



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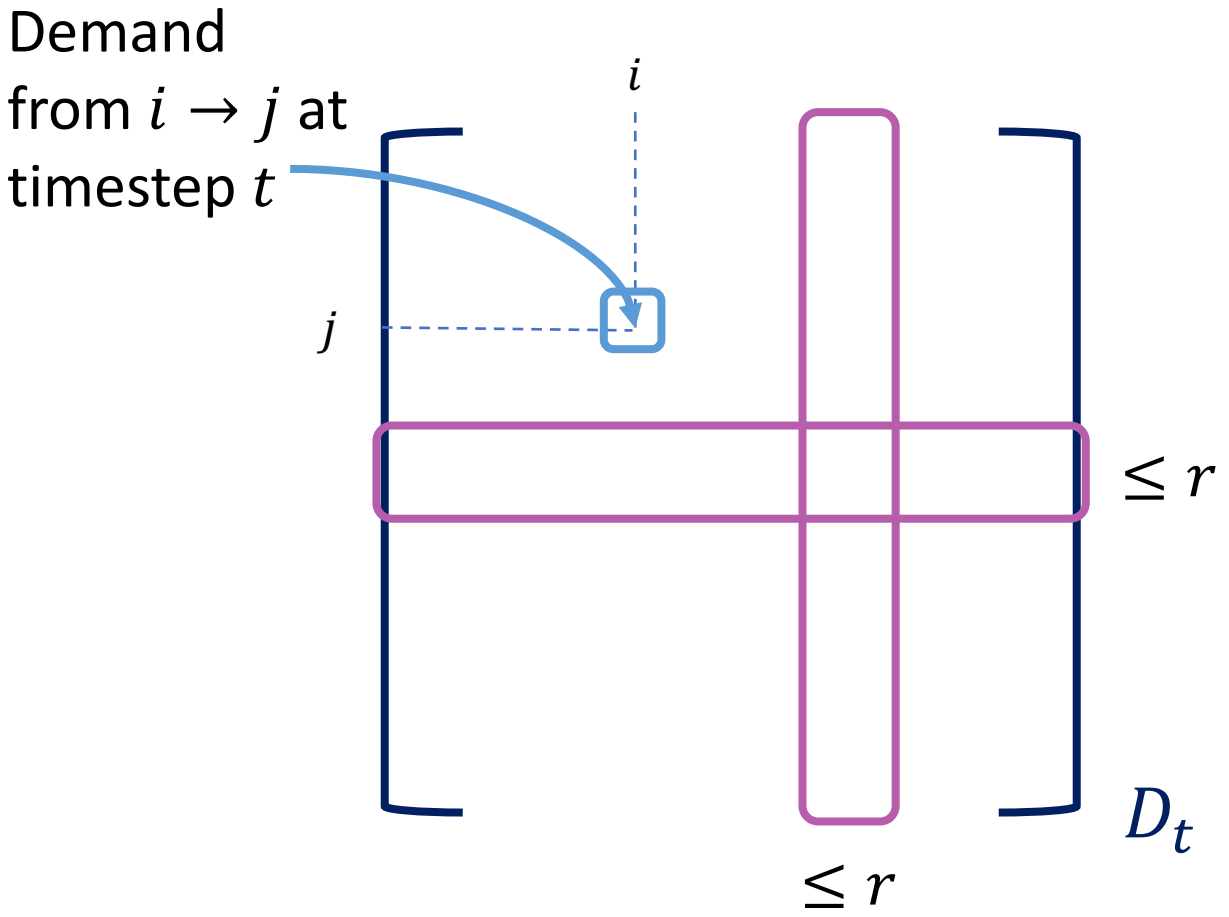
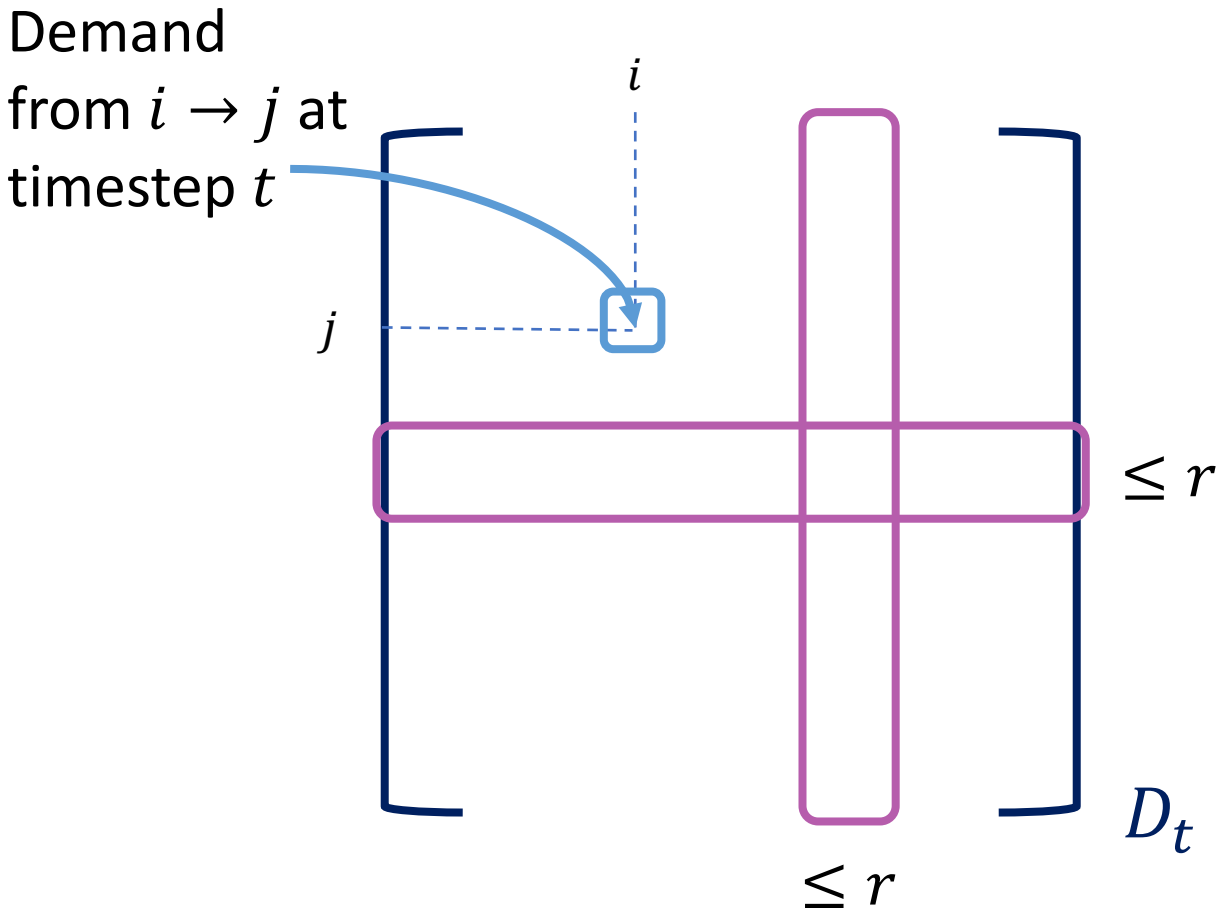


Throughput

- A matrix requests throughput r if…
  - Row/column sums $\leq r$
- An ORN design guarantees throughput r if it can route all matrices requesting throughput r without overloading edges



Main Result

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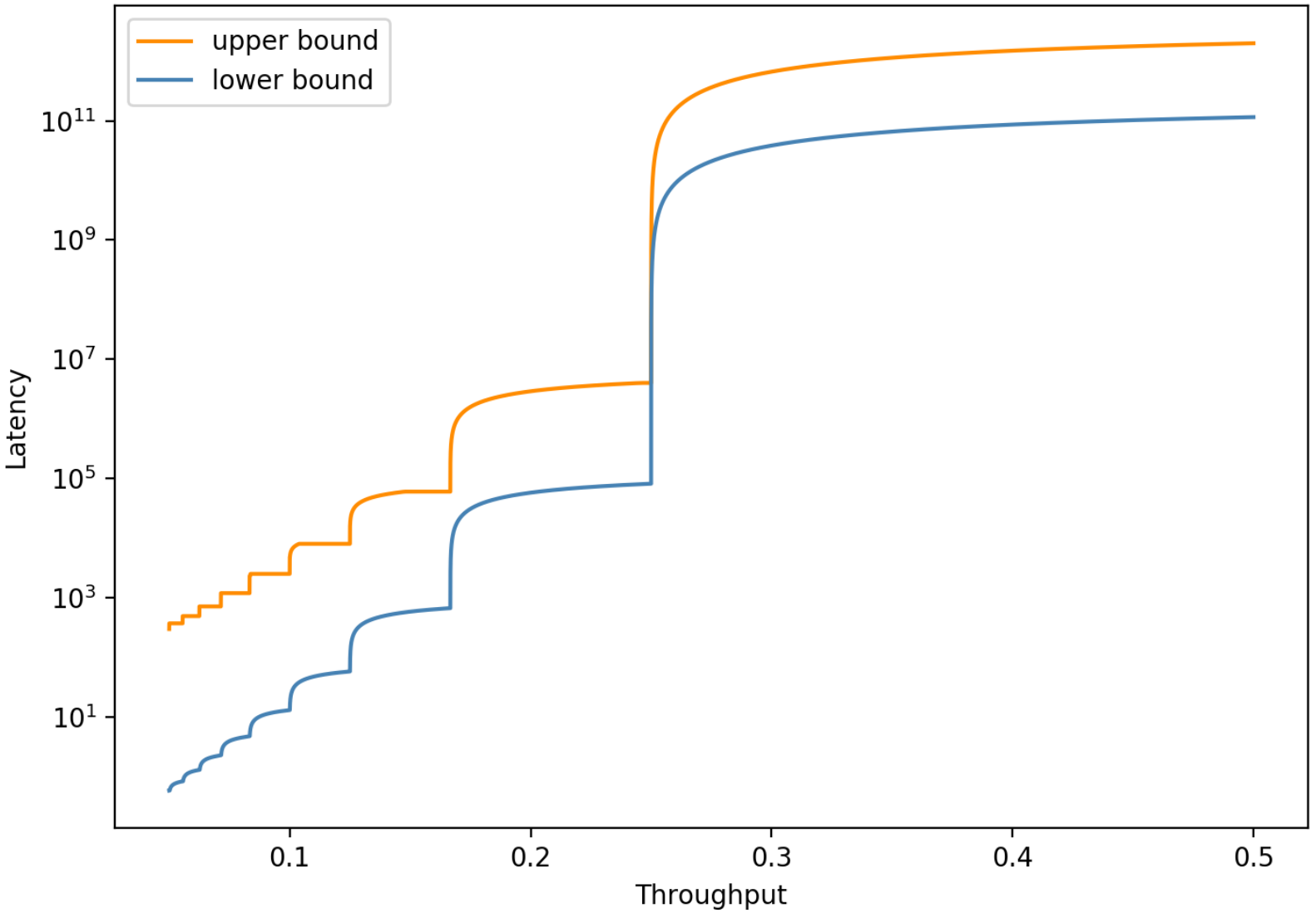
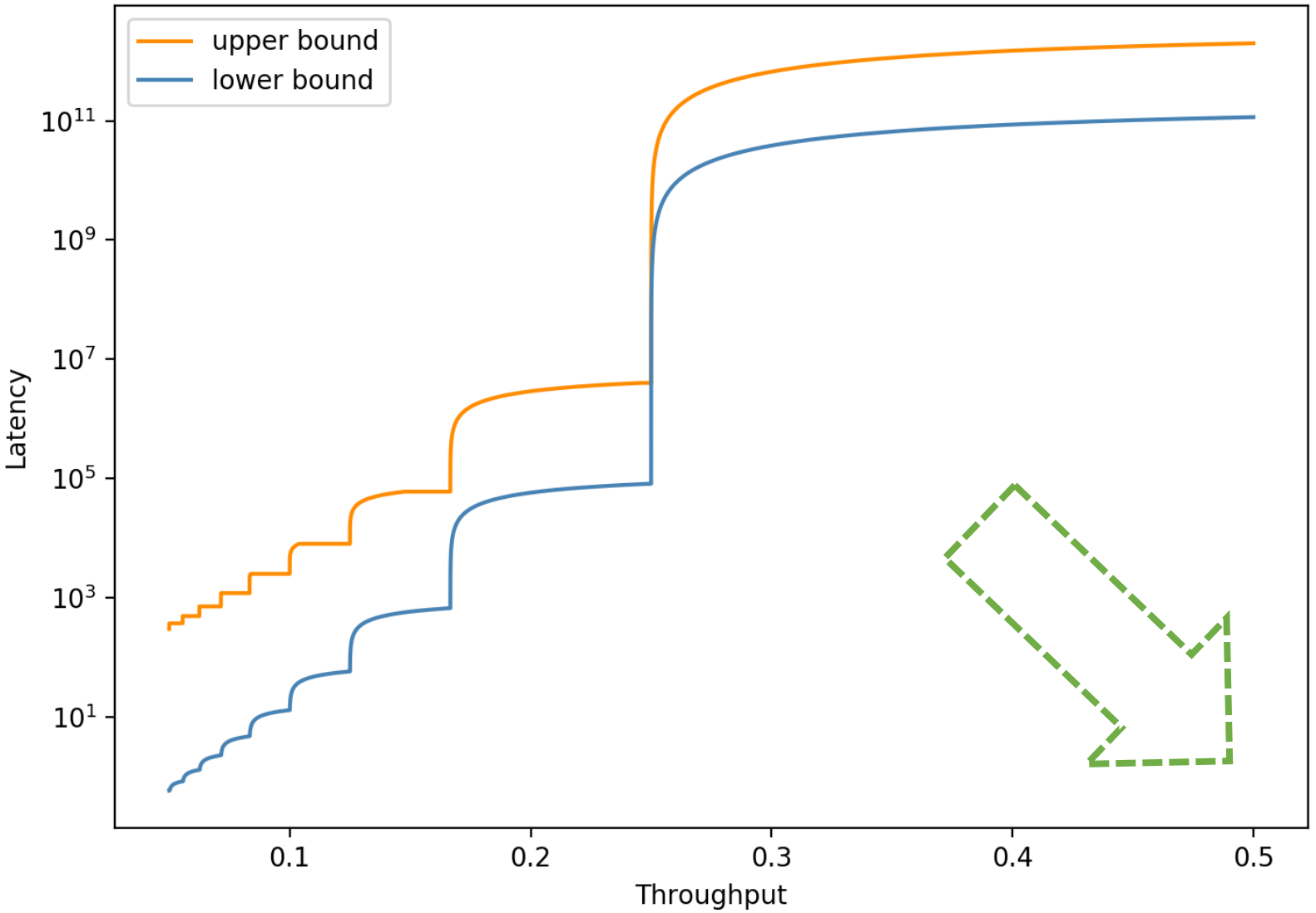
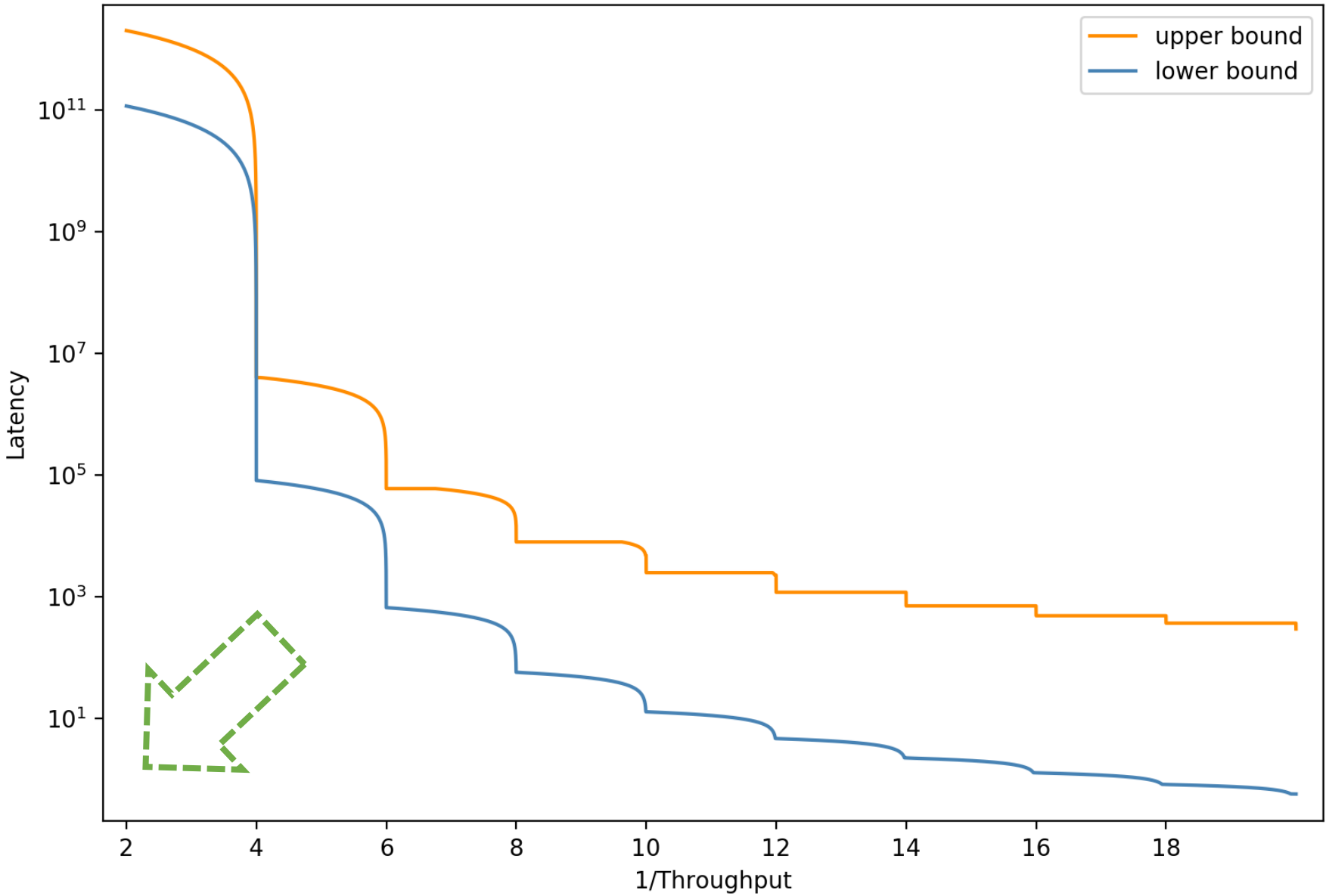
We fully resolve up to a constant factor!

Throughput v. Latency, $N = 10^{12}$

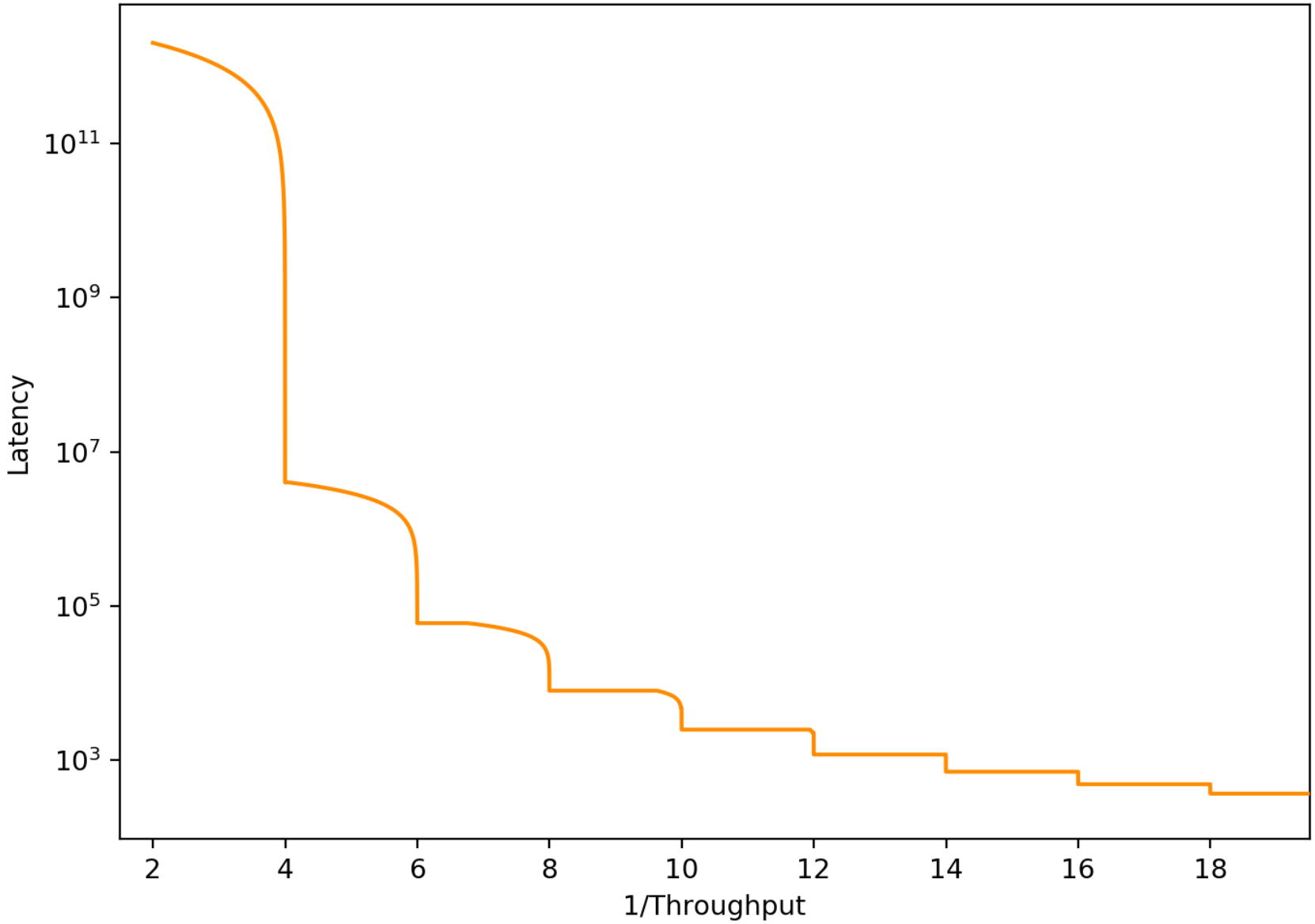


Throughput v. Latency, $N = 10^{12}$




upper bound
lower bound
Latency
10^{11}
10^{9}
10^{7}
10^{5}
10^{3}
10^{1}
2
4
6
8
10
12
14
16
18
1/Throughput

Upper Bound



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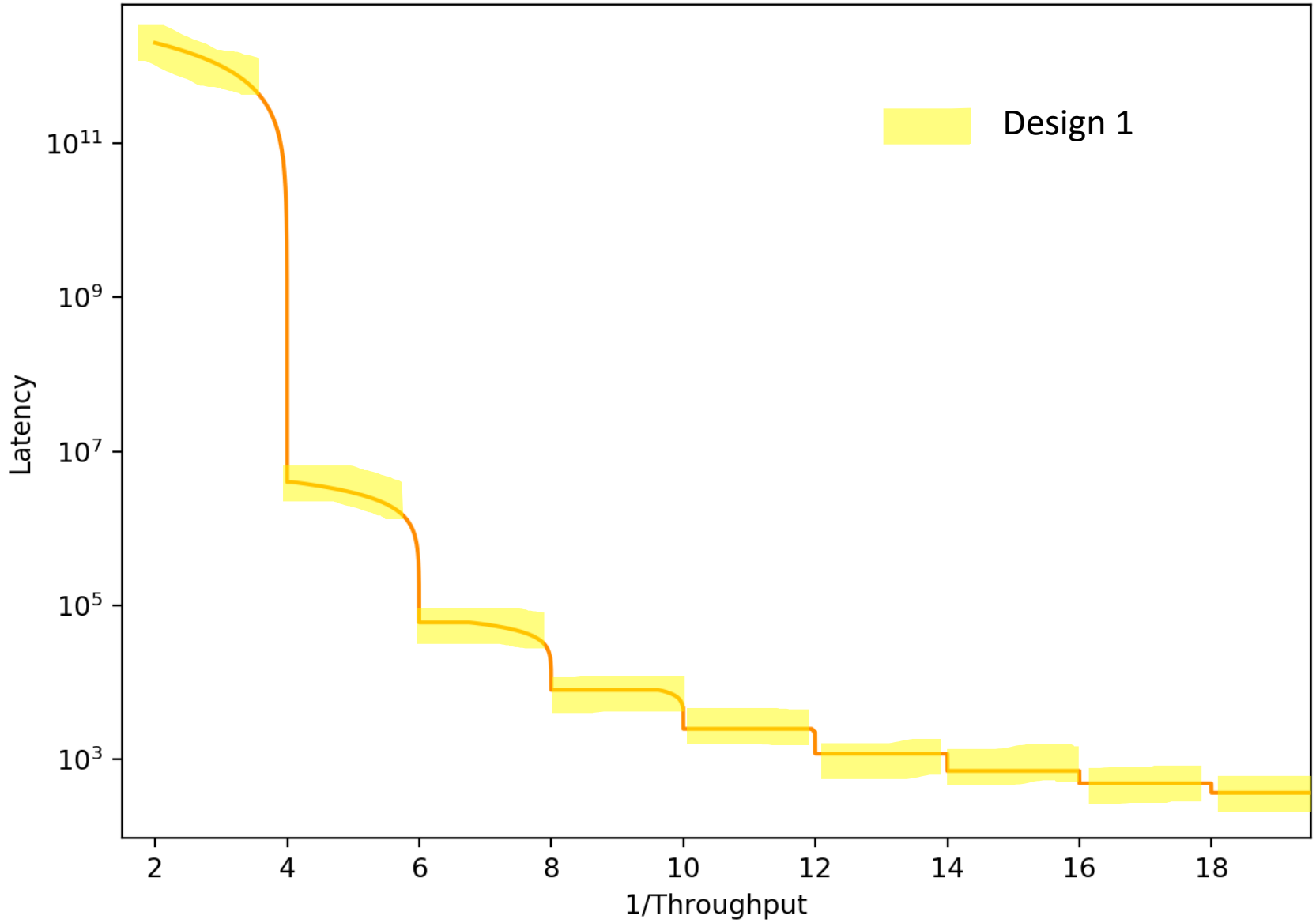
Design 1
Latency
10^{11}
10^{9}
10^{7}
10^{5}
10^{3}
2
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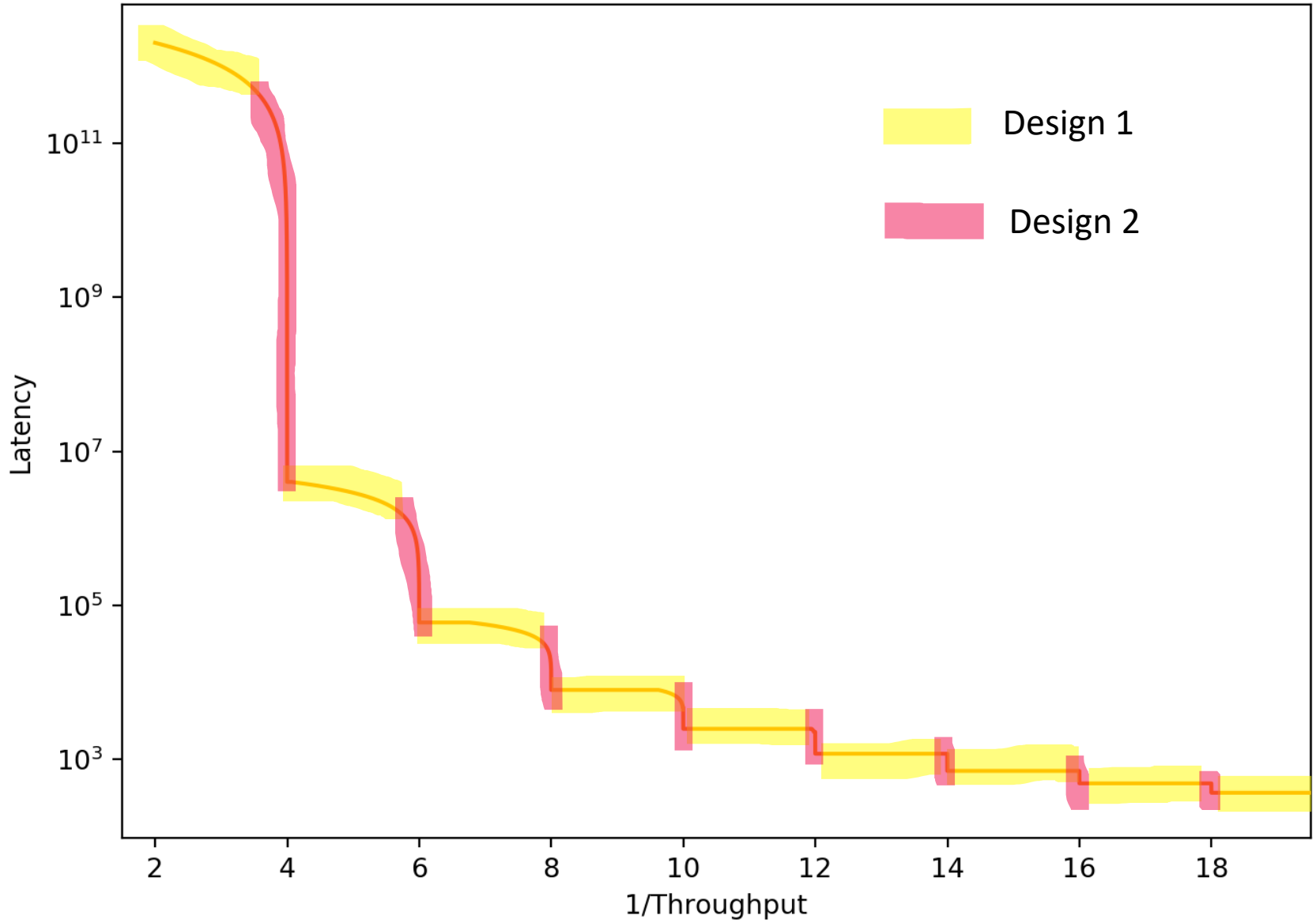
Design 1
Design 2
Latency
10^{11}
10^{9}
10^{7}
10^{5}
10^{3}
2
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8
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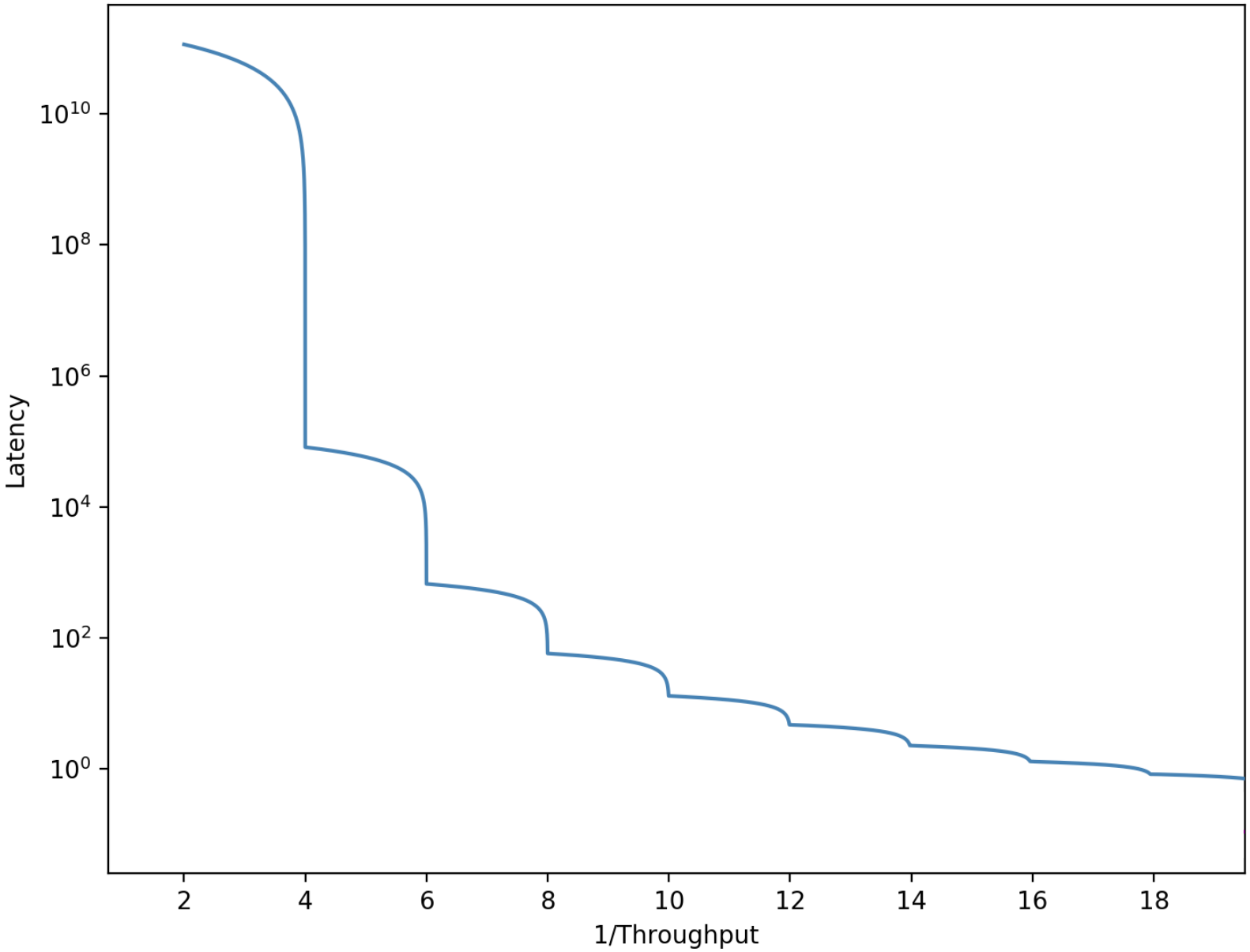
1/Throughput

Lower Bound


10^{10}
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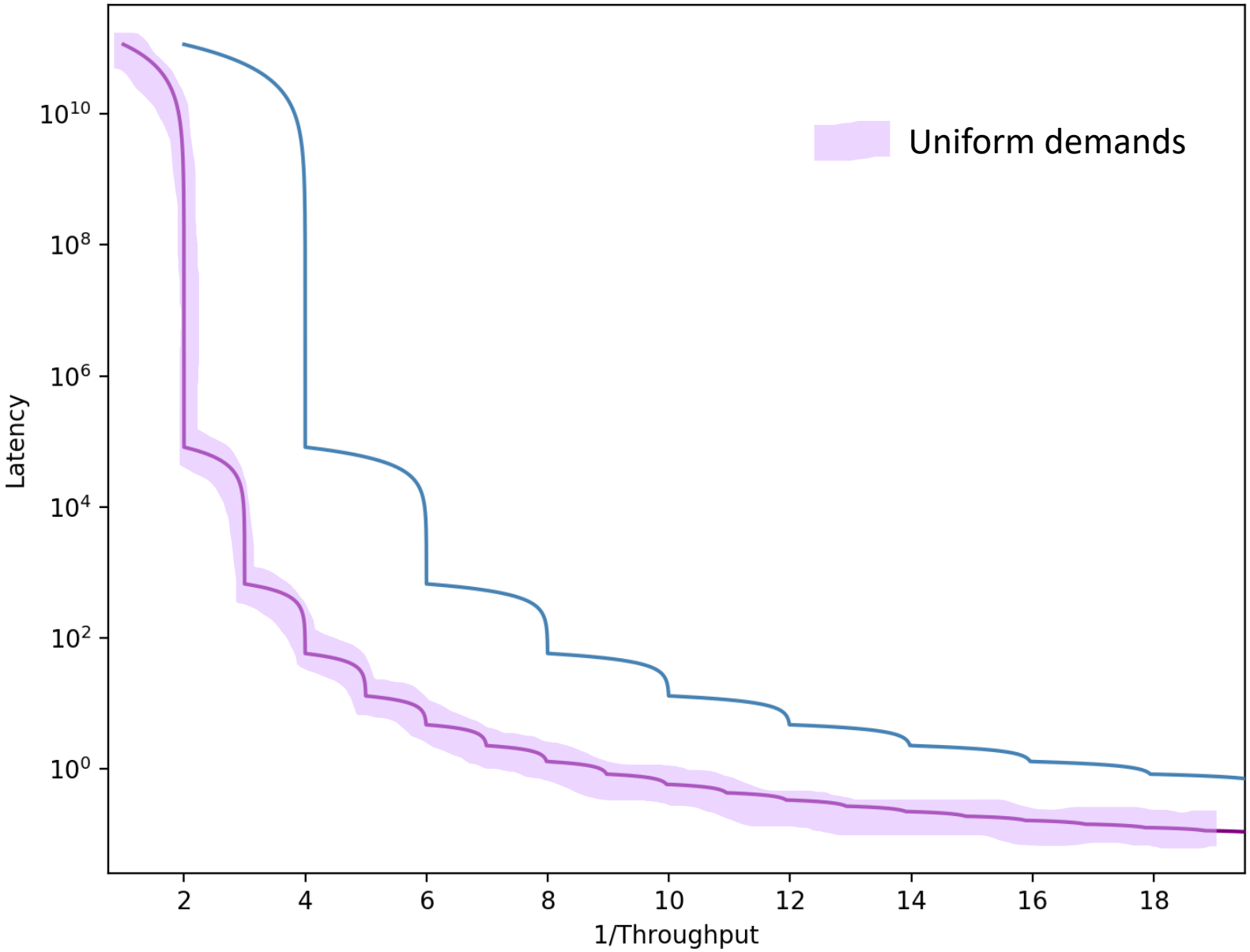
Uniform demands
Latency
10^{10}
10^{8}
10^{6}
10^{4}
10^{2}
10^{0}
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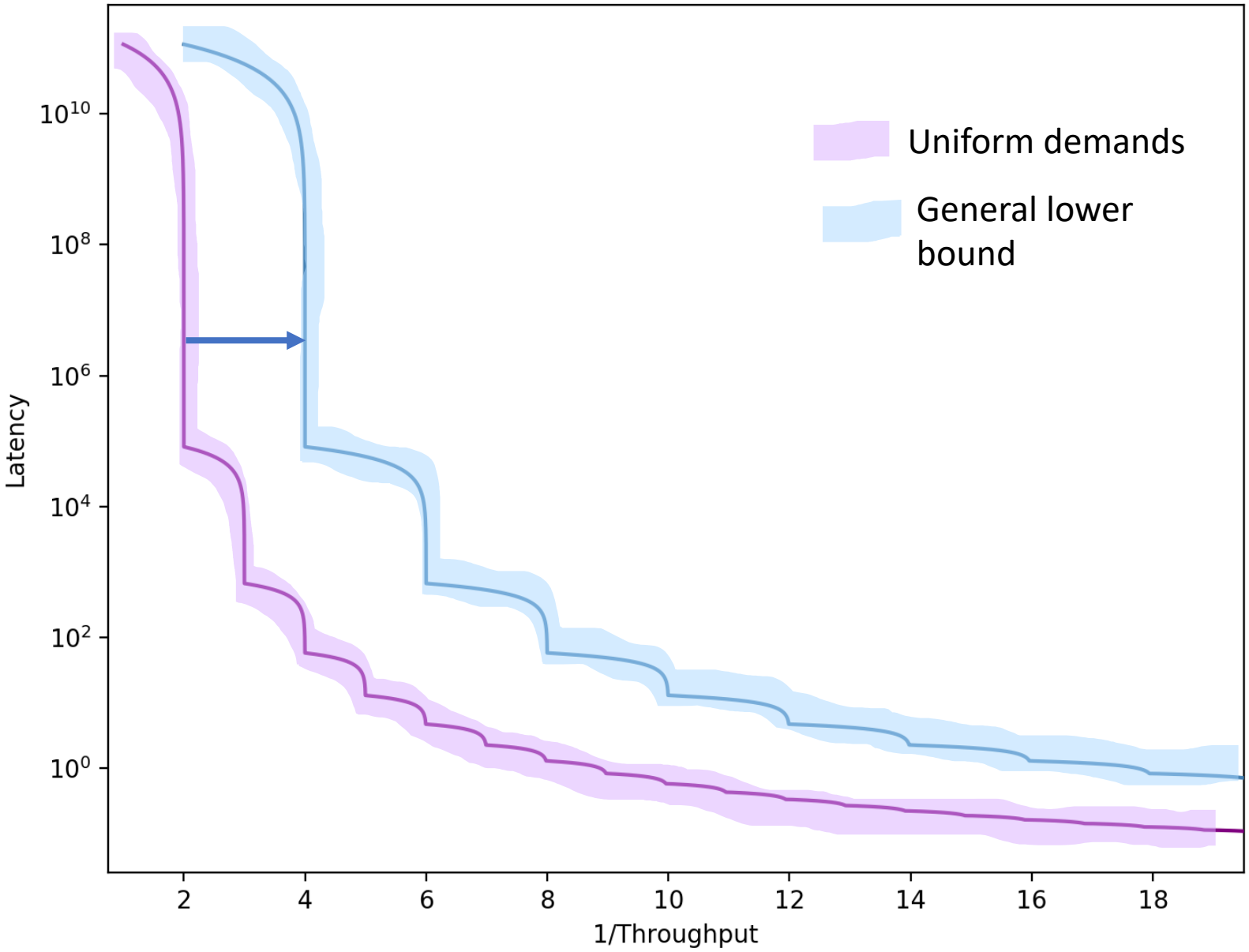
14
16
18
1/Throughput

Lower Bound


Uniform demands
General lower bound
Latency
10^{10}
10^{8}
10^{6}
10^{4}
10^{2}
10^{0}
2
4
6
8
10
12
14
16
18
1/Throughput

Ongoing/Future Work

- ORN designs for all N — not just infinitely many
- Semi-oblivious designs and analysis
  - Network still oblivious, but routing may be optimized for traffic
- Practical implementations – Daniel Amir

Thank You! Questions?

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