More Efficient Oblivious Transfer Extensions with Security for Malicious Adversaries

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Yehuda Lindell
Thomas Schneider
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EUROCRYPT 2015

This Talk

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- Oblivious Transfer Extension

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  - Benny’s talk (Sunday)

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- Oblivious Transfer Extension
  - Benny's talk (Sunday)
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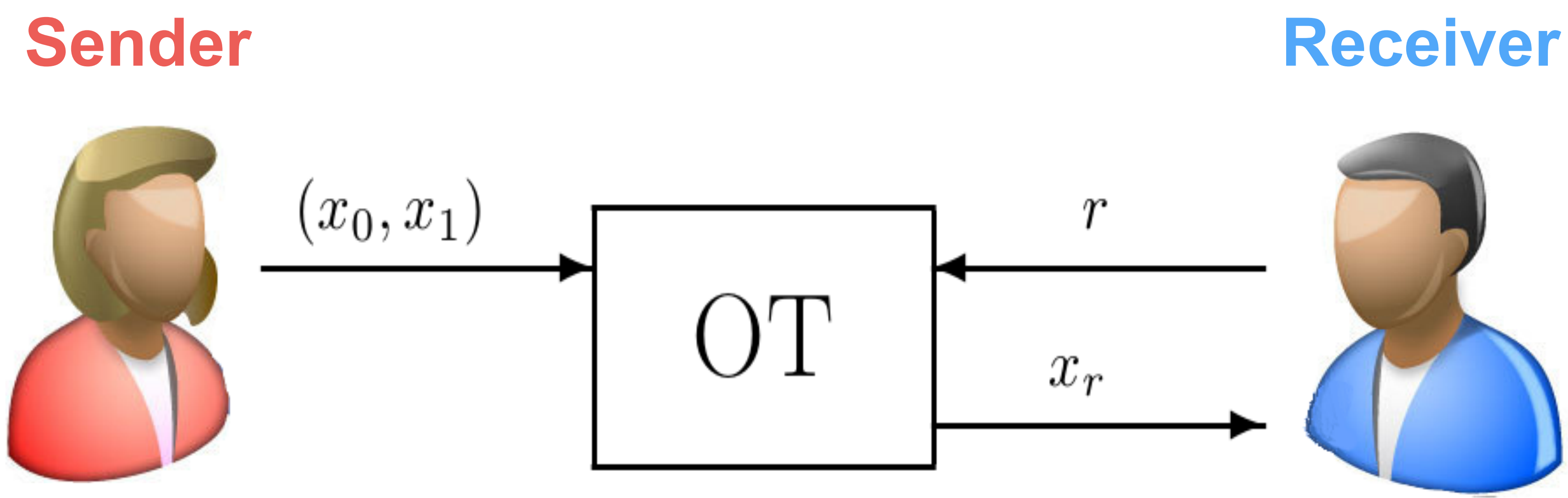
  - Claudio's talk (Tuesday)
  - This talk (Thursday)
- Concrete efficiency in the malicious model
  - Most efficient OT extension protocol, yet
  - Optimized protocol, proofs and implementation

1-out-of-2 Oblivious Transfer



- **INPUT:** **Sender** holds two strings (x_0,x_1), **Receiver** holds r
- **OUTPUT:** **Sender** learns nothing, **Receiver** learns x_r,

Oblivious Transfer and Secure Computation

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  1 OT per ***input***
  [LP07,LPS08,PSSW09,KSS12,FN13,SS13,LR14,HKK+14,FJN14]

Oblivious Transfer and Secure Computation

- OT is a basic ingredient in (almost) all protocols for secure computation
- **Protocols based on Garbled Circuits (Yao):**
  1 OT per ***input***
  [LP07,LPS08,PSSW09,KSS12,FN13,SS13,LR14,HKK+14,FJN14]
- **Protocols based on GMW:**
  1+ OT per ***AND-gate***
  TinyOT [NNOB12,LOS14] MiniMac protocols [DZ13,DLT14]

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  - 1G (2^{30}) OTs > 45000 minutes > 1 month…

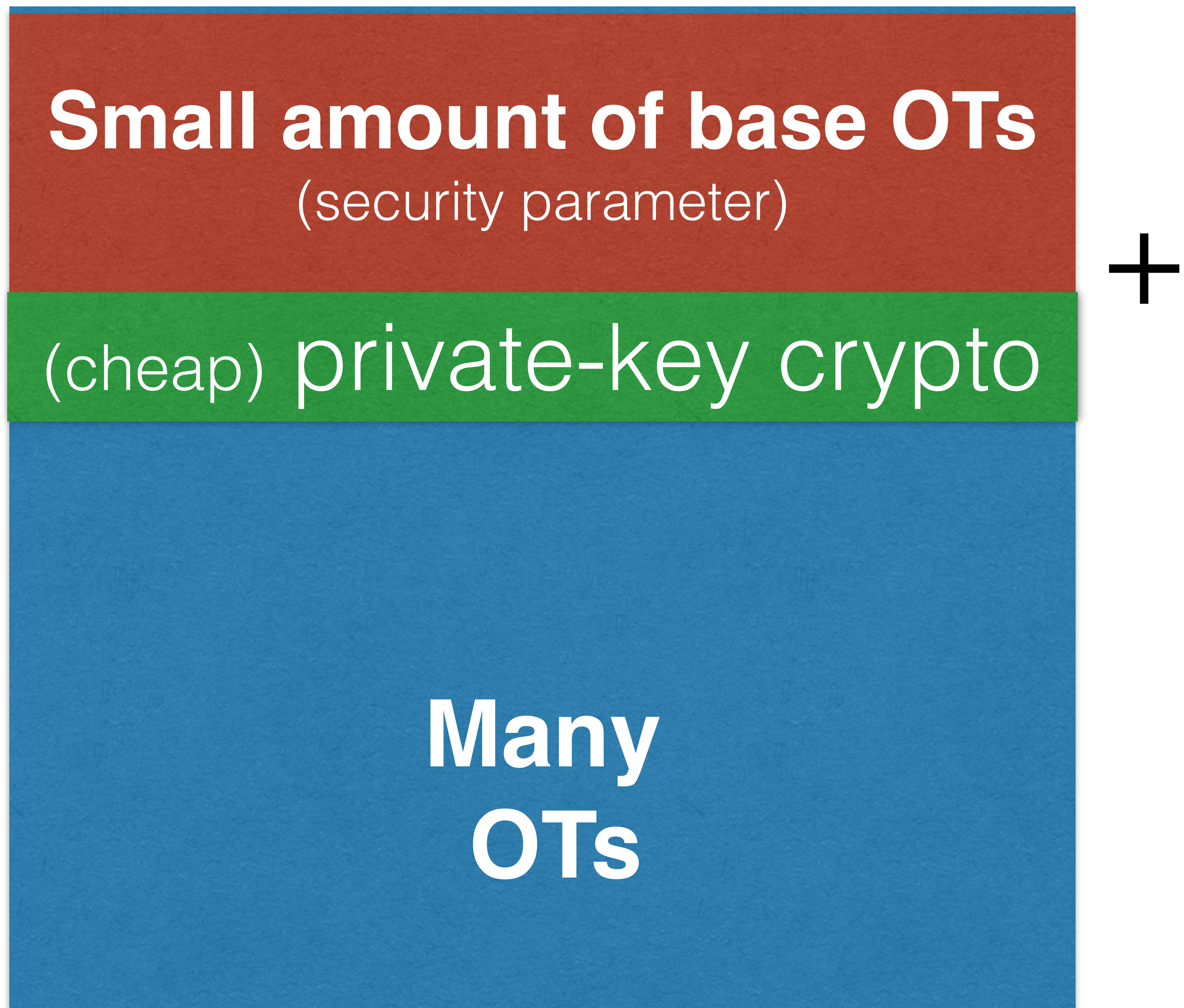
OT Extensions

Small amount of base OTs
(security parameter)

\+

(cheap) private-key crypto

OT Extensions



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- Introduced in [Beaver96]
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  "Extending Oblivious Transfer Efficiently"
- Optimizations semi-honest: [KK13, ALSZ13]
- Optimizations malicious:
  [Lar14,NNOB12,HIKN08,Nie07]

Contents

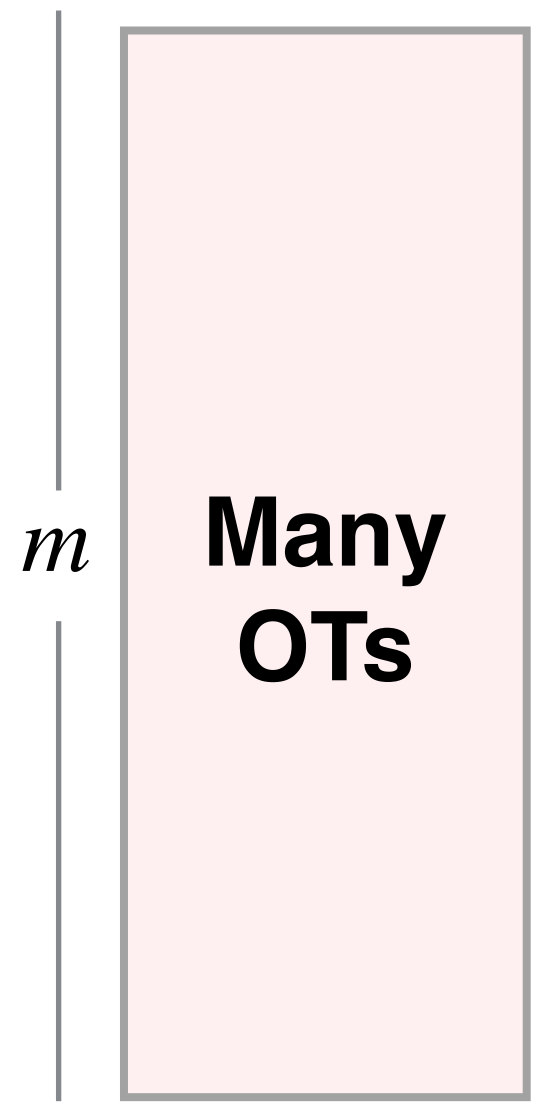
- IKNP protocol
- Our Protocol, Security
- Performance

Extending OT Efficiently[1]

[IKNP03]

[1]Semi-honest

IKNP - Idea



expensive

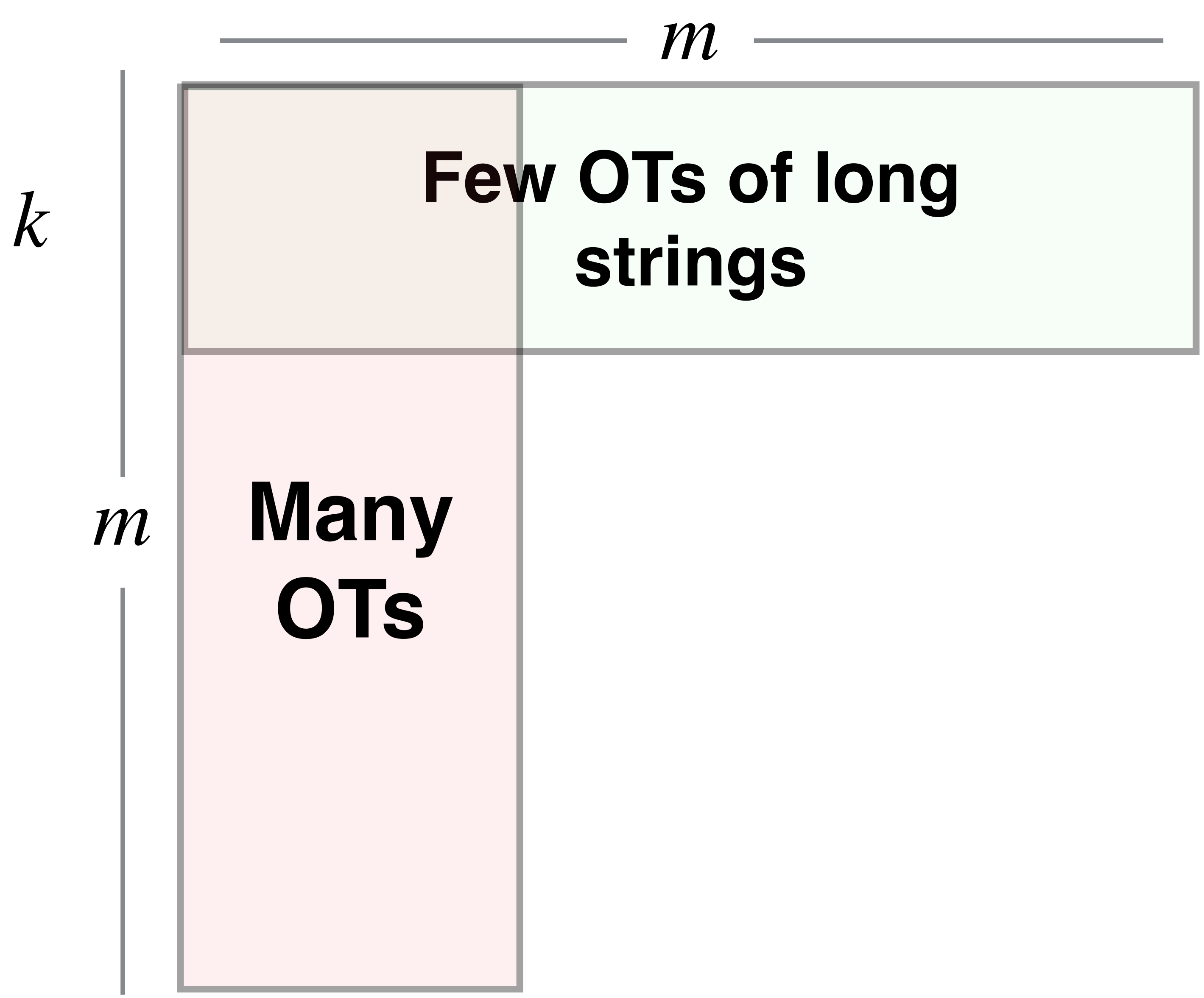
IKNP - Idea

m

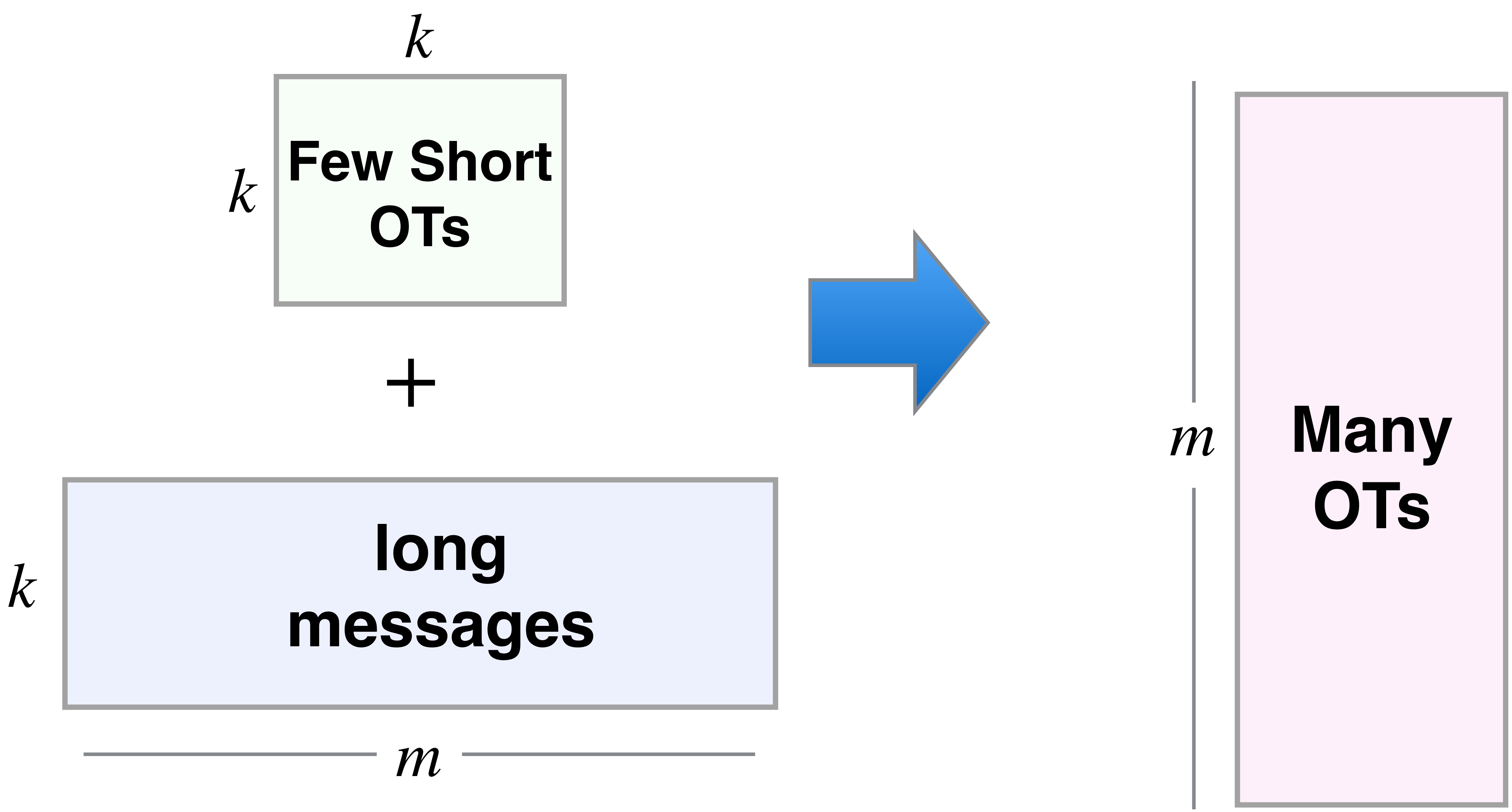
k

Few OTs of long strings

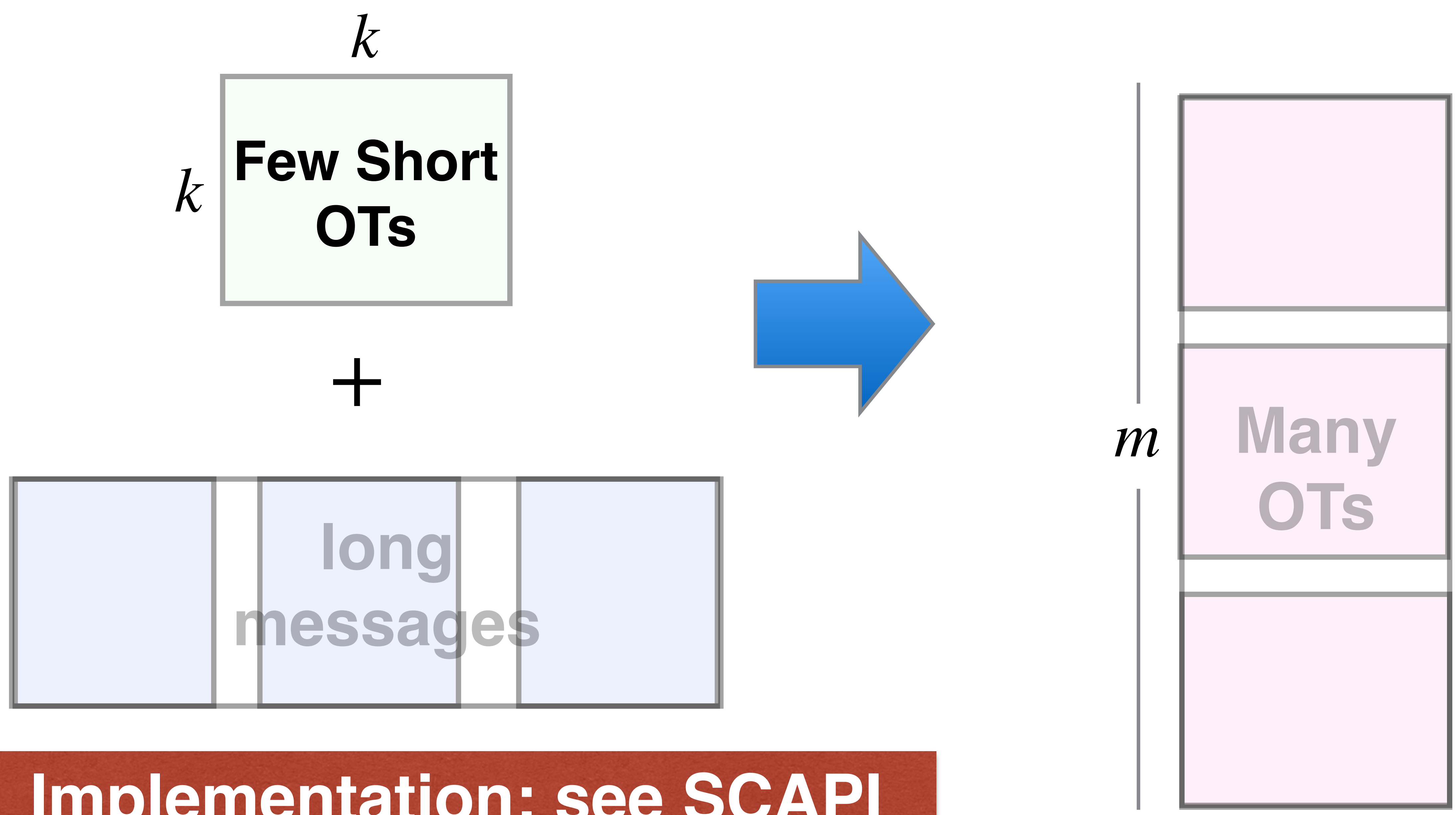
IKNP - Idea



IKNP - Implementation



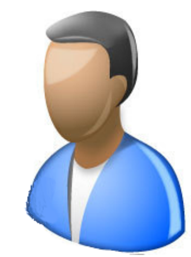
In Practice [ALSZ13]



Implementation: see SCAPI

IKNP

$\{x_j^0, x_j^1\}_{j=1}^m$ 

 $\mathbf{r} = (r_1, \ldots, r_m)$

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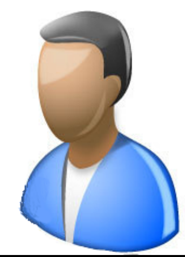
$\{x_j^0, x_j^1\}_{j=1}^m$   $\mathbf{r} = (r_1, \ldots, r_m)$

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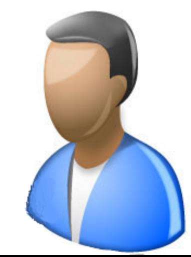

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$\mathbf{u}^i = G(\mathbf{k}_i^0) \oplus G(\mathbf{k}_i^1) \oplus \mathbf{r}$ *

$\mathbf{Q}$

$\mathbf{T}$

IKNP

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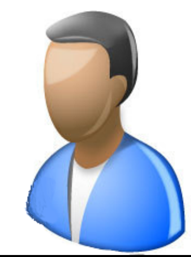

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* $y_j^0 = x_j^0 \oplus H(\mathbf{q}_j)$

$y_j^1 = x_j^1 \oplus H(\mathbf{q}_j \oplus \mathbf{s})$

$\xrightarrow{y_j^0, y_j^1}$

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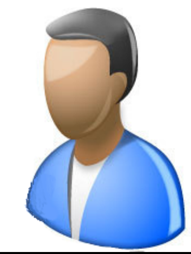
- We add consistency check of $\mathbf{r}$
- **Sender** checks that **Receiver** uses the same $\mathbf{r}$ with each $\mathbf{u}^i$

The Protocol

$\{x_j^0, x_j^1\}_{j=1}^m$



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Q

T

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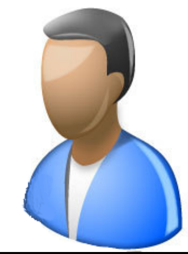

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Consistency Check of **r**

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The Consistency Checks

Consistency Check

$$\mathbf{u}^{i} = G(\mathbf{k}_{i}^{0}) \oplus G(\mathbf{k}_{i}^{1}) \oplus \mathbf{r}$$

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$$\mathrm{H}(\boxed{\mathbf{u}^i \oplus \mathbf{u}^j \oplus \mathbf{t}_i^{s_i} \oplus \mathbf{t}_j^{s_j}}) \;?= \; \mathrm{H}(\boxed{\mathbf{t}_i^{1-s_i} \oplus \mathbf{t}_j^{1-s_j}})$$

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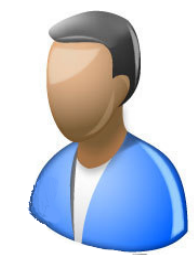

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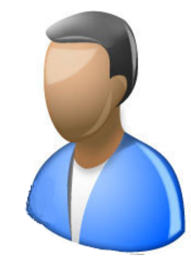

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Does it really work?

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if $\mathbf{s}_i$=0 **Passes**

if $\mathbf{s}_i$=1 **Gets caught**

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- It can succeed only with 2-out-of-4 possibilities of (s^i, s^j)
  With probability 1/2, we catch the adversary!

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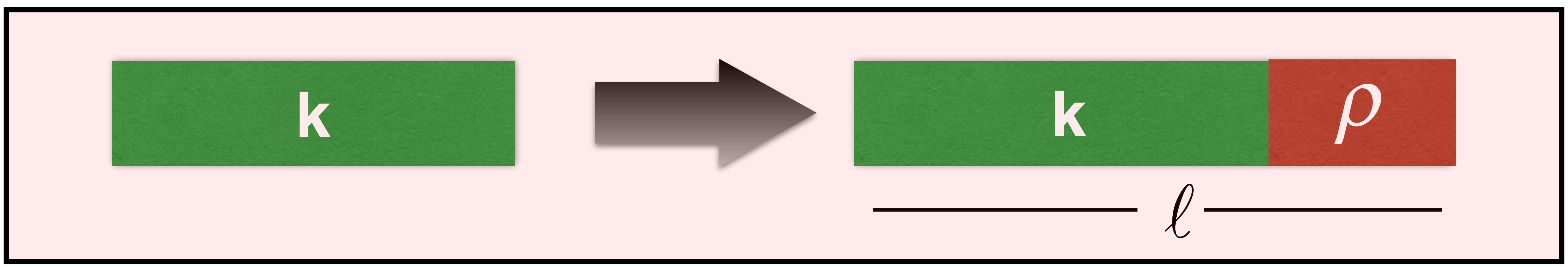

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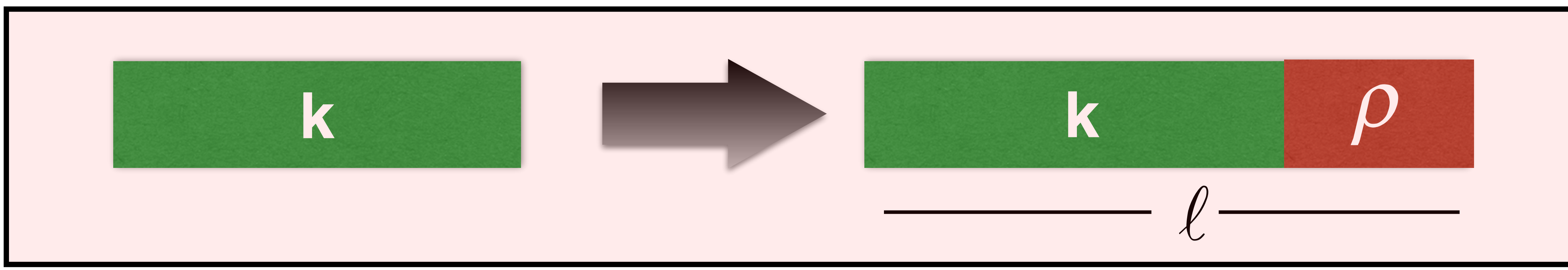

- With probability $1-2^{-\rho}$, still k bits of **s** are completely hidden!

$$y_j^0 = x_j^0 \oplus H(\mathbf{q}_j)$$

$$y_j^1 = x_j^1 \oplus H(\mathbf{q}_j \oplus \mathbf{s})$$

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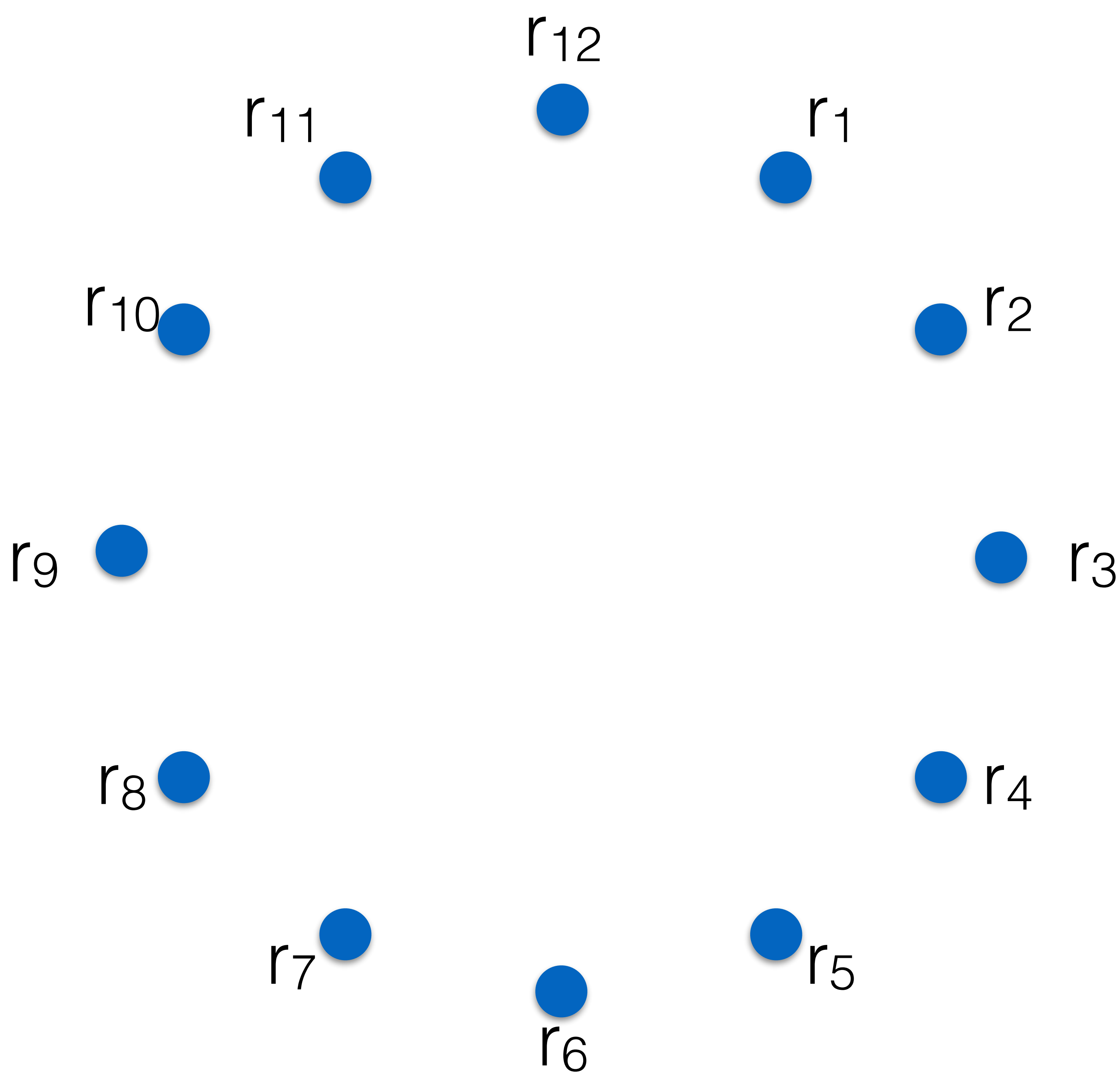
(**Reminder**: [NNOB12] uses 8/3k = 341 base OTs)
- Checks: all pairs ~ 14028
- We have to reduce the number of checks!
(at the expense of increasing the number of base-OTs)

How many checks do we really need?



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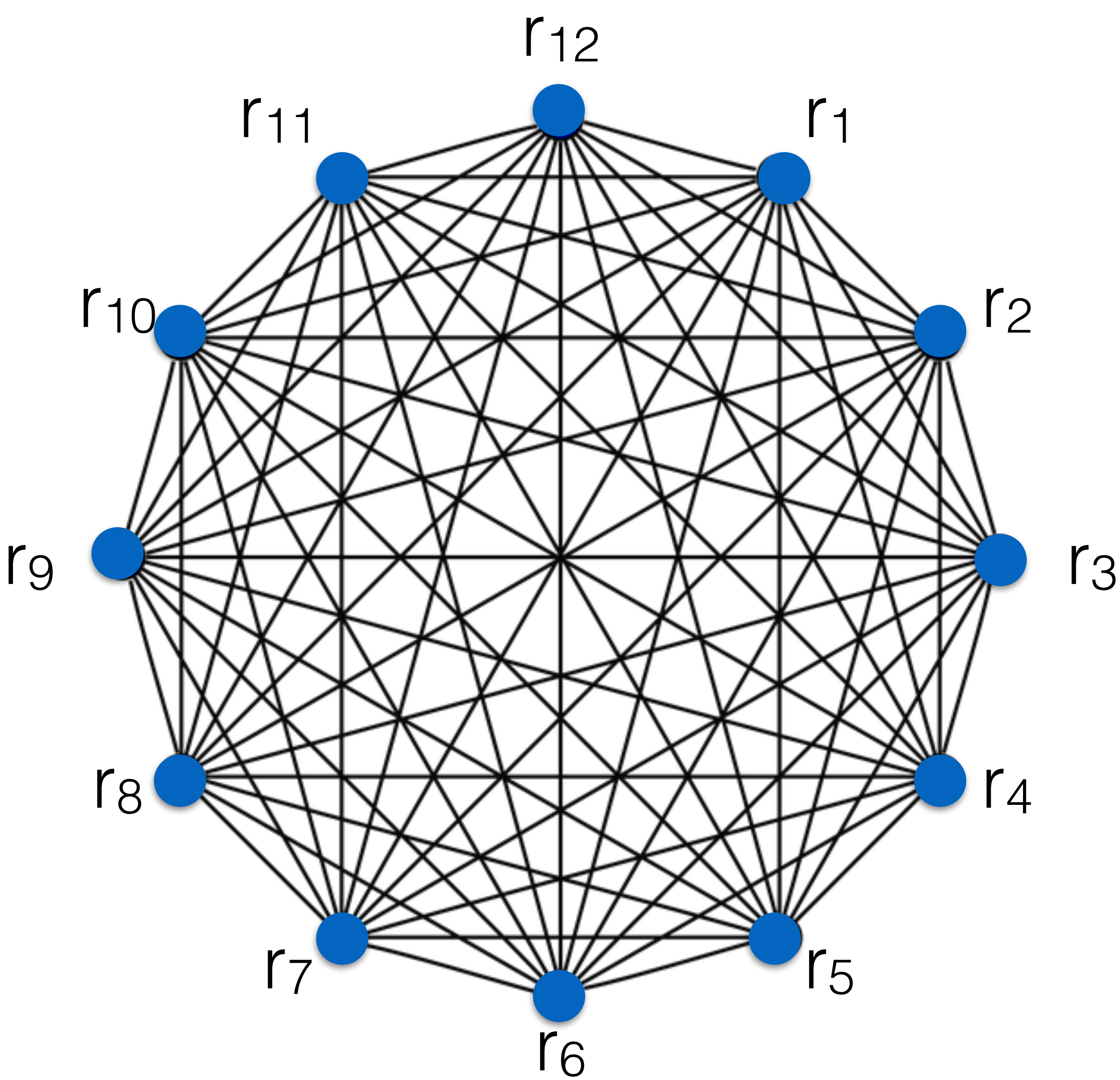

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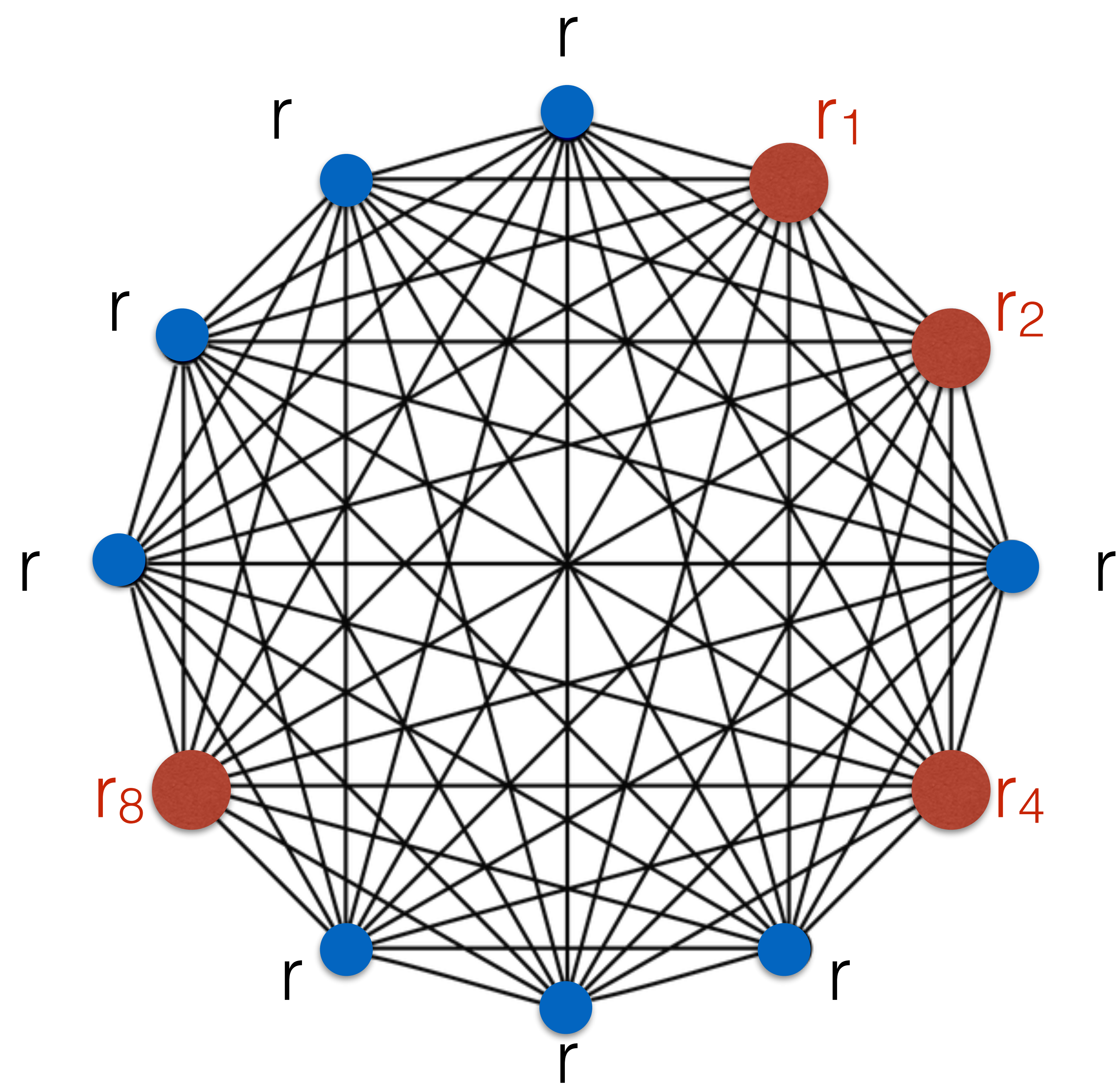

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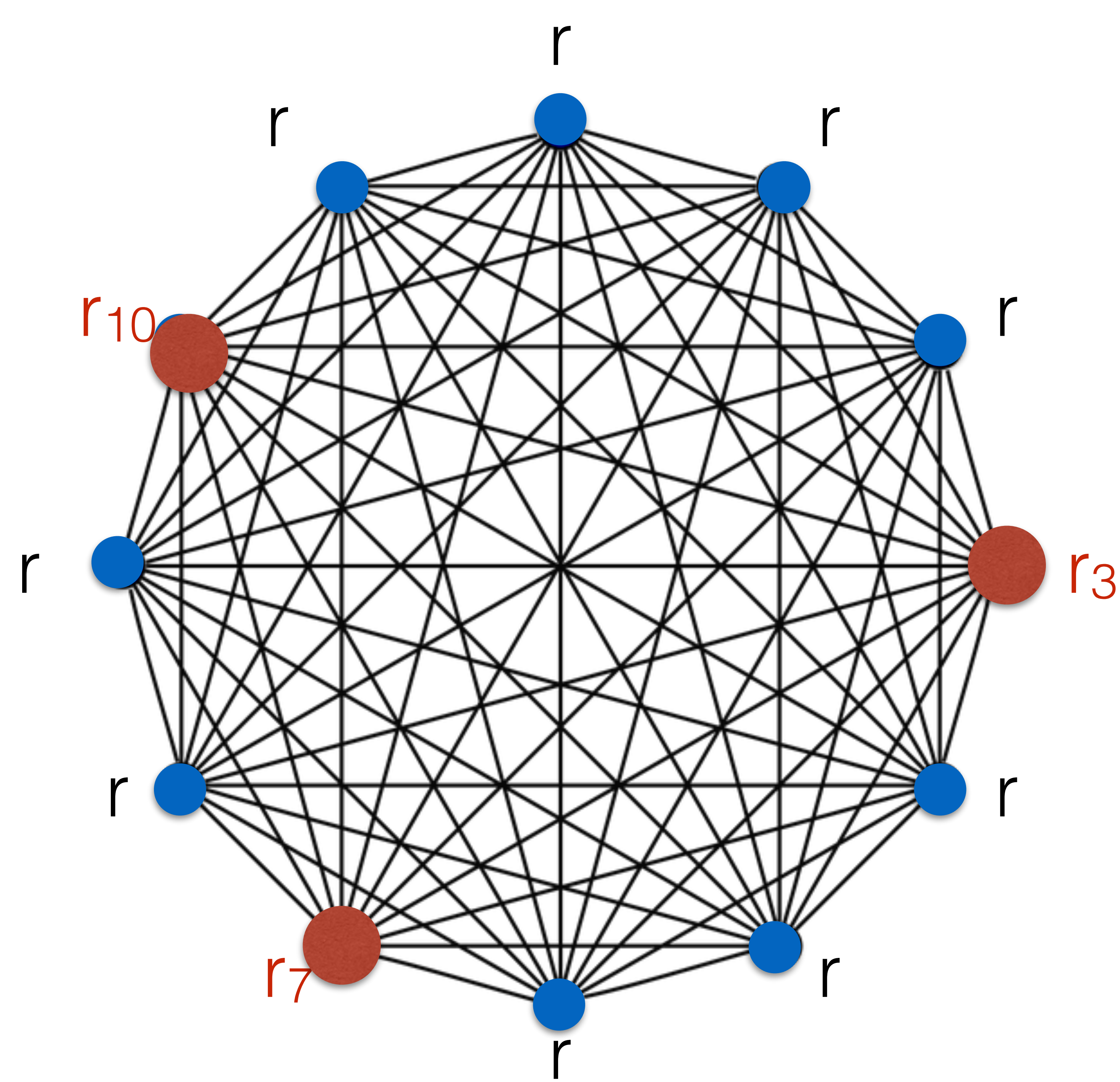

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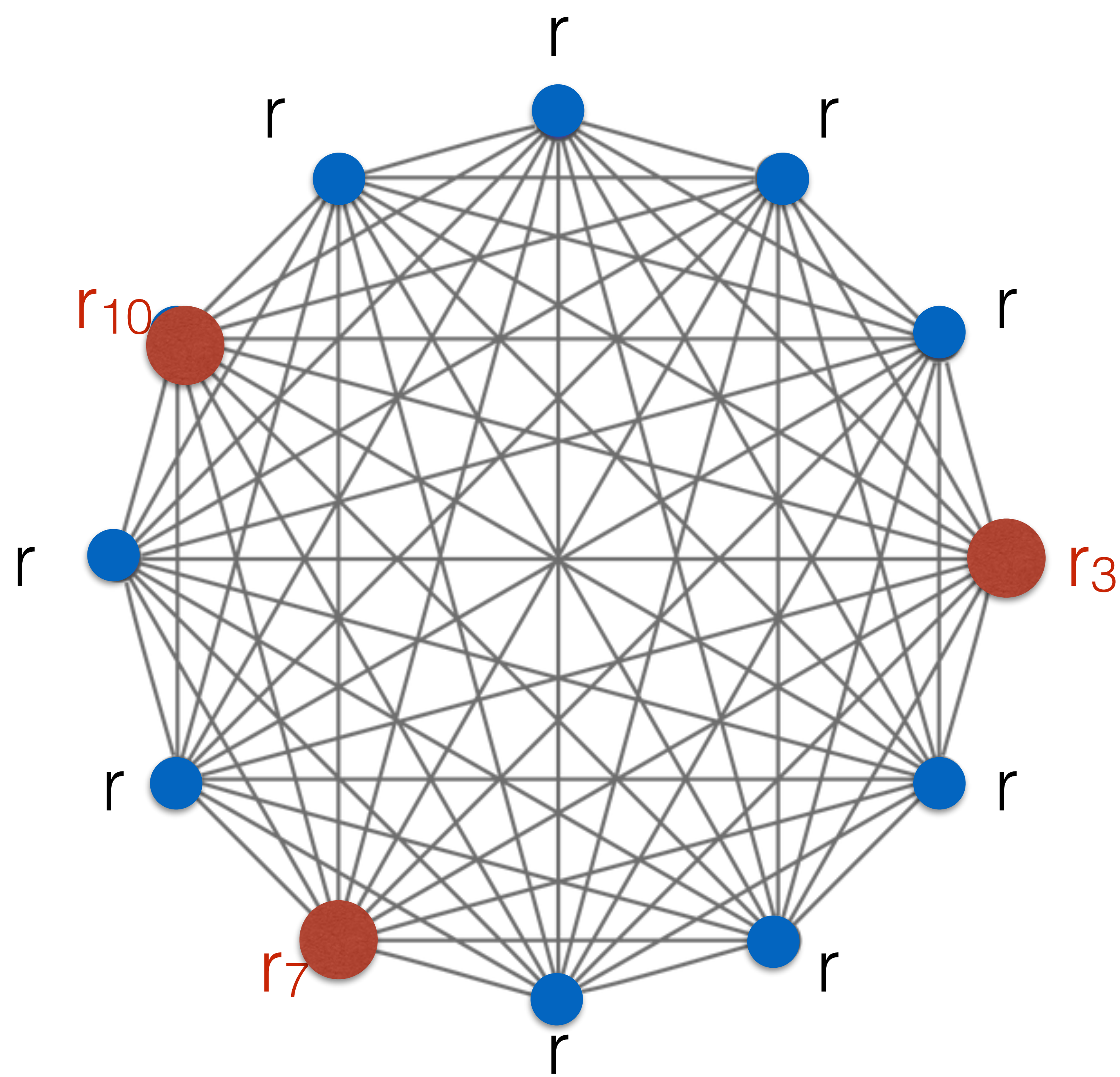

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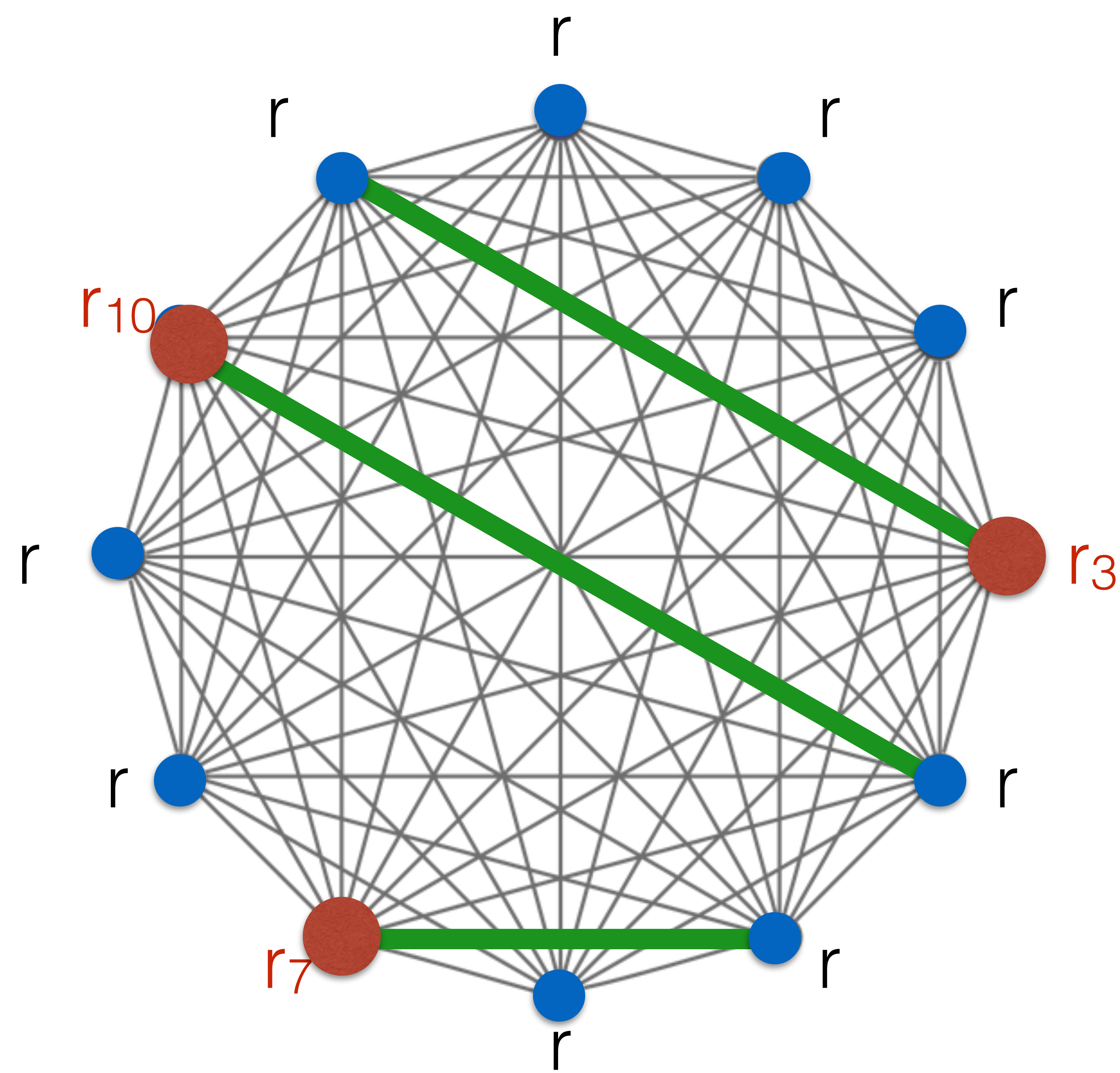

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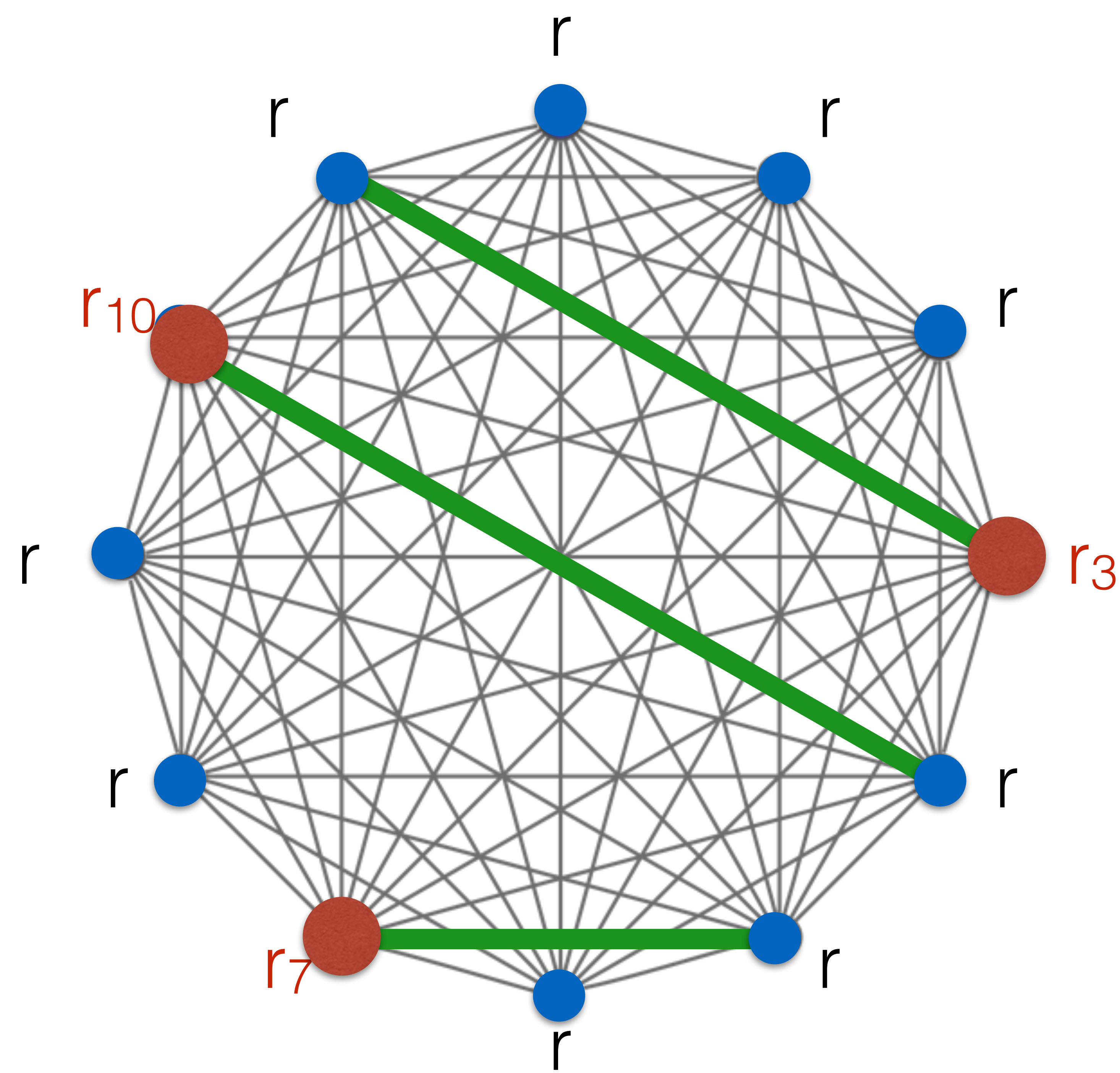
For any “large enough" set of **bad** vertices
(> p=40), **there exists** p-matching with the **good** vertices



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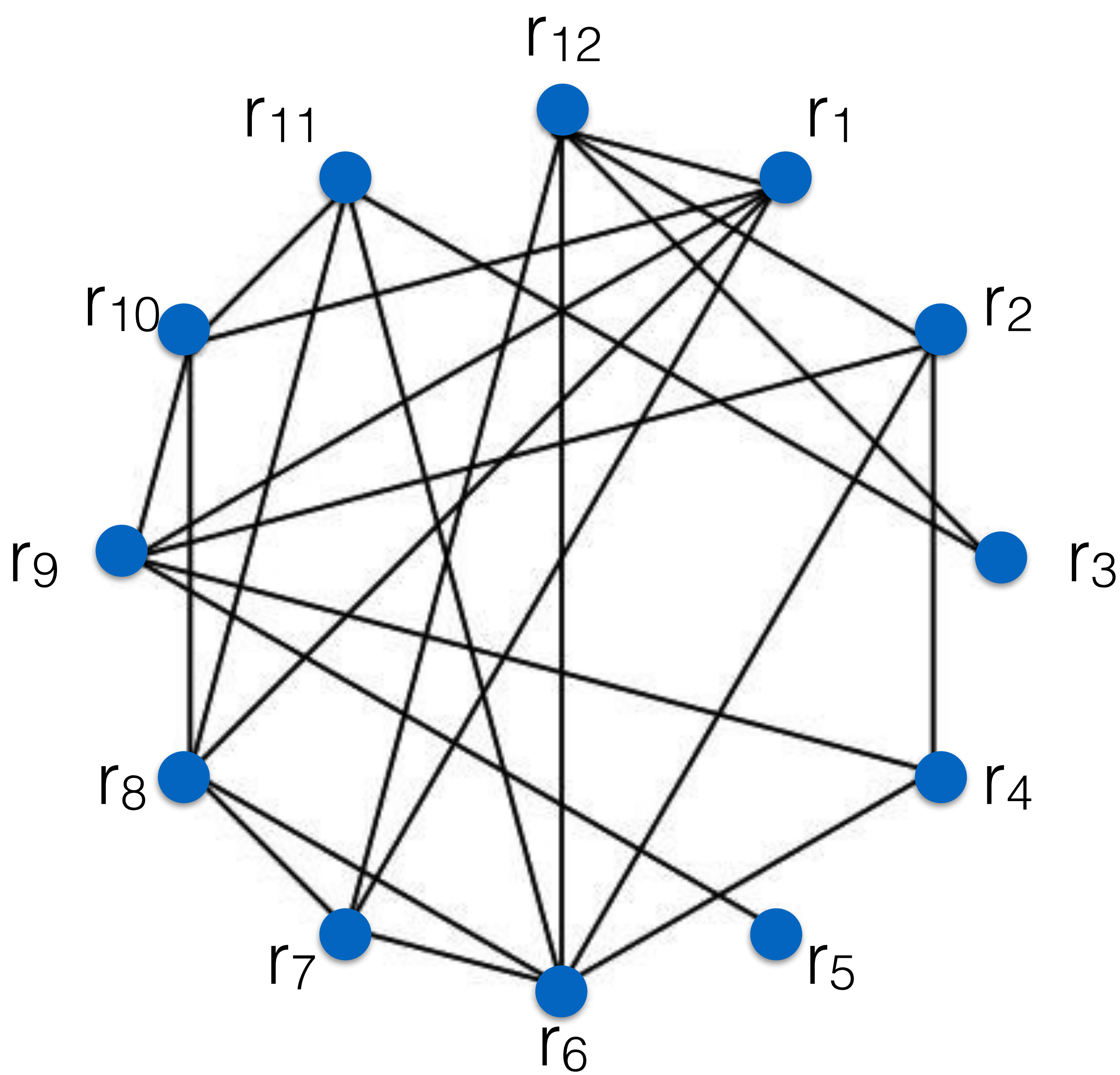

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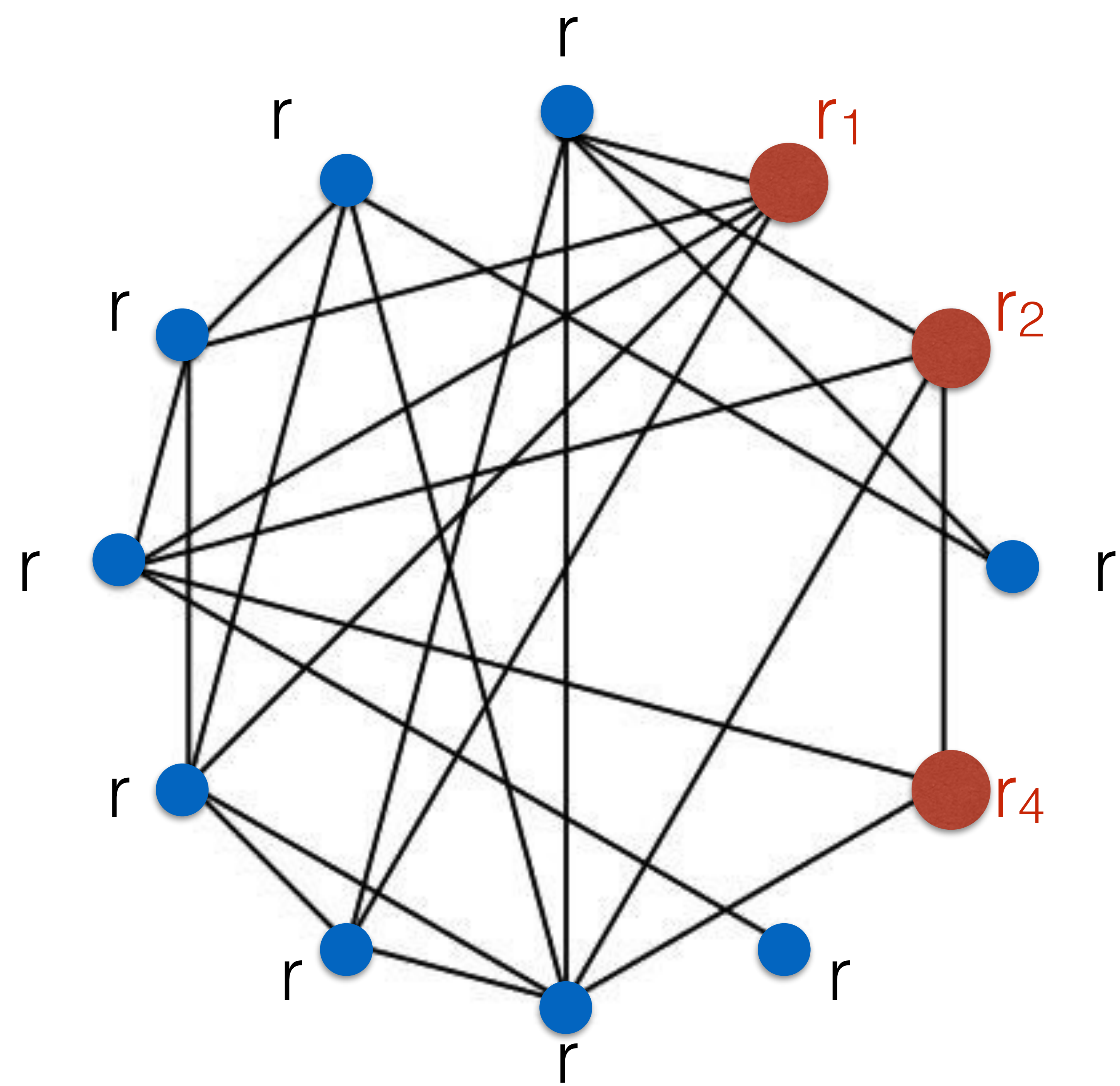

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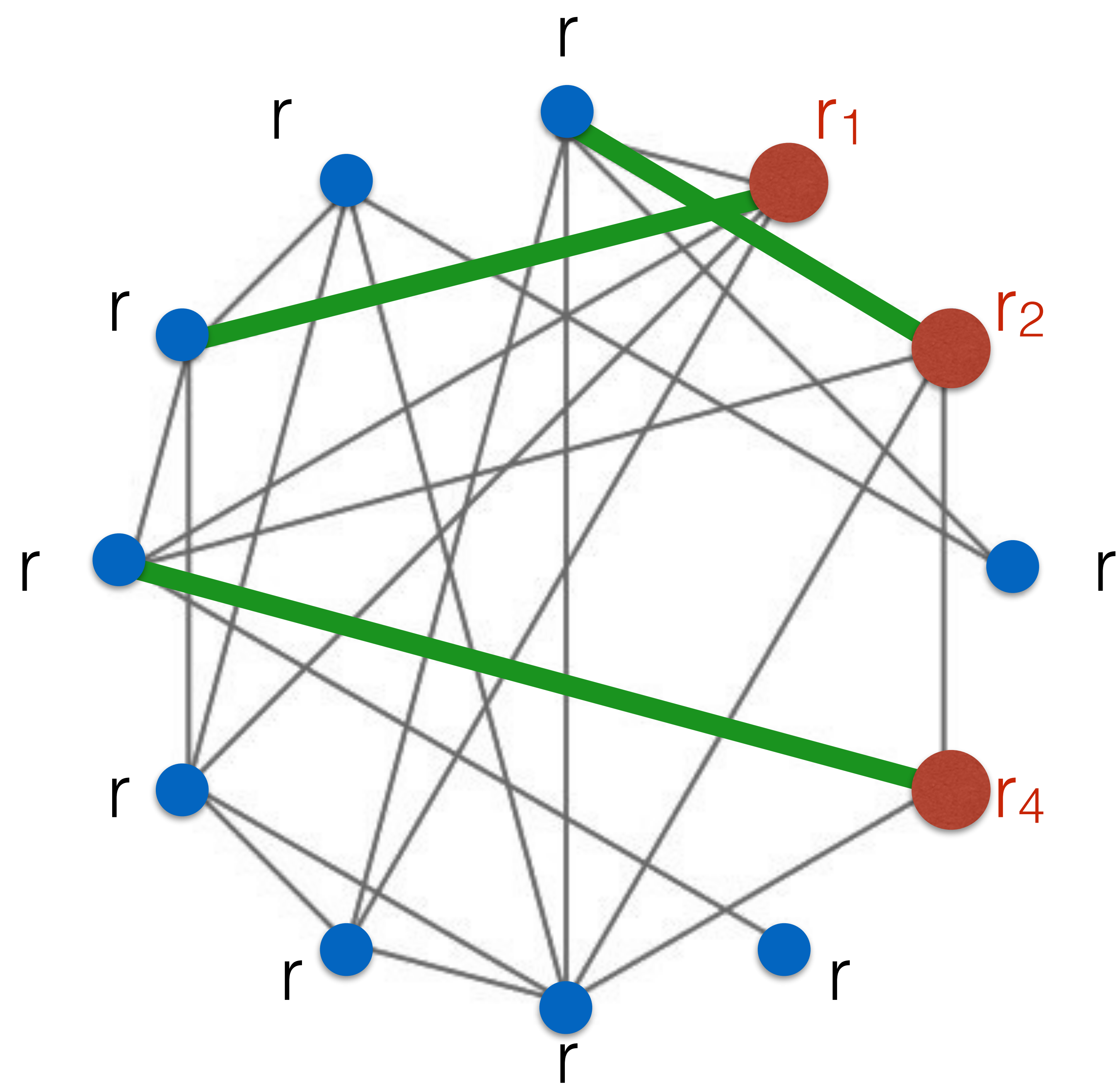

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- **Covert**: probability 1/2, just random 7 checks!

Instantiation of **H**

Correlation Robustness:

$$\{H(t_1 \oplus \mathbf{s}),\ldots,H(t_\ell \oplus \mathbf{s})\} \stackrel{c}{=} U_{\ell \times n}$$

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$\mathbf{s}$ is taken from a source χ with min entropy k

Performance

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  Two servers in different continents
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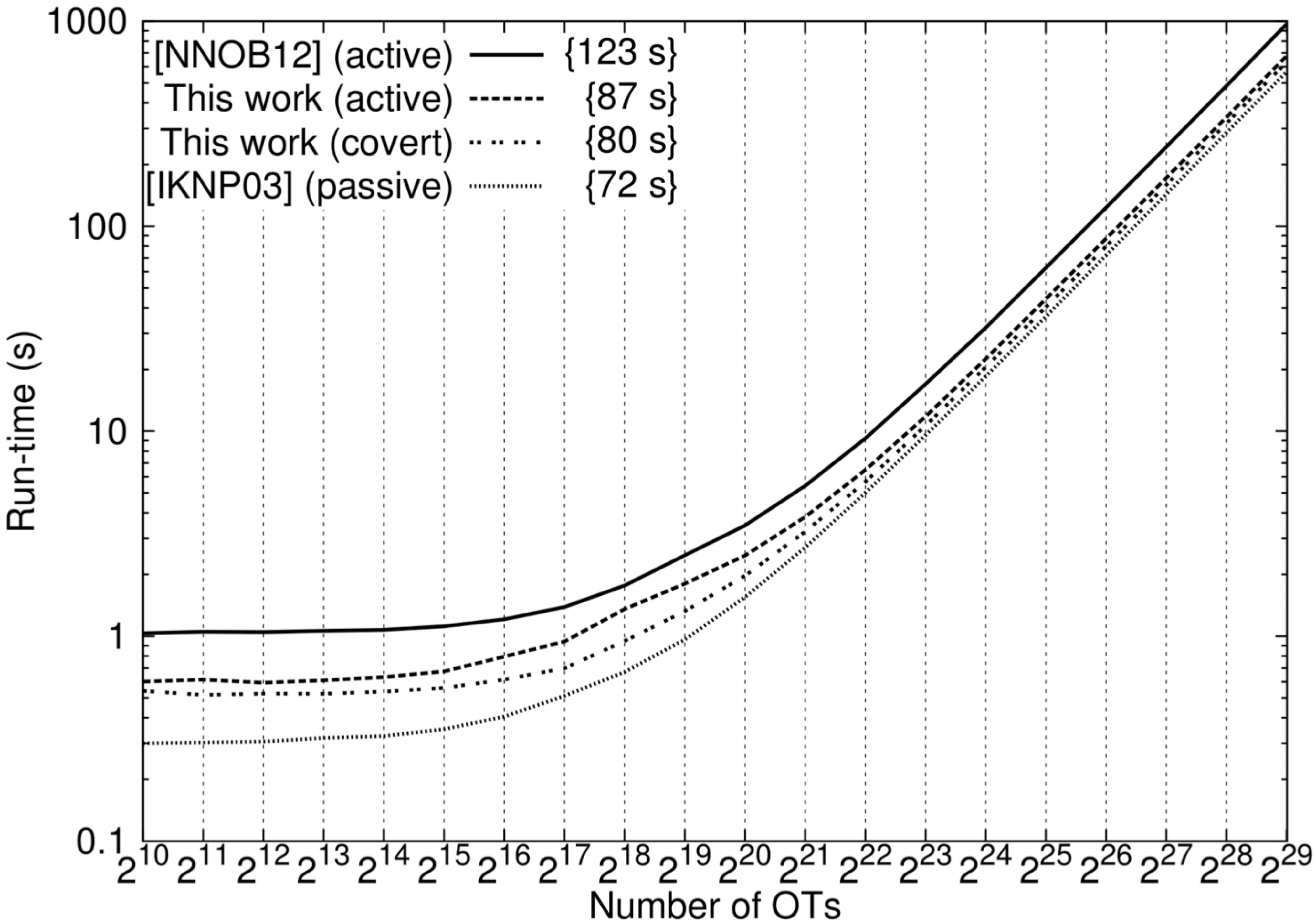
  64 sec (174 base OTs, 696 checks)

Comparison - LAN Setting



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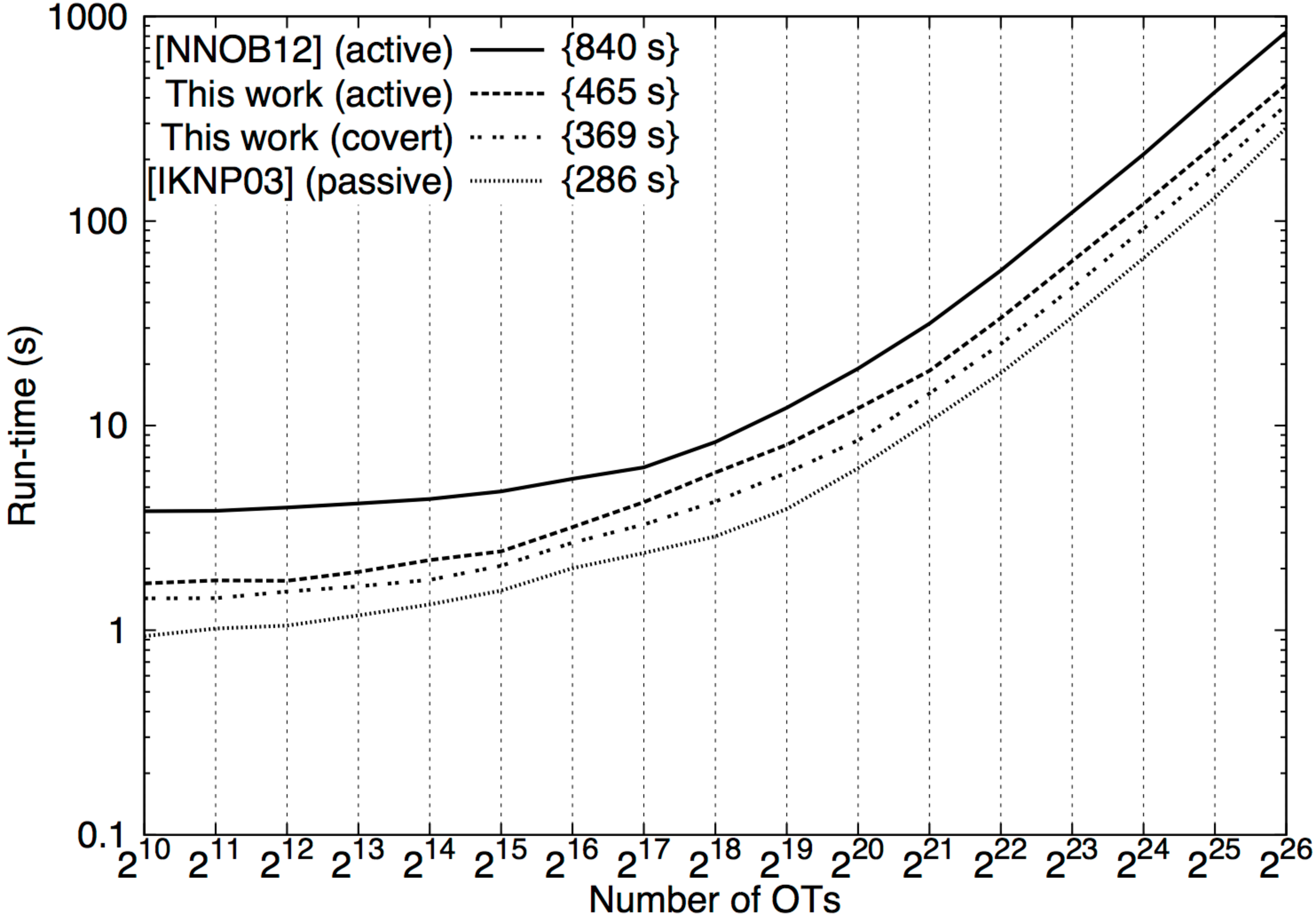

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Thank You!