# Black Box Crypto is Useless for Doubly Efficient PIR

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Interactive protocol between a server $S$ and a client $C$

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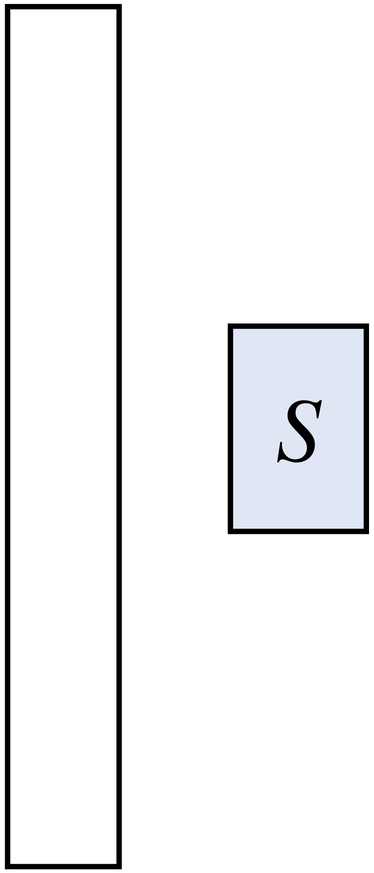

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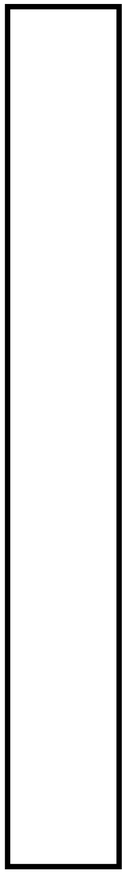

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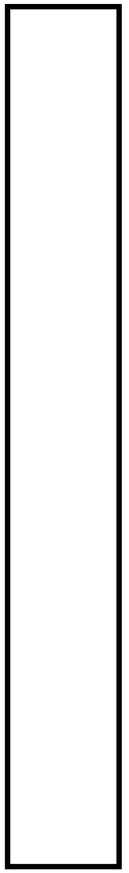

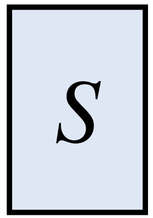


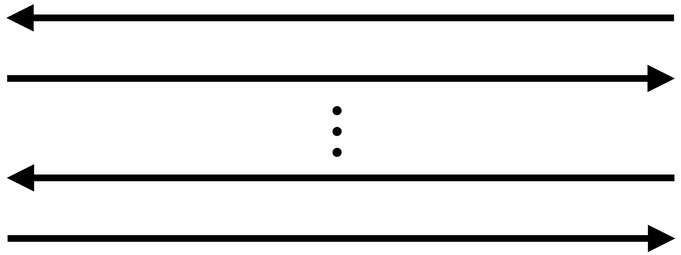

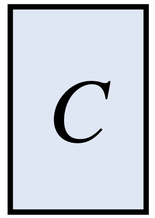


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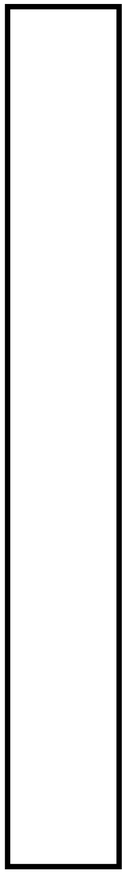

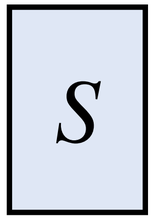


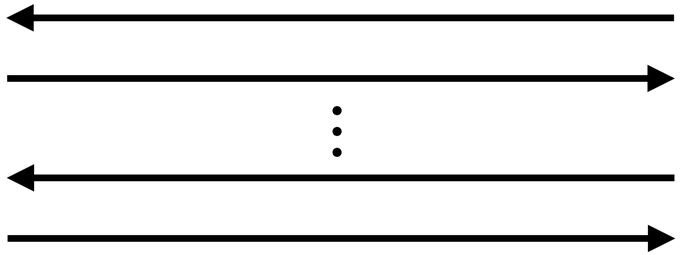

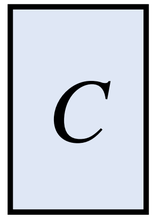


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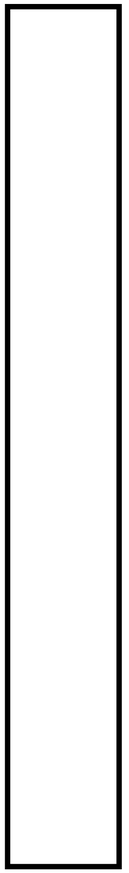

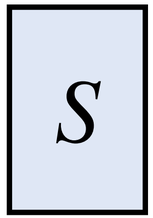


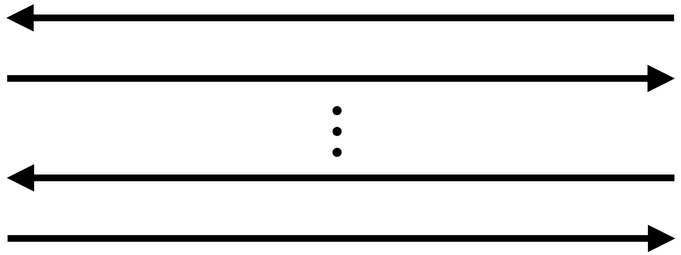

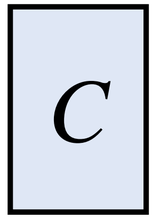


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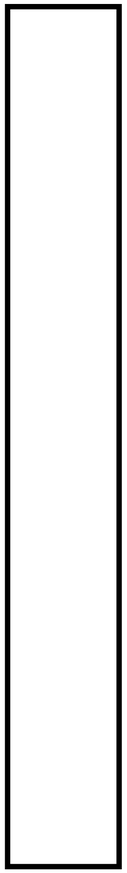

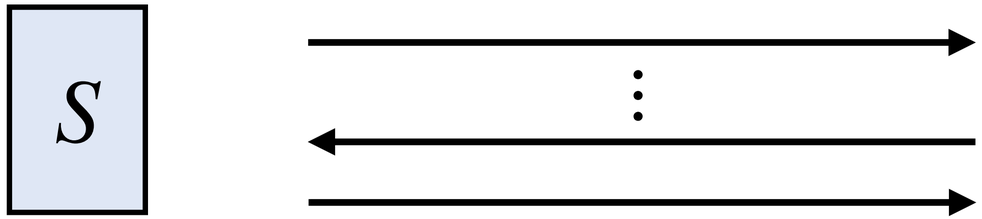


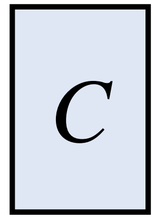


input: $i \in [N]$

output: $\mathrm{DB}[i]$

Communication: $o(N)$

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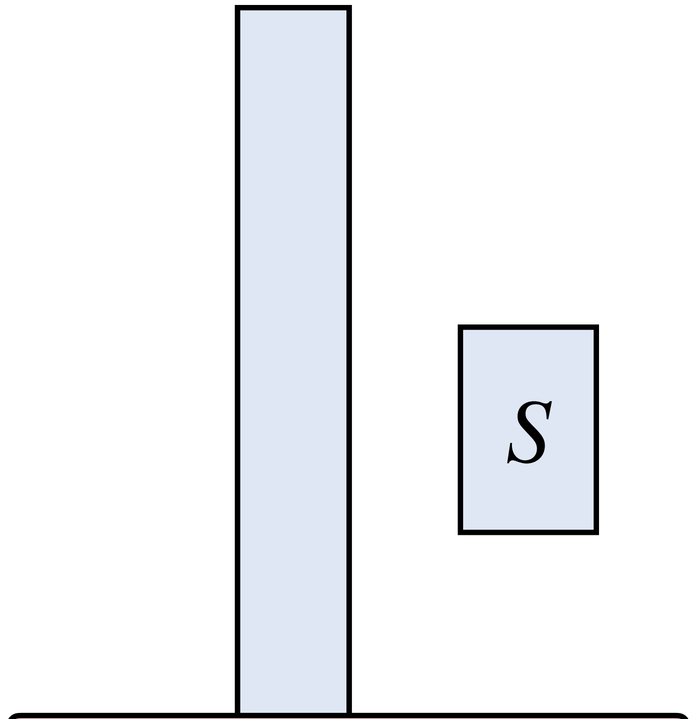

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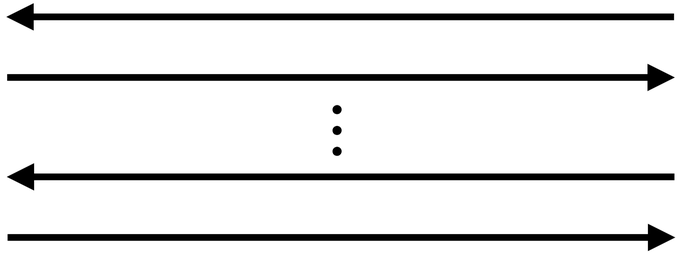

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input: $i \in [N]$

output: $\mathrm{DB}[i]$

Lower bound: Server must touch ***all*** locations in $\mathrm{DB} \Rightarrow$ time $\Omega(N)$

Communication: $o(N)$

Security: Server learns nothing about $i$

# Doubly Efficient PIR (DEPIR)

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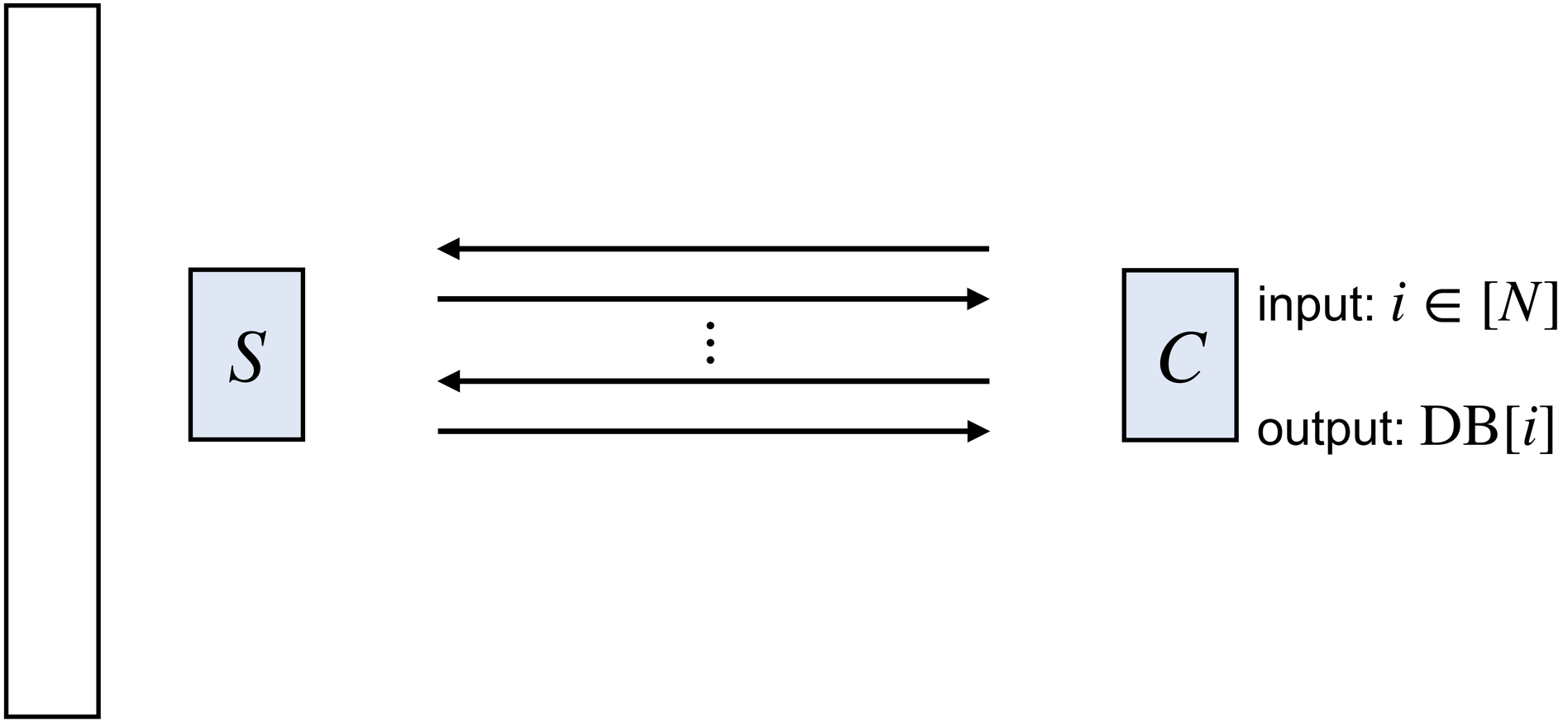

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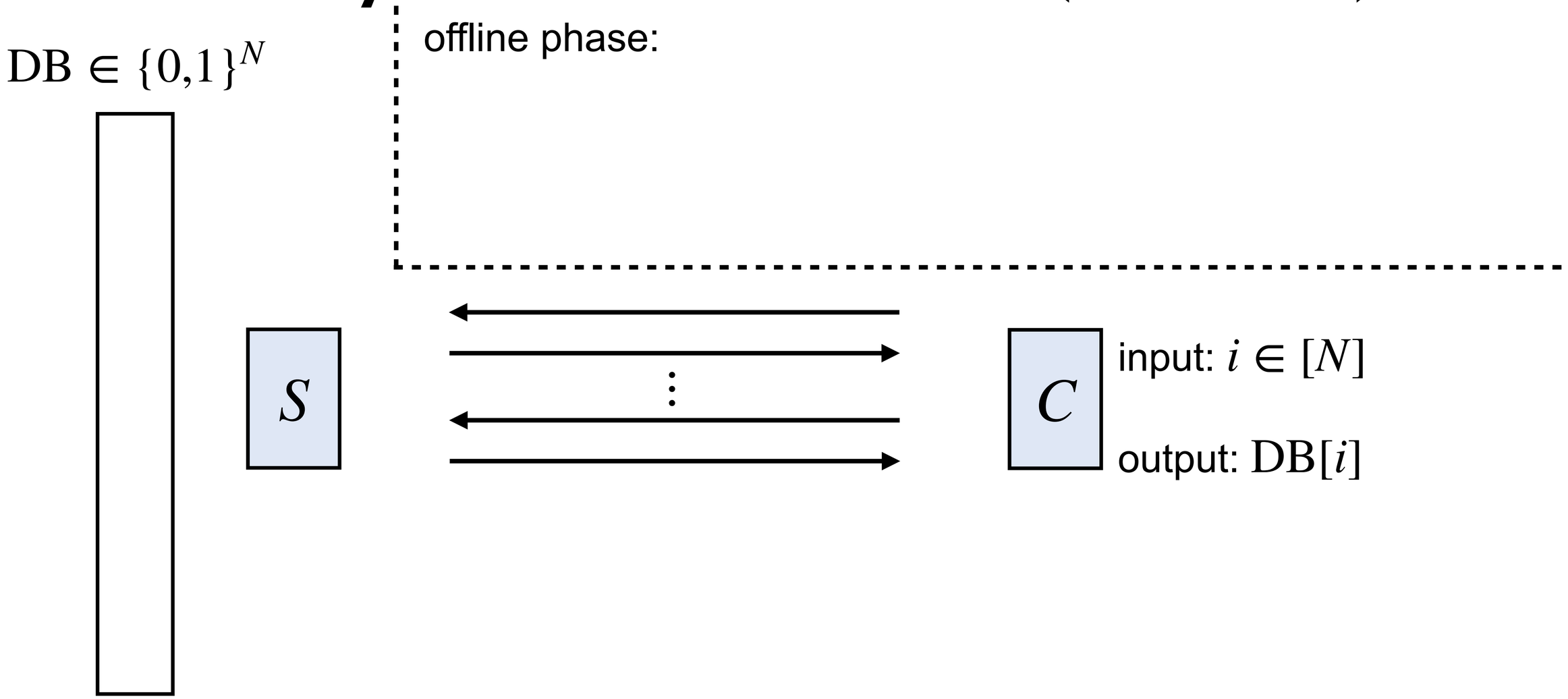

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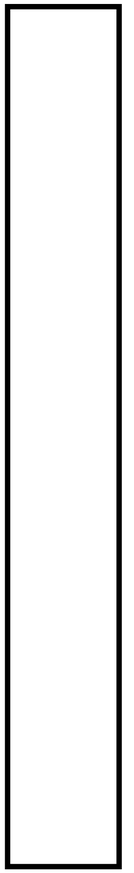
$\mathrm{DB} \in \{0,1\}^N$

offline phase: $k \leftarrow \mathsf{KeyGen}(1^\lambda)$

$k$ DB-ind. and static



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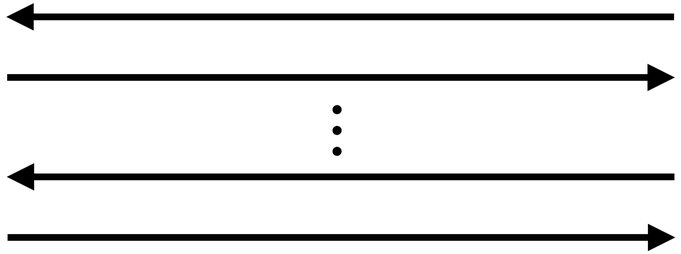

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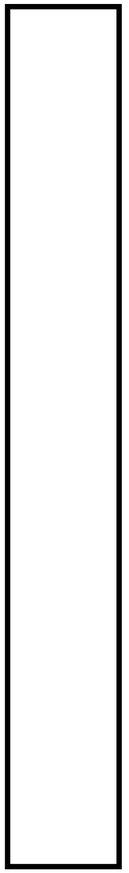

offline phase:

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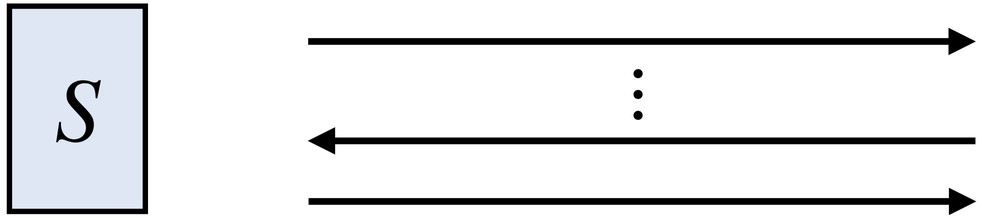
DB one-time preprocessed

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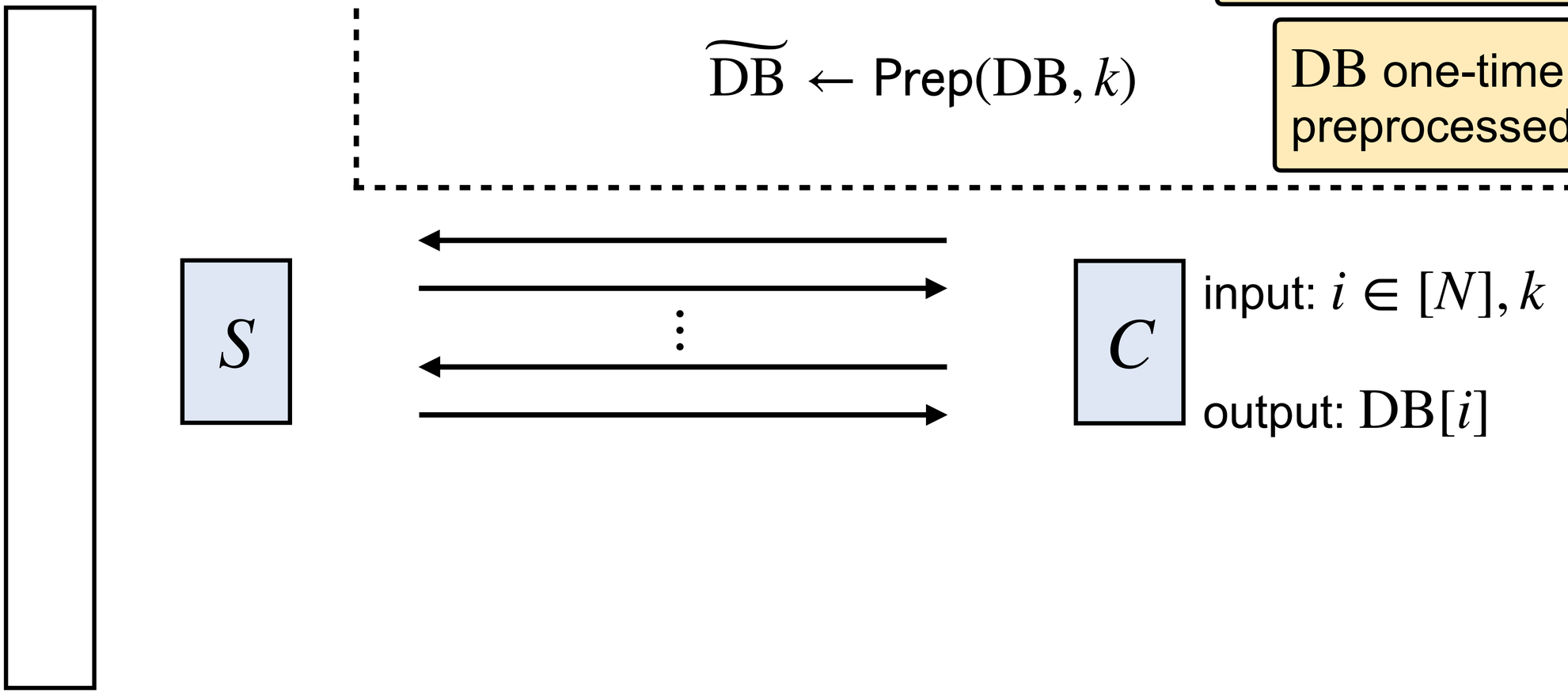

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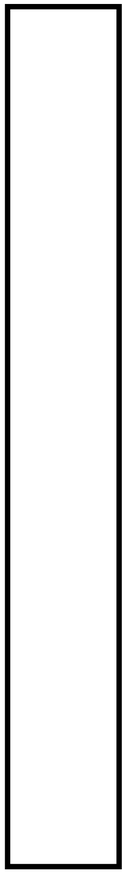

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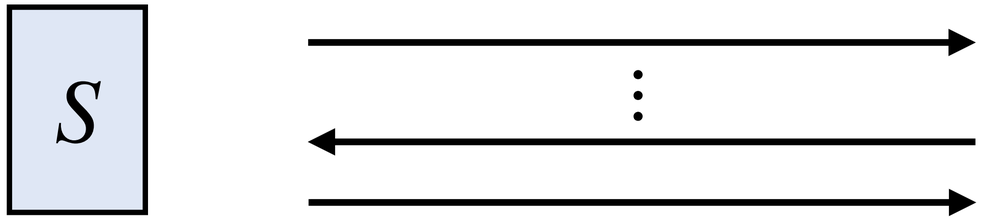


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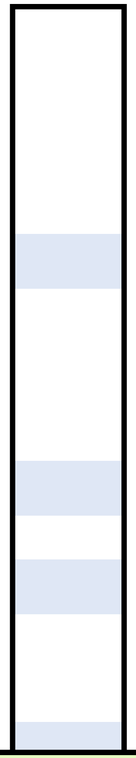

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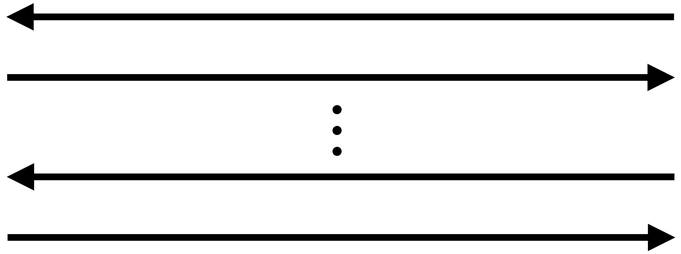

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input: $i \in [N], k$

output: $\mathrm{DB}[i]$

Efficiency: Server touches $o(N)$ locations

Communication: $o(N)$

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# Three Flavors of DEPIR

Prior constructions

Secret-Key
(SK-DEPIR)

---

Public-Key
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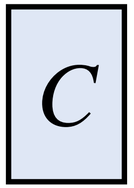


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[CHR'17,BIPW'17]: From "permuted codes with noise"

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⇓

(Standard) PIR

# How does (SK,PK,UK)-DEPIR relate to other crypto primitives?

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Partial progress ruling out SK-DEPIR from OWFs

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- ***Then:*** there is a BB construction of SK-DEPIR from OWFs

Partial progress ruling out SK-DEPIR from OWFs

**Theorem 2**: There is no BB construction of ***2-round, passive server*** SK-DEPIR from OWFs

# Techniques

**Starting point:** An SK-DEPIR that exists in an idealized world

$$\text{DEPIR} = (\text{Prep}^{\mathcal{O}_P}, C^{\mathcal{O}_P}, S^{\mathcal{O}_P})$$

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$\mathcal{O}_P$ = oracle implementing $P$

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Compile into an SK-DEPIR where the server doesn't use the oracle

$$\widetilde{\text{DEPIR}} = (\text{Prep}^{\mathcal{O}_P}, \tilde{C}^{\mathcal{O}_P}, \tilde{S})$$

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Inspired by techniques of [Dujmovic-Hajiabadi'24]

Compile into an SK-DEPIR where the server doesn't use the oracle

$$\widetilde{\text{DEPIR}} = (\text{Prep}^{\mathcal{O}_P}, \tilde{C}^{\mathcal{O}_P}, \tilde{S})$$

If $\mathcal{O}_P$ is *"nice"*, then the client can emulate $\mathcal{O}_P$ with just a PRF

$$\overline{\text{DEPIR}} = (\overline{\text{Prep}}^{\text{PRF}}, \overline{C}^{\text{PRF}}, \tilde{S})$$

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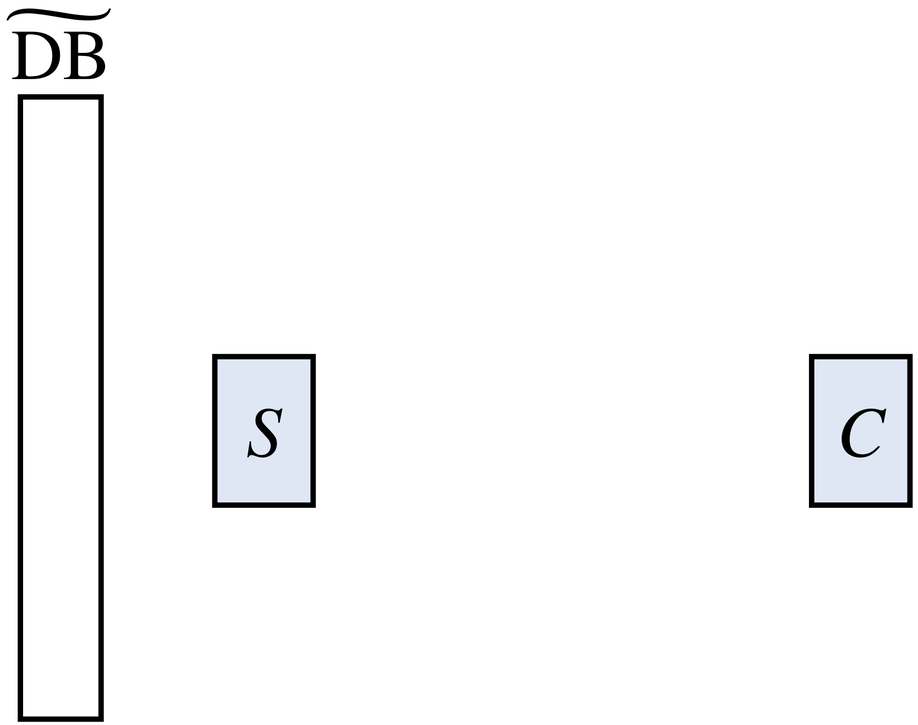

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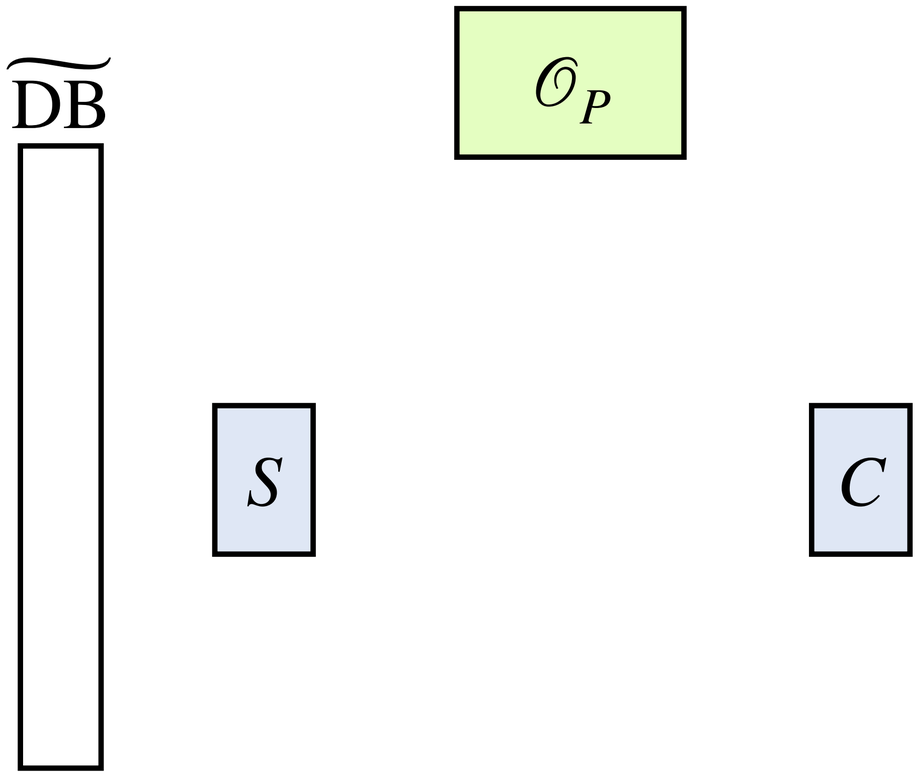

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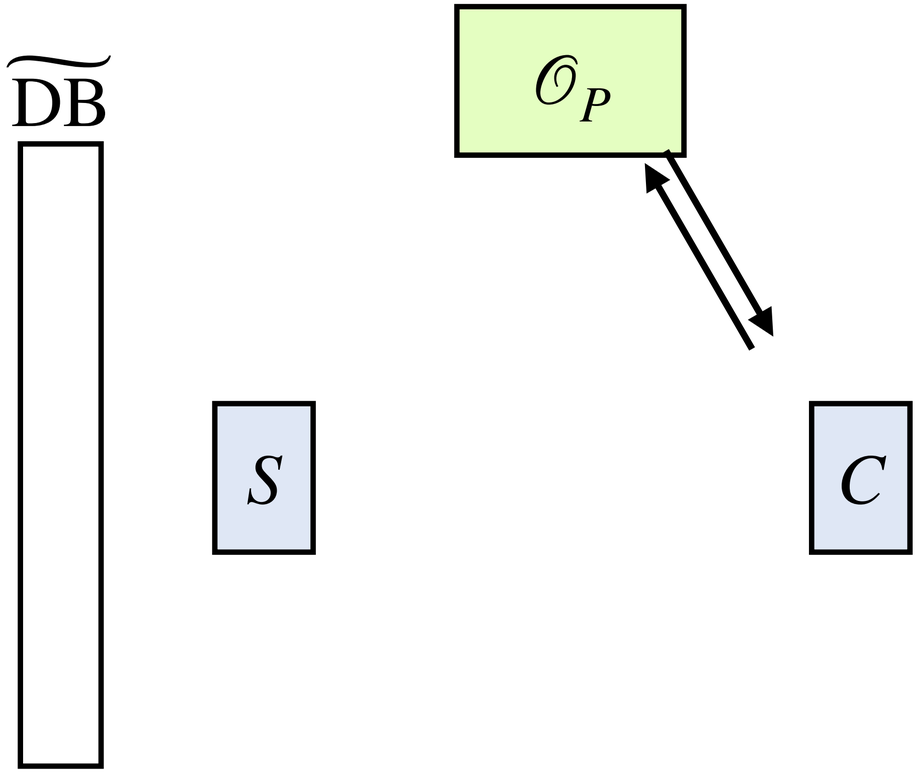

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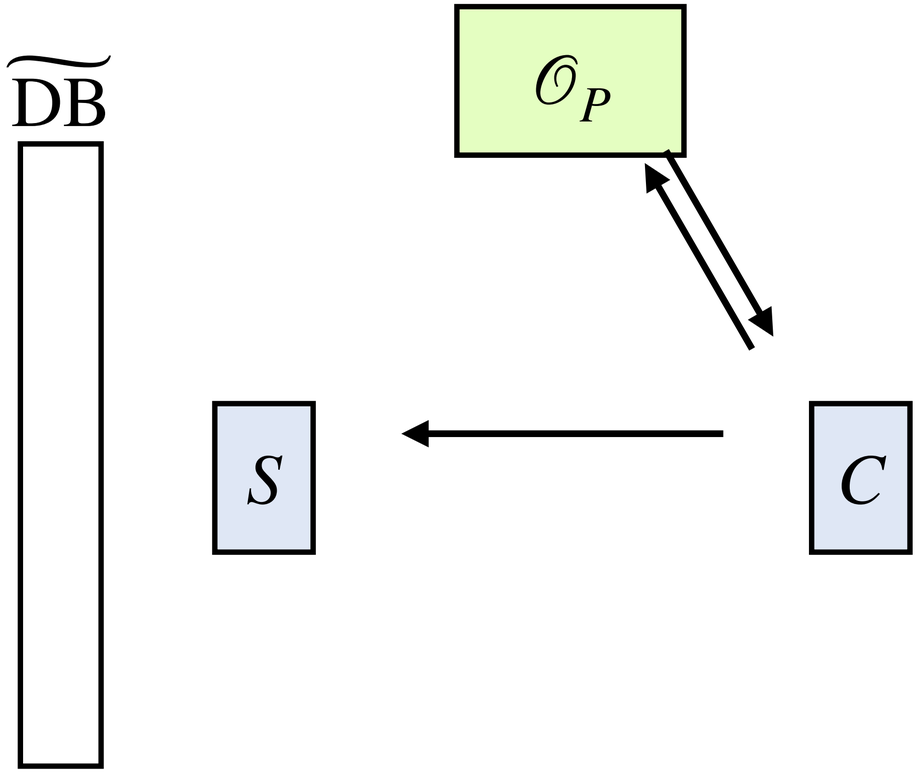

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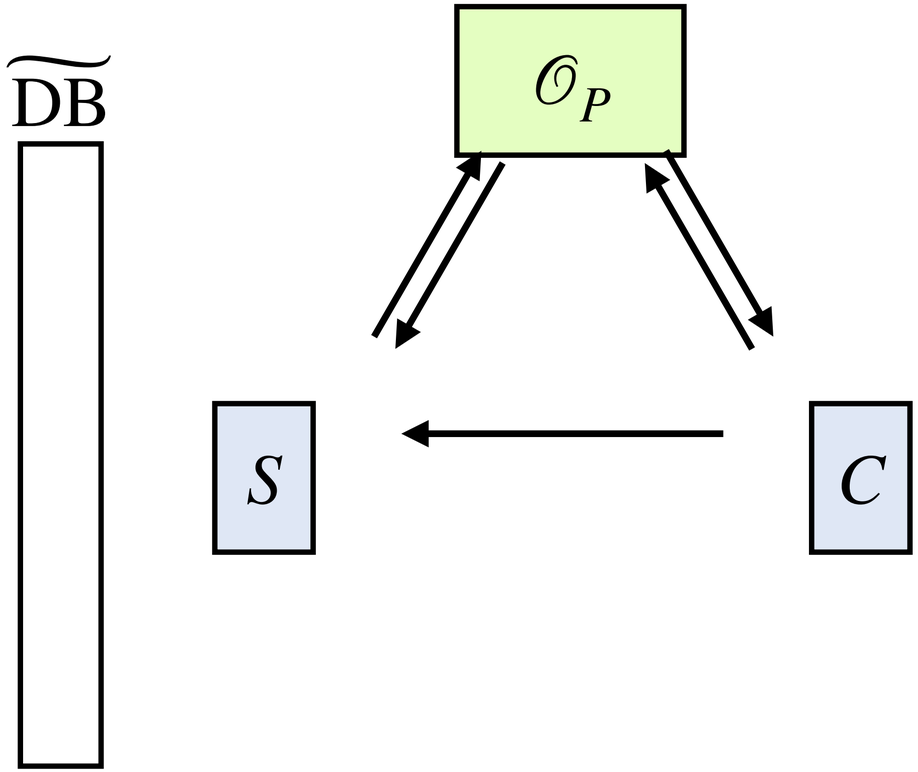

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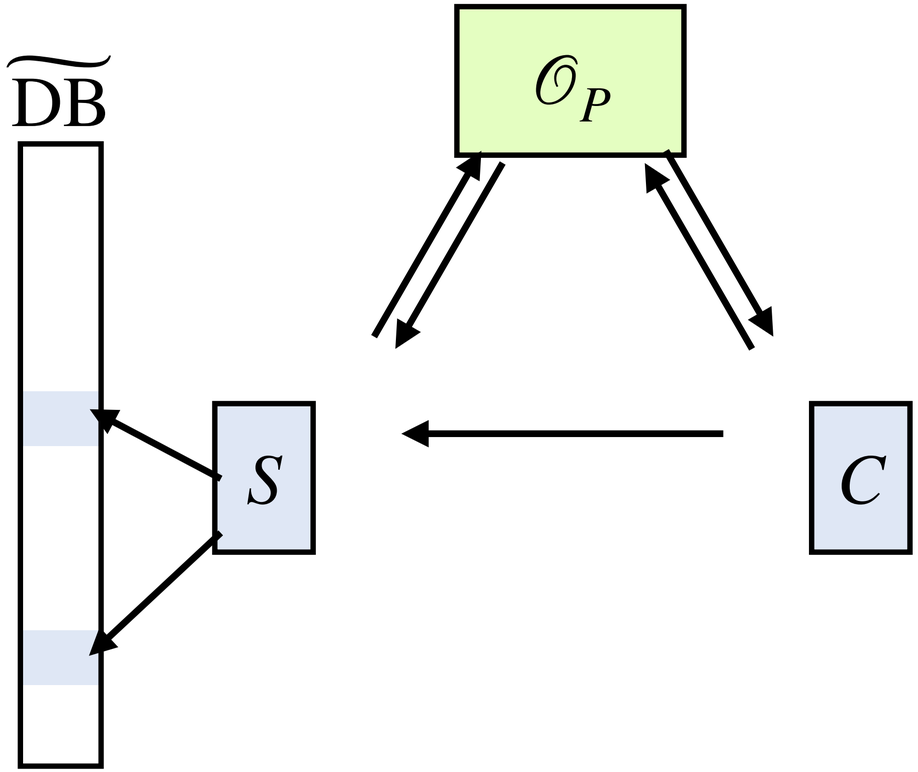

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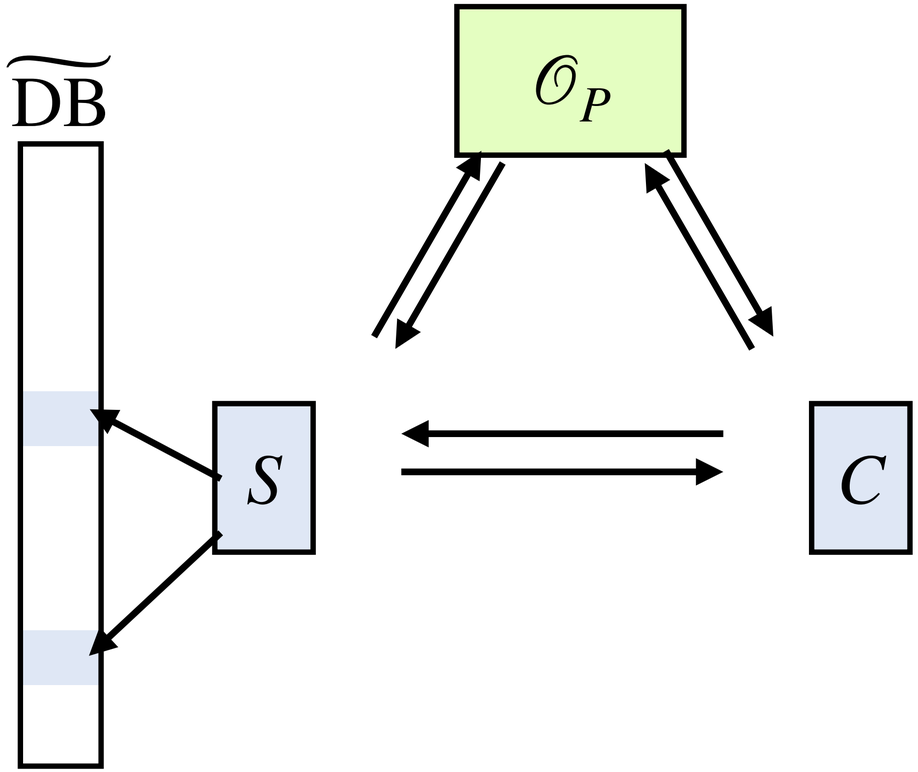

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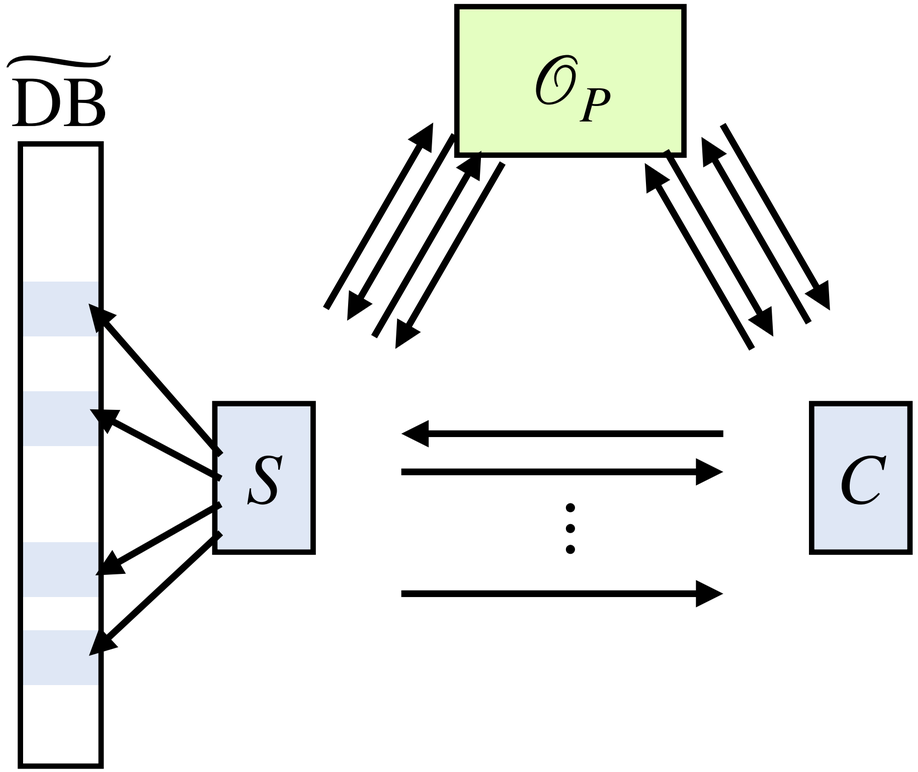

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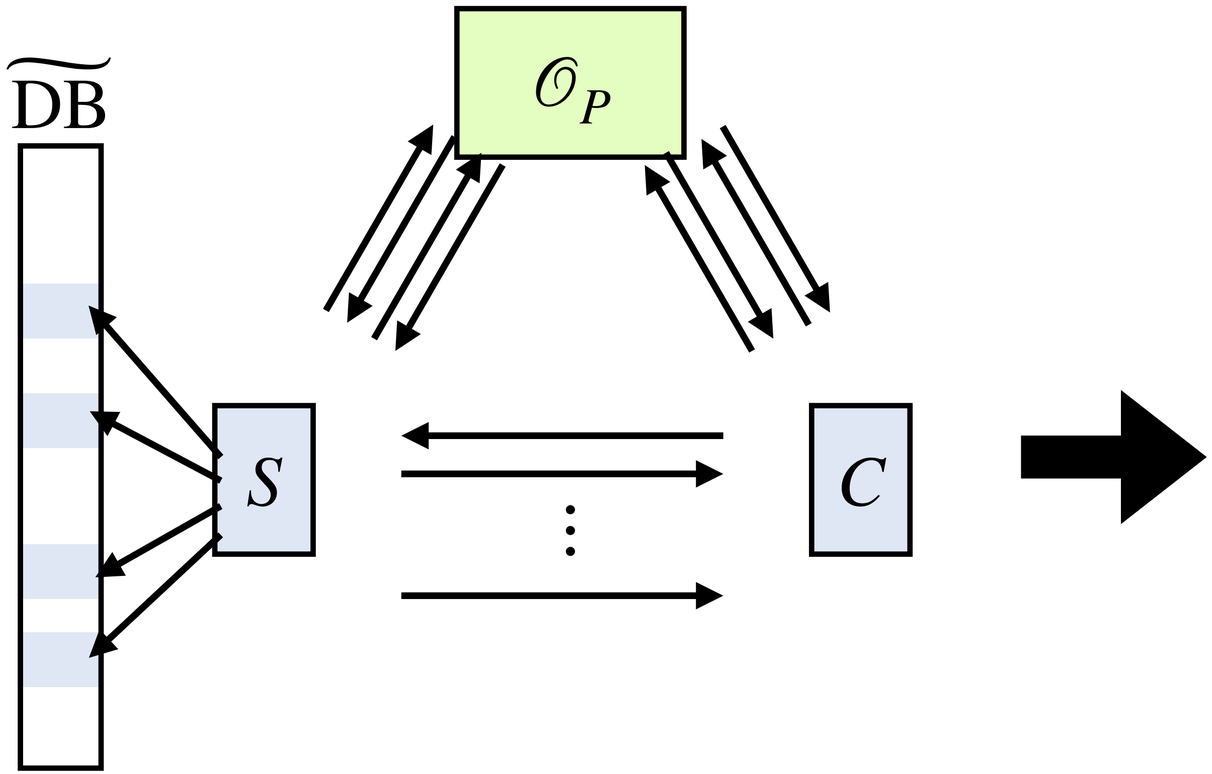

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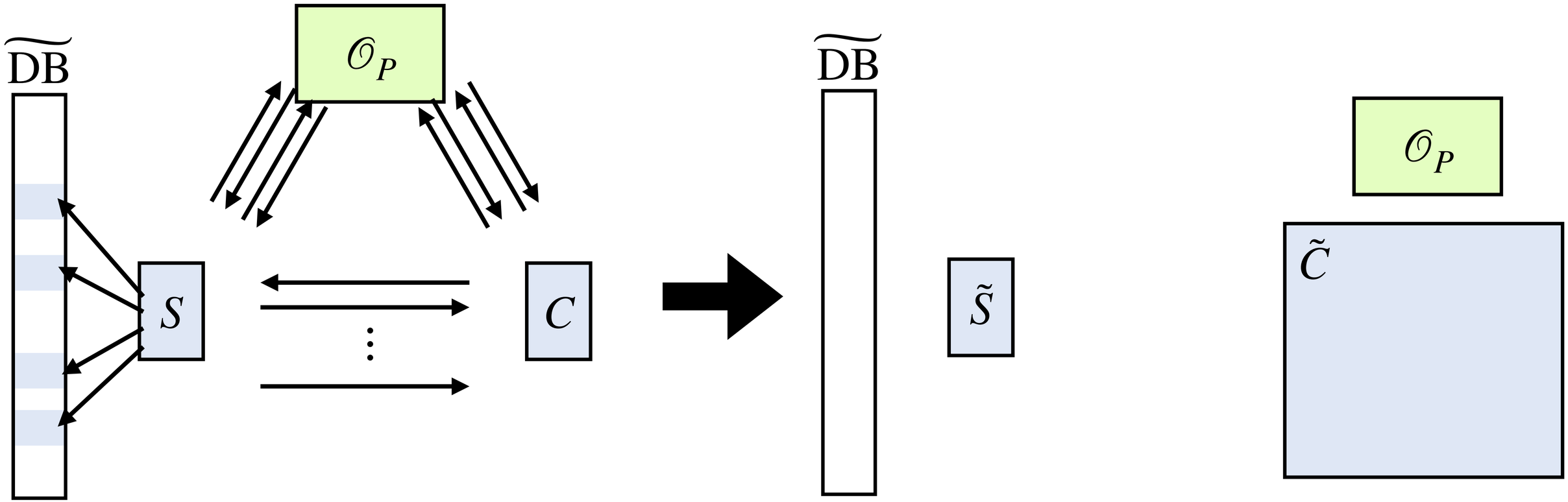

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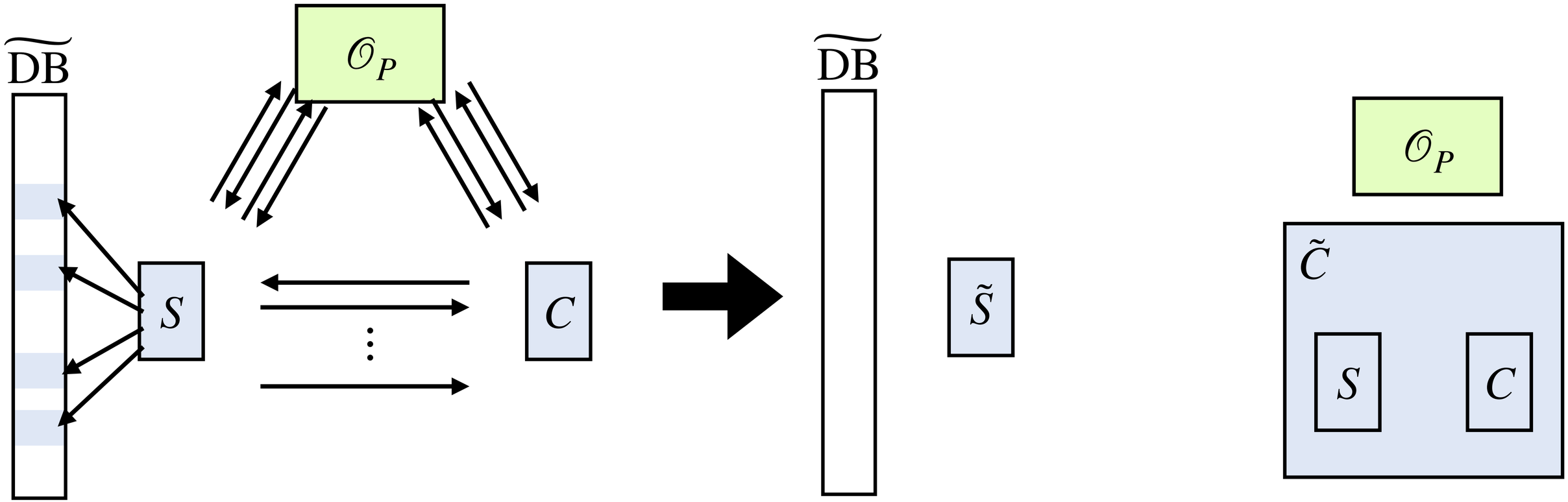

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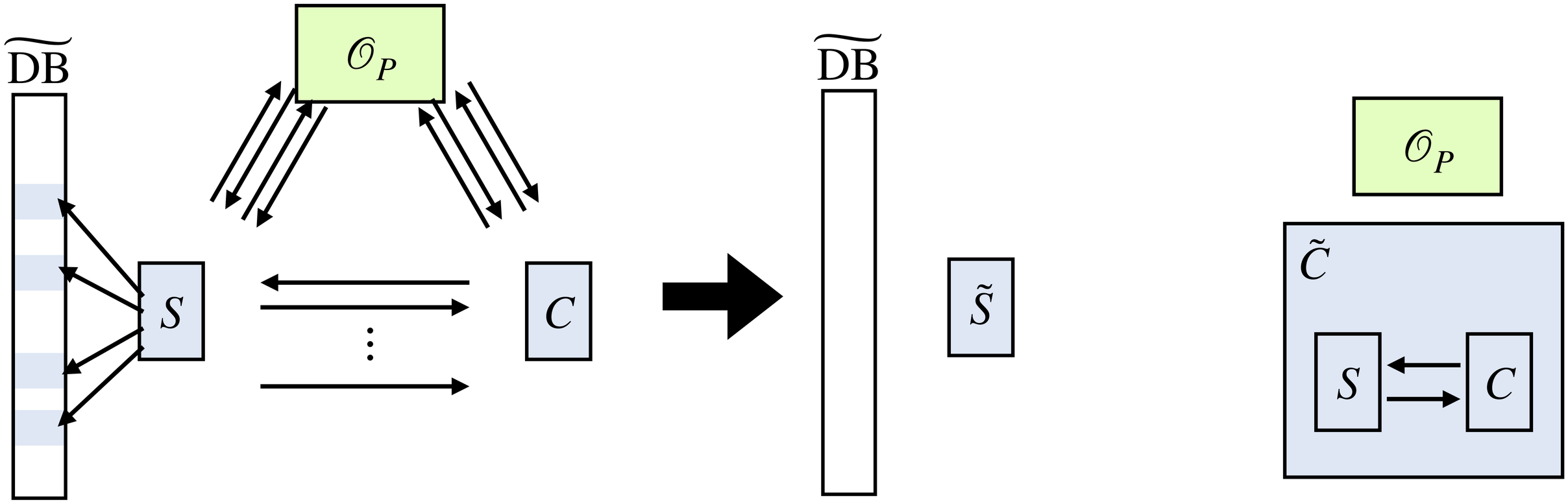

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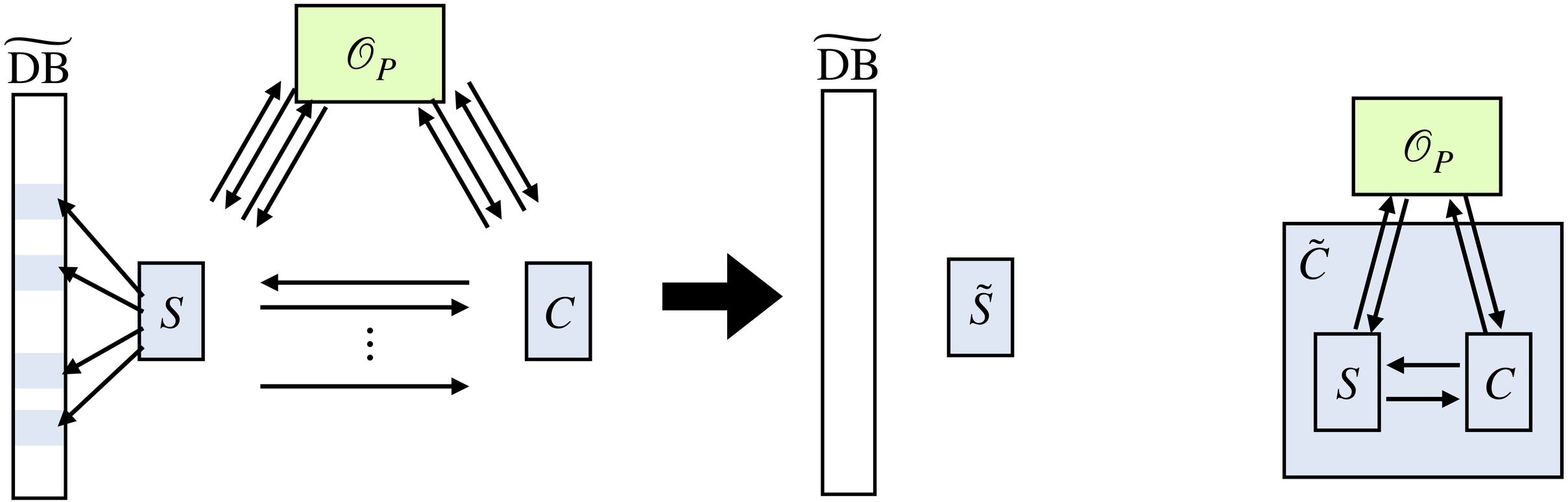

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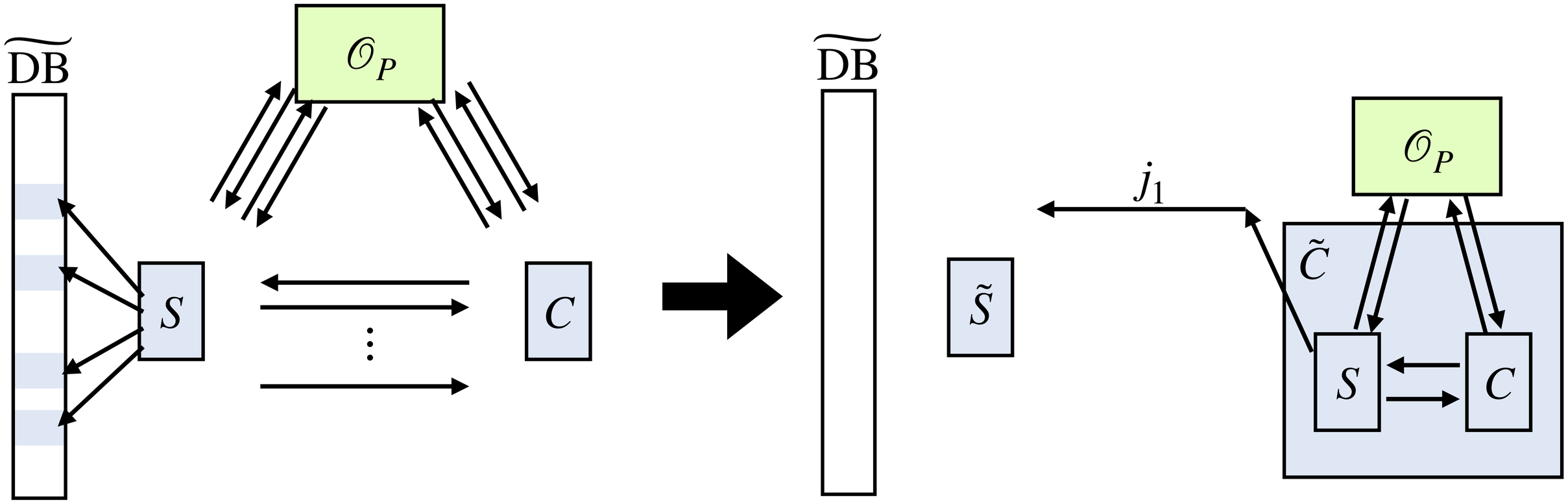

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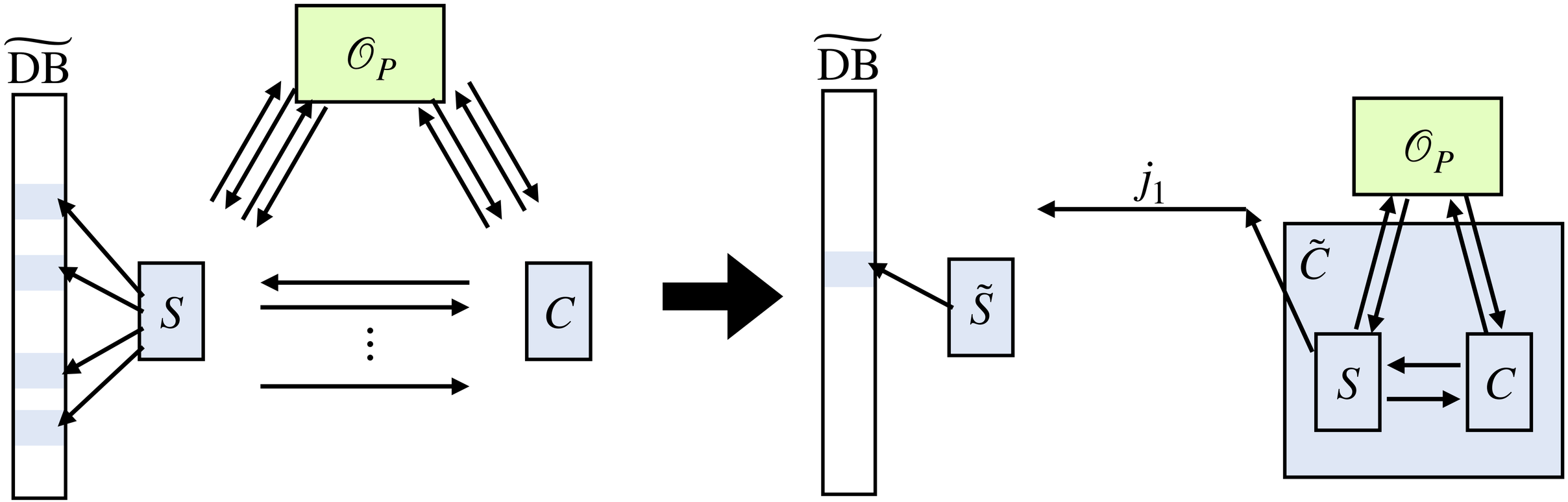

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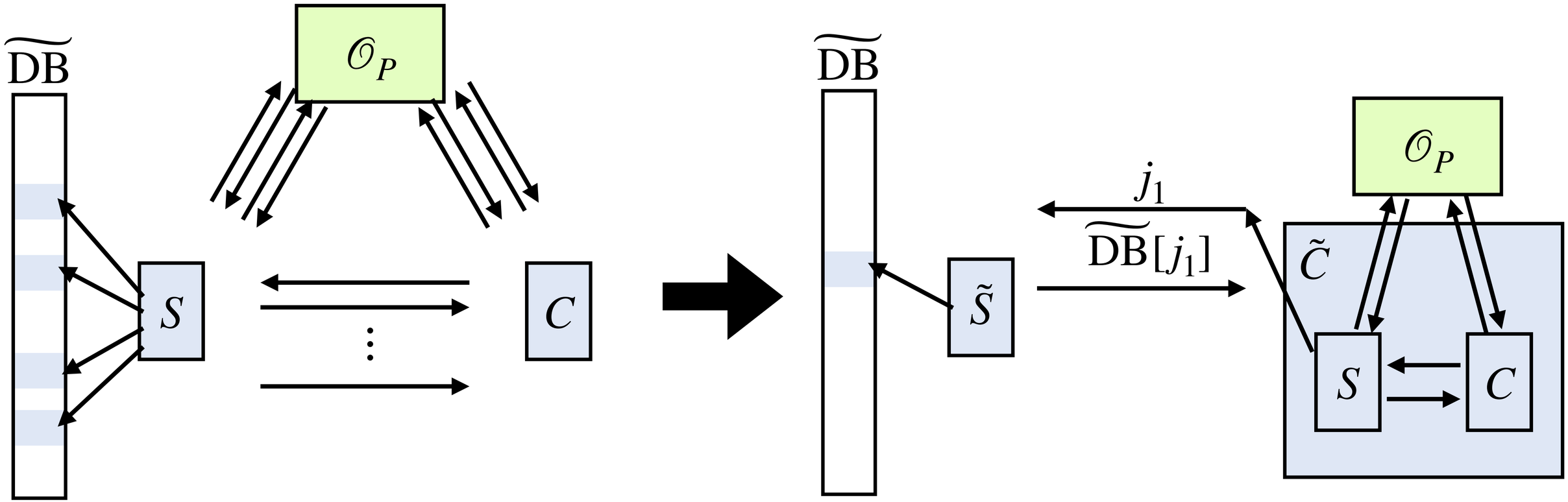

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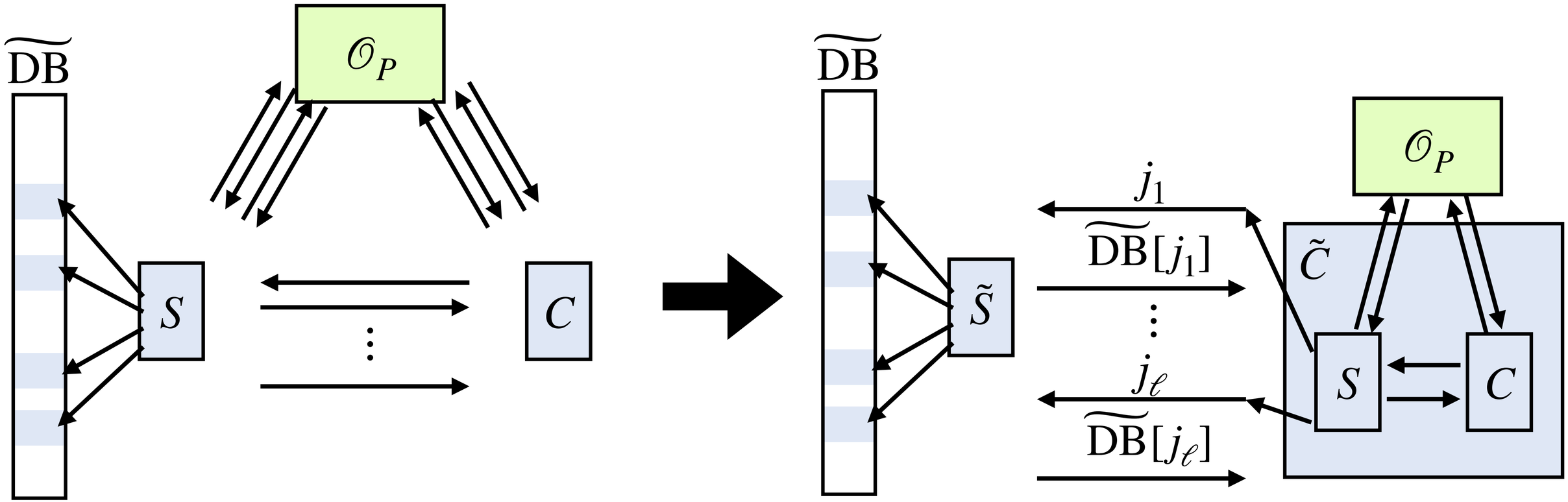

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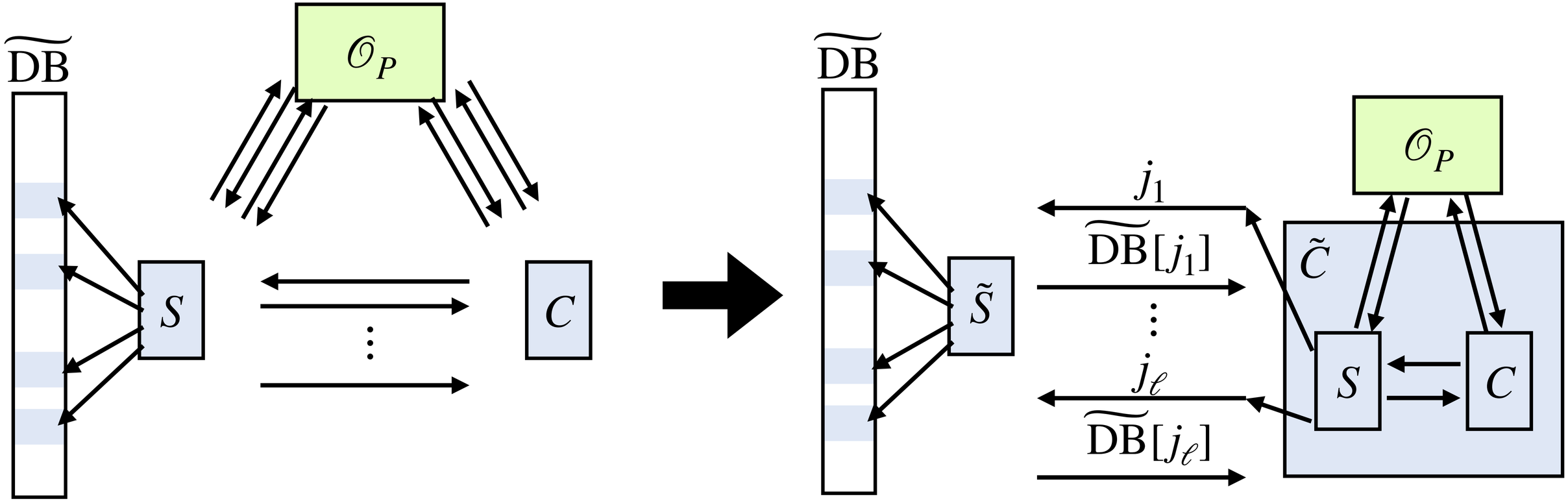


Communication & $\tilde{S}$ efficiency:
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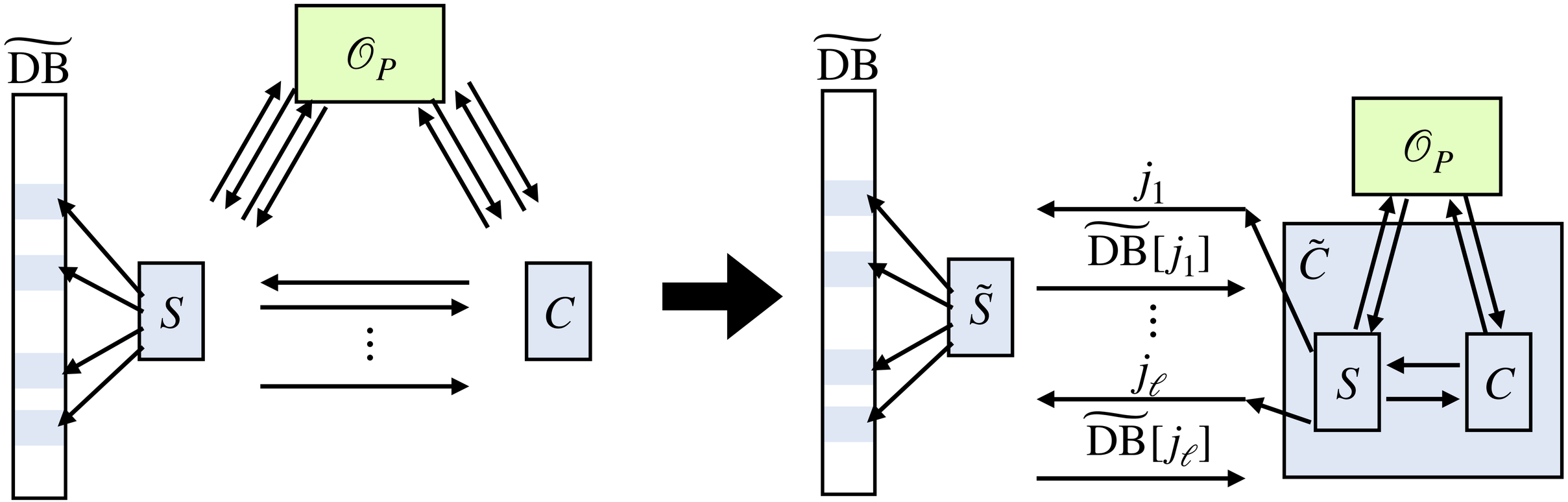


$\tilde{S}$ is purely passive

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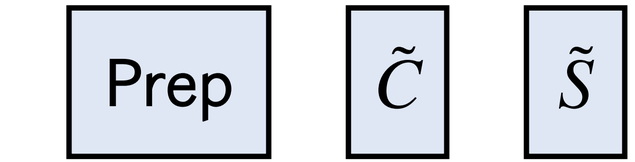


Passive server SK-DEPIR

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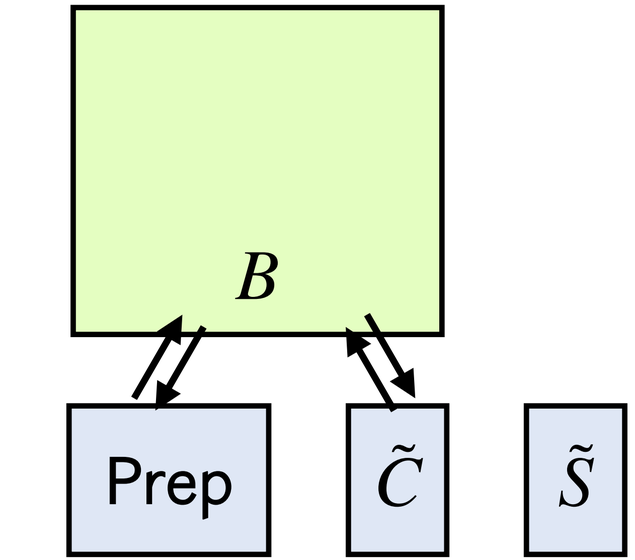


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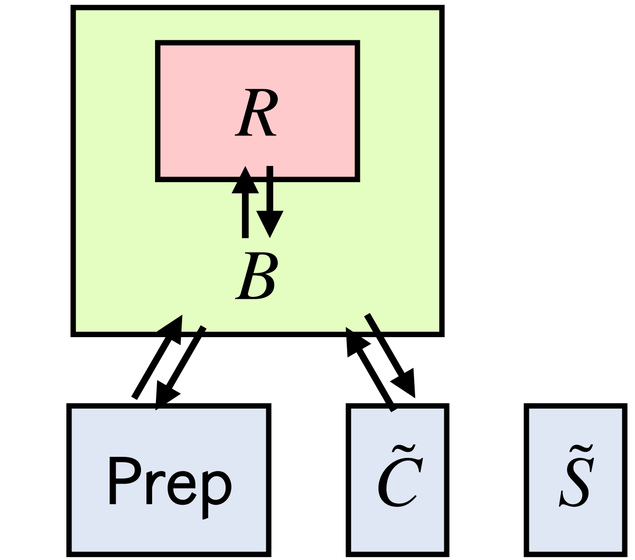


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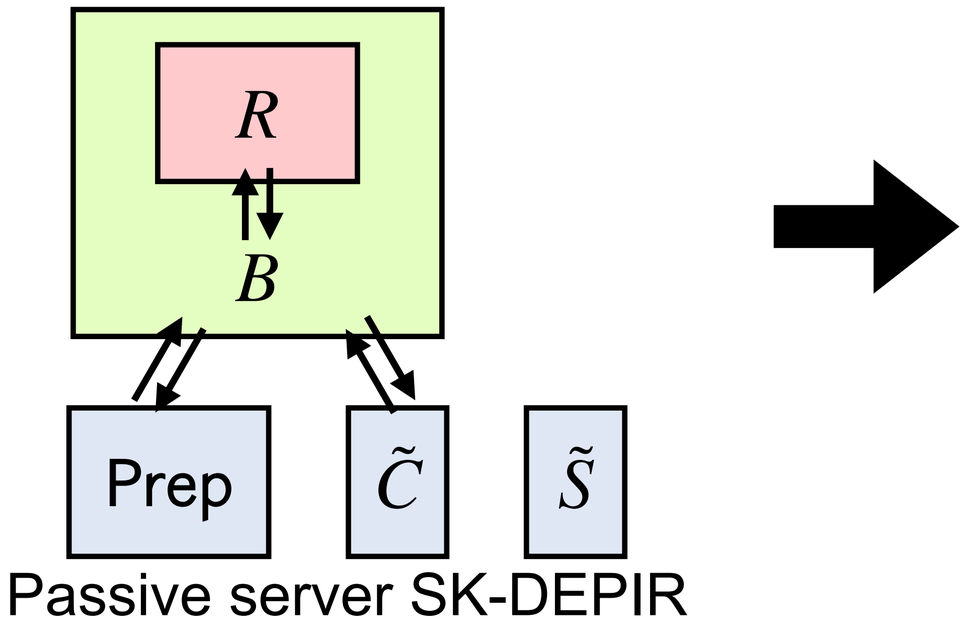

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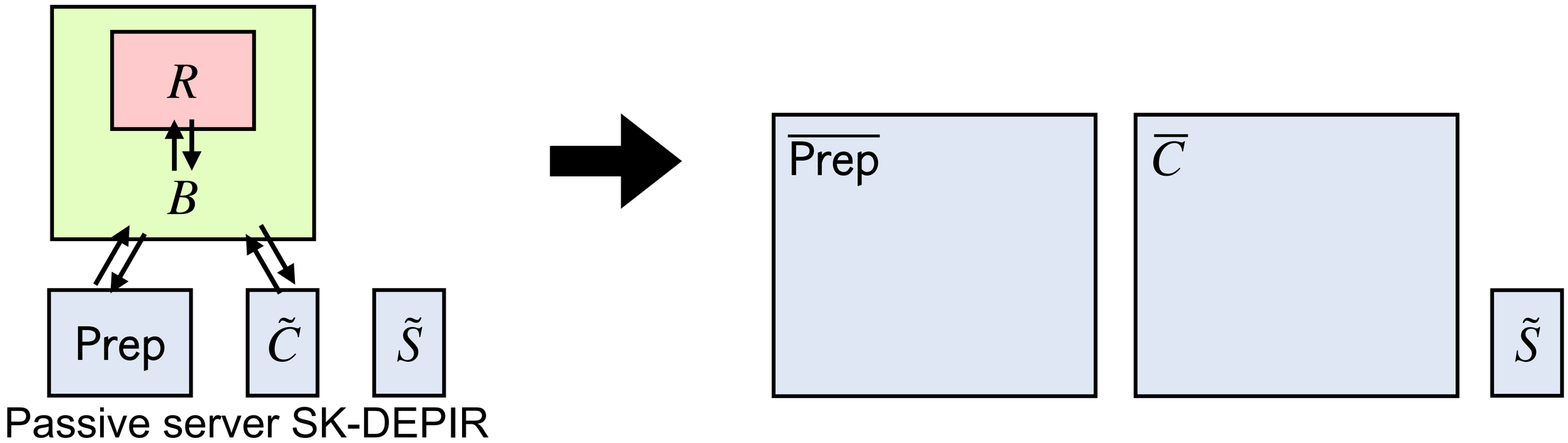

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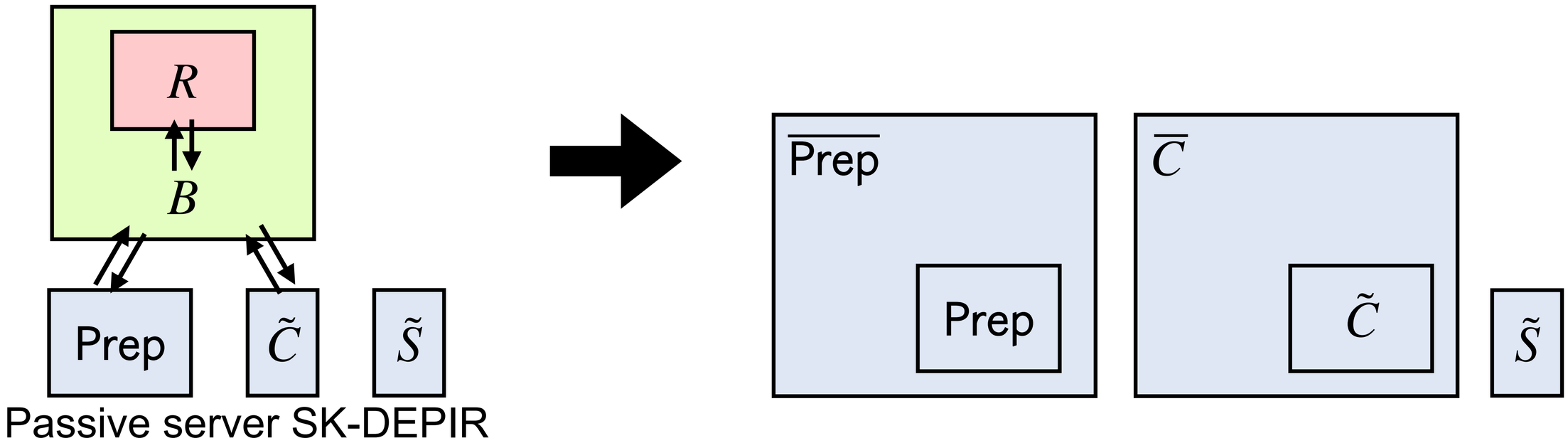

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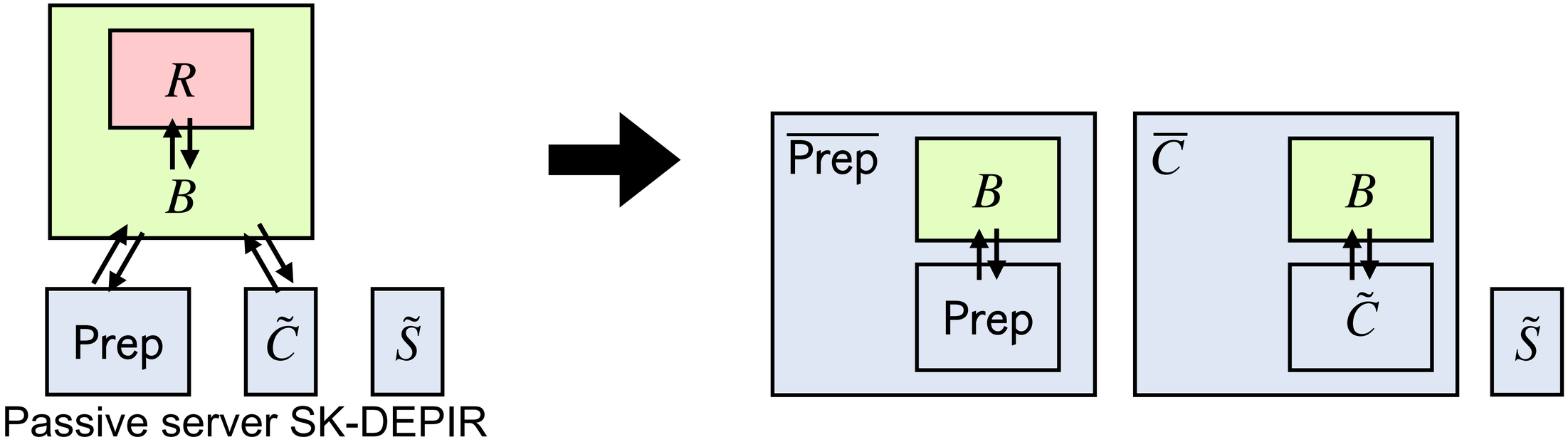

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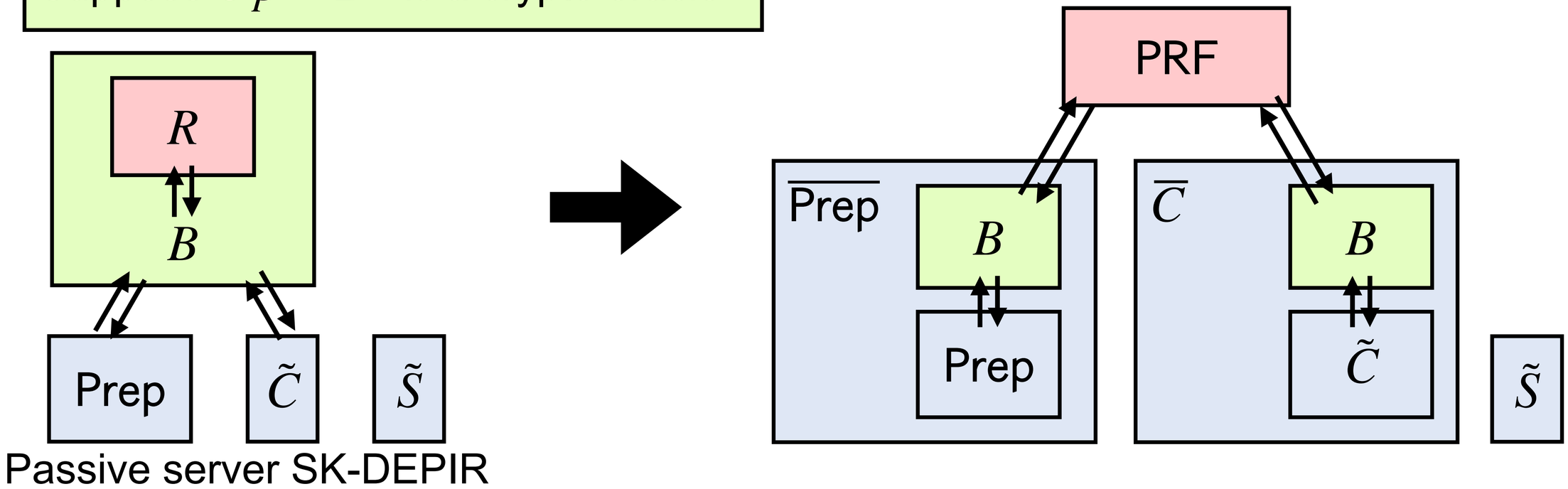


Passive server SK-DEPIR

# Our Results

Black-box use of advanced crypto is ***useless*** for constructing DEPIR

**Theorem 1**: Let $P$ be a crypto primitive that *large class (to be specified)*

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Partial progress ruling out SK-DEPIR from OWFs

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Adapted from [CHR'17] info. theoretic lower bound

↳see paper for details

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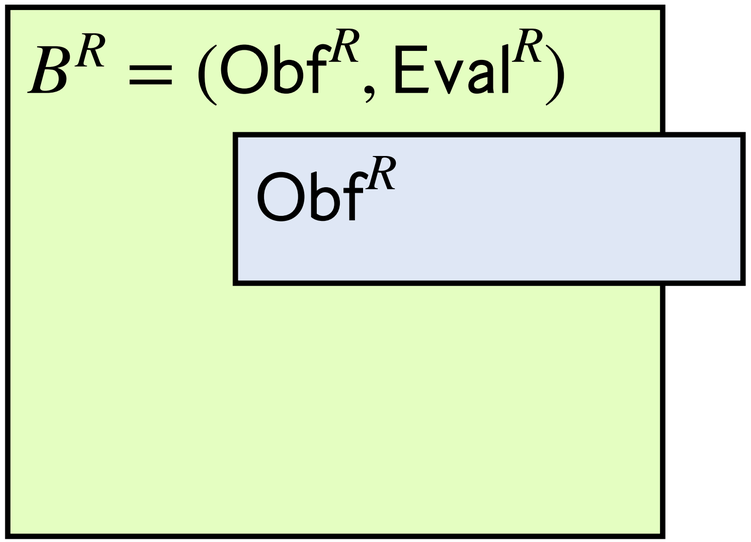

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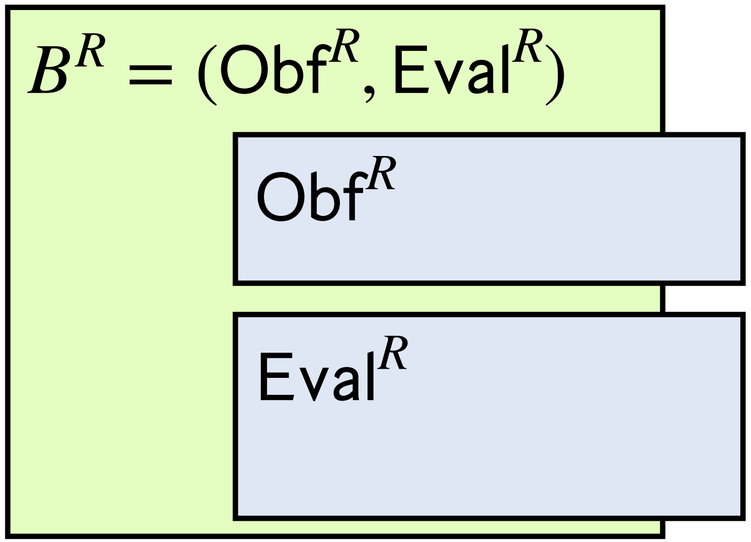

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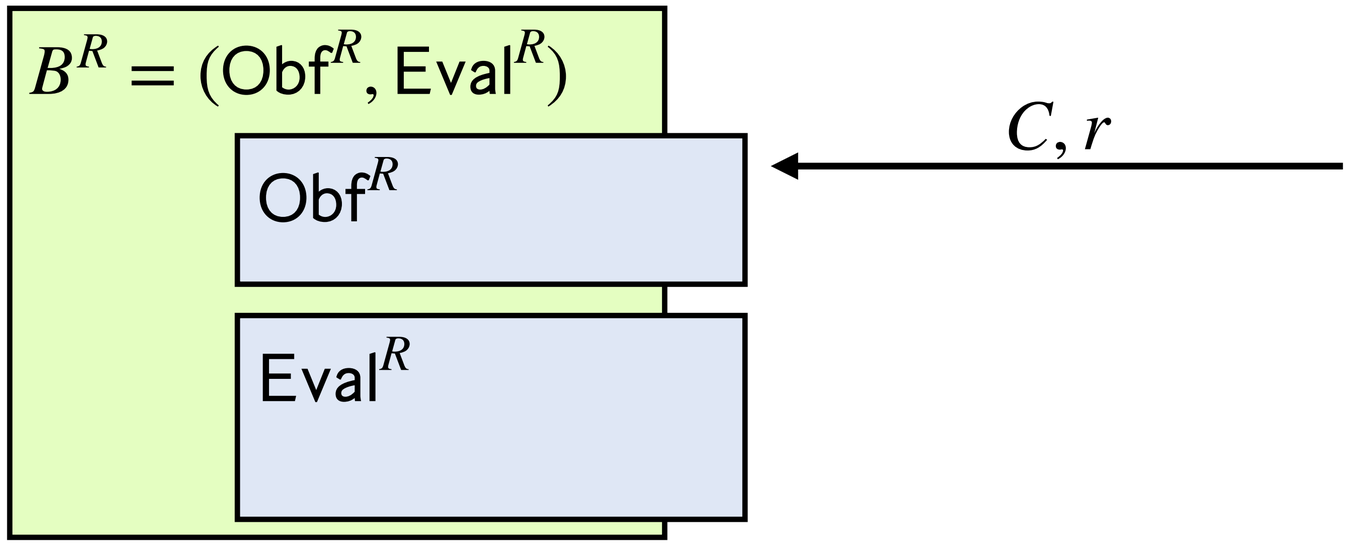

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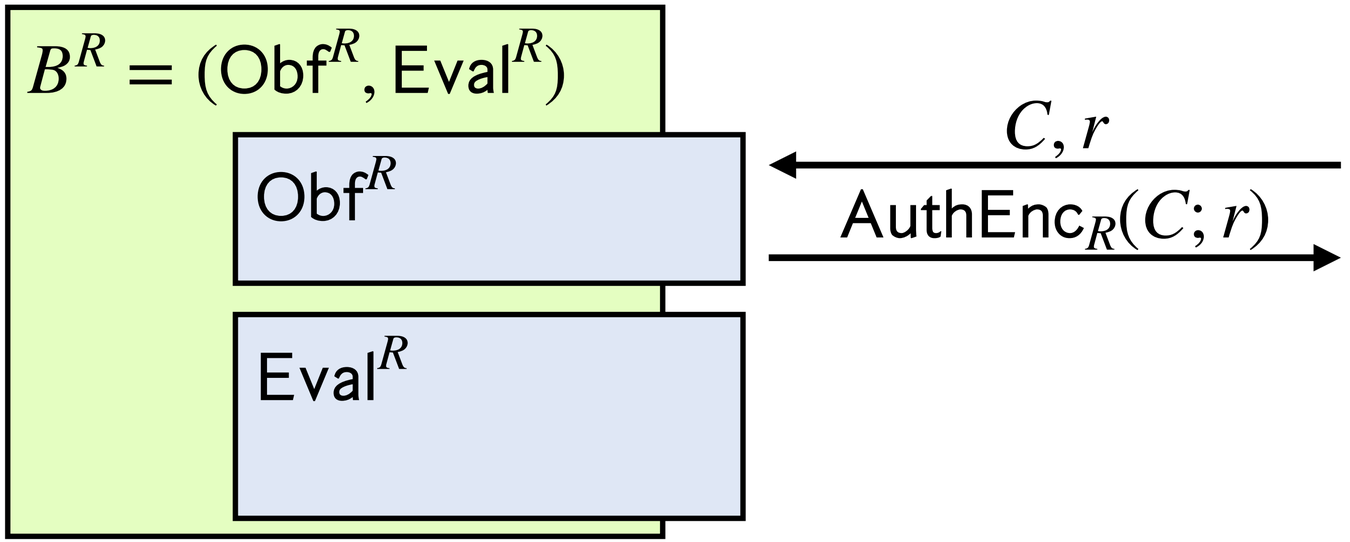

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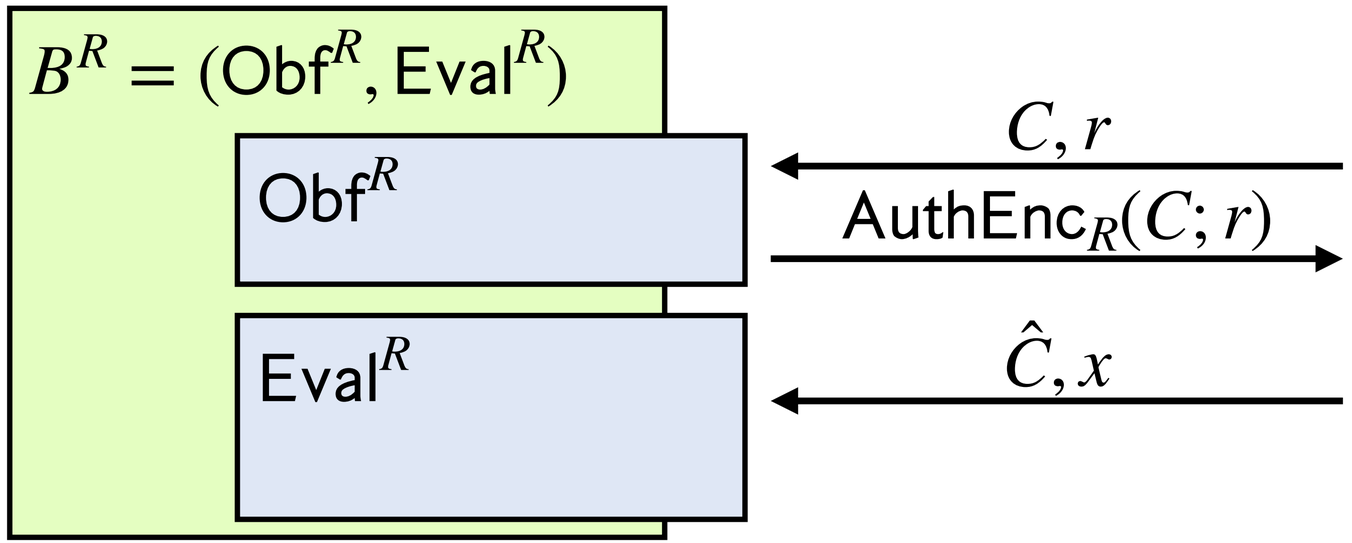

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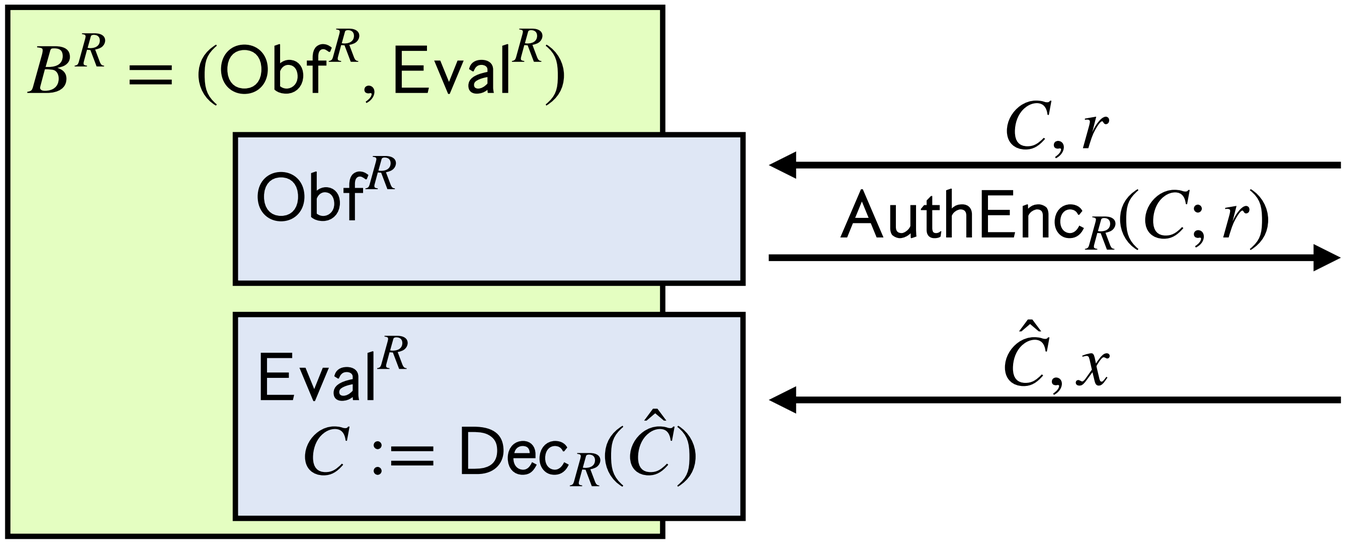

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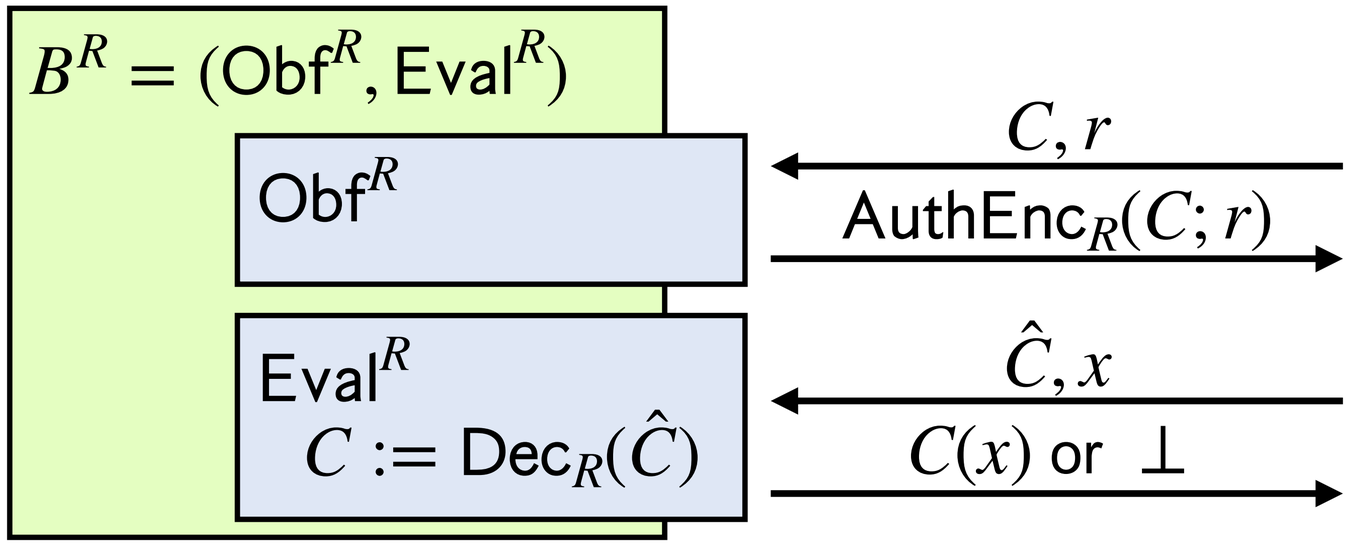

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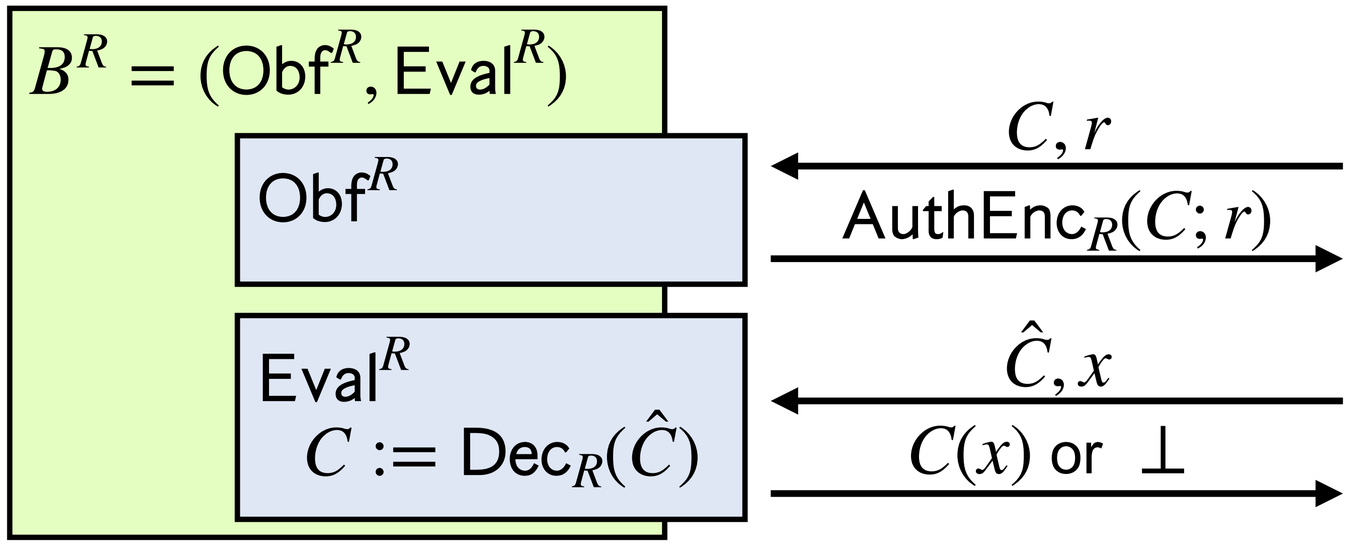


**Lemma:** The generic multi-linear group model can be realized as a crypto oracle ⇒ OT, FHE, … can as well

# Corollaries & Interpretation

Crypto oracles capture a wide array of primitives, even combinations

**Corollary**:

- ***If:*** there is a BB construction of SK-DEPIR from $P$
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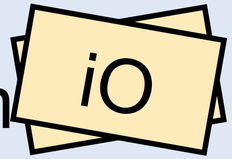
- ***If:*** there is a BB construction of SK-DEPIR from 

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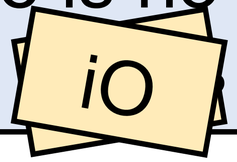
**Corollary**: There is no BB construction of ***2-round, passive server*** SK-DEPIR from 

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Prior lemma gives VBB for oracle-aided circuits
⇒ capture non-BB techniques like “eval crypto under obfuscation”

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**Crucial:** need DDH over a ***concrete group*** (e.g. $\mathbb{Z}_p^*$), the generic group can be realized as crypto oracle

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**Recall:** Prior positive results

- SK-DEPIR from “permuted codes with noise” [CHR’17,BIPW’17]
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Both make use of concrete algebraic structure of the underlying assumption

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**Our result:** This concreteness is ***inherent***

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The class: constructible relative to crypto oracle

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Thank you!

eprint: 2025/552