Asynchronous Byzantine Agreement with Subquadratic Communication

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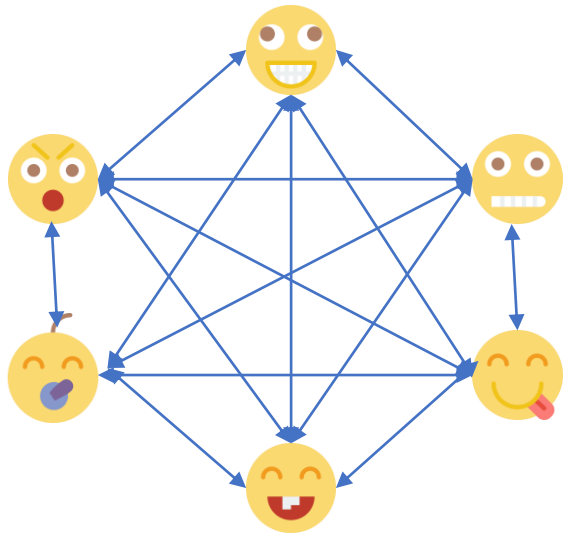
Byzantine Agreement



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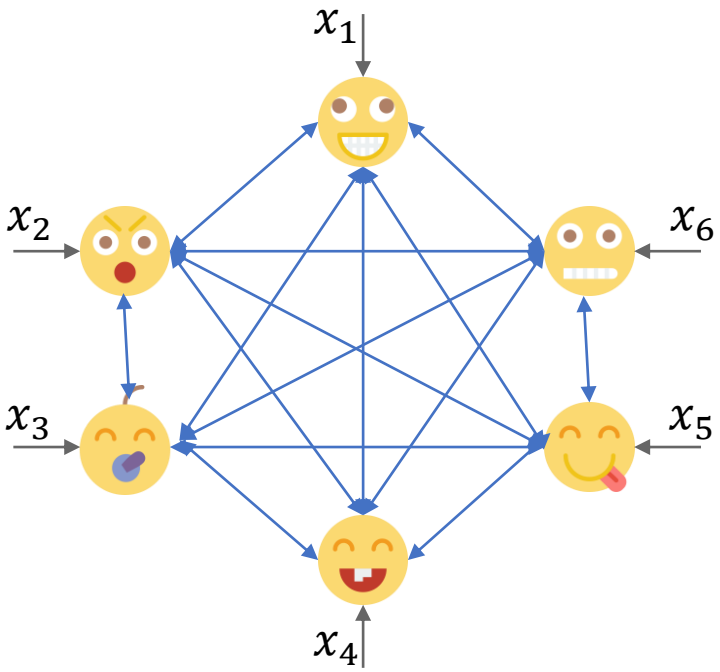

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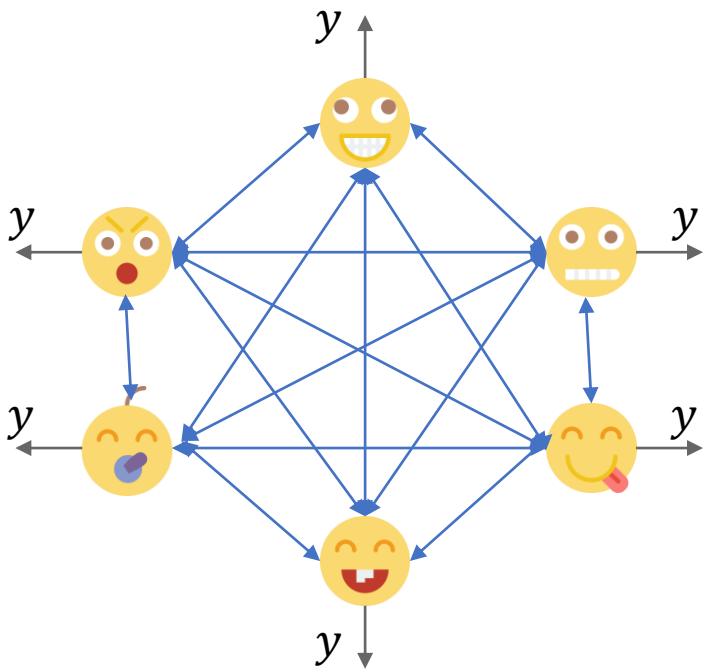
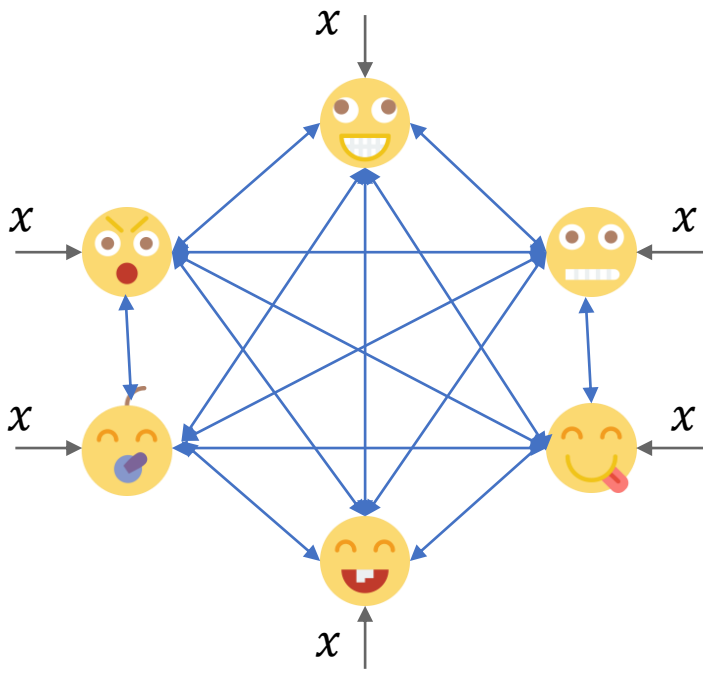


All honest parties agree on the same output

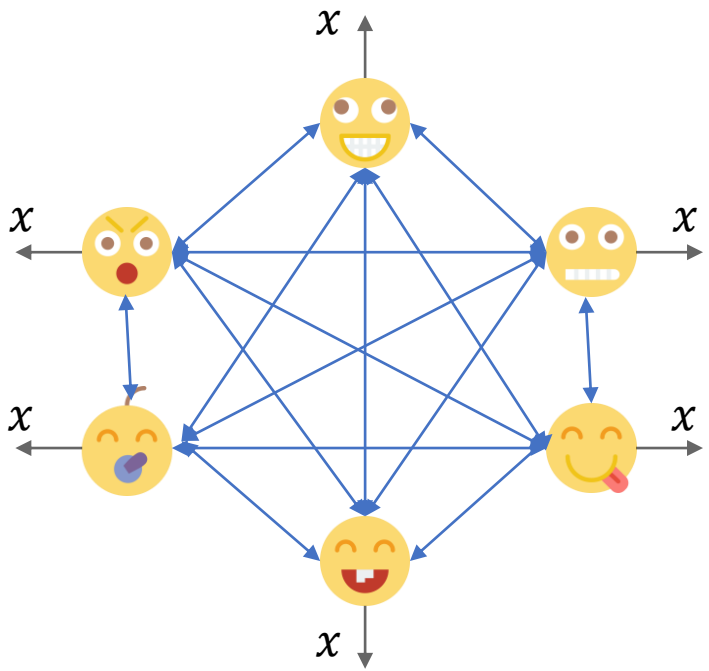
Byzantine Agreement



All honest parties agree on the same output

If honest parties have the same input, they keep the same value as output

Byzantine Agreement



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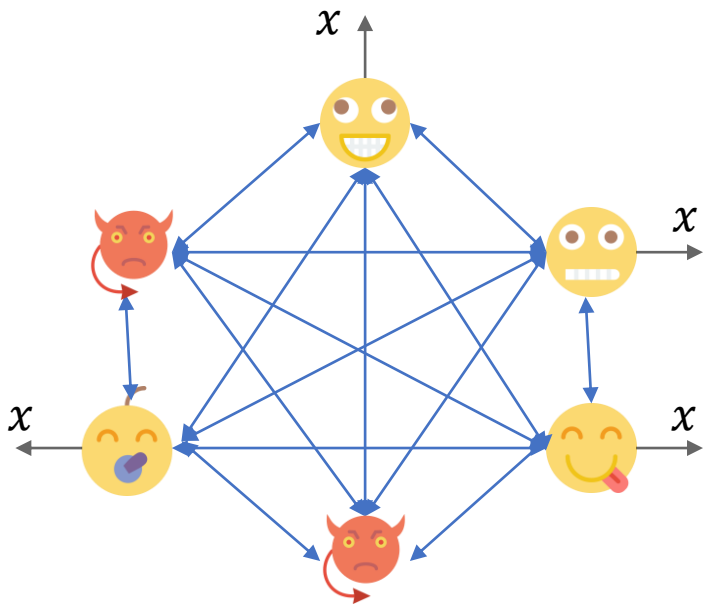

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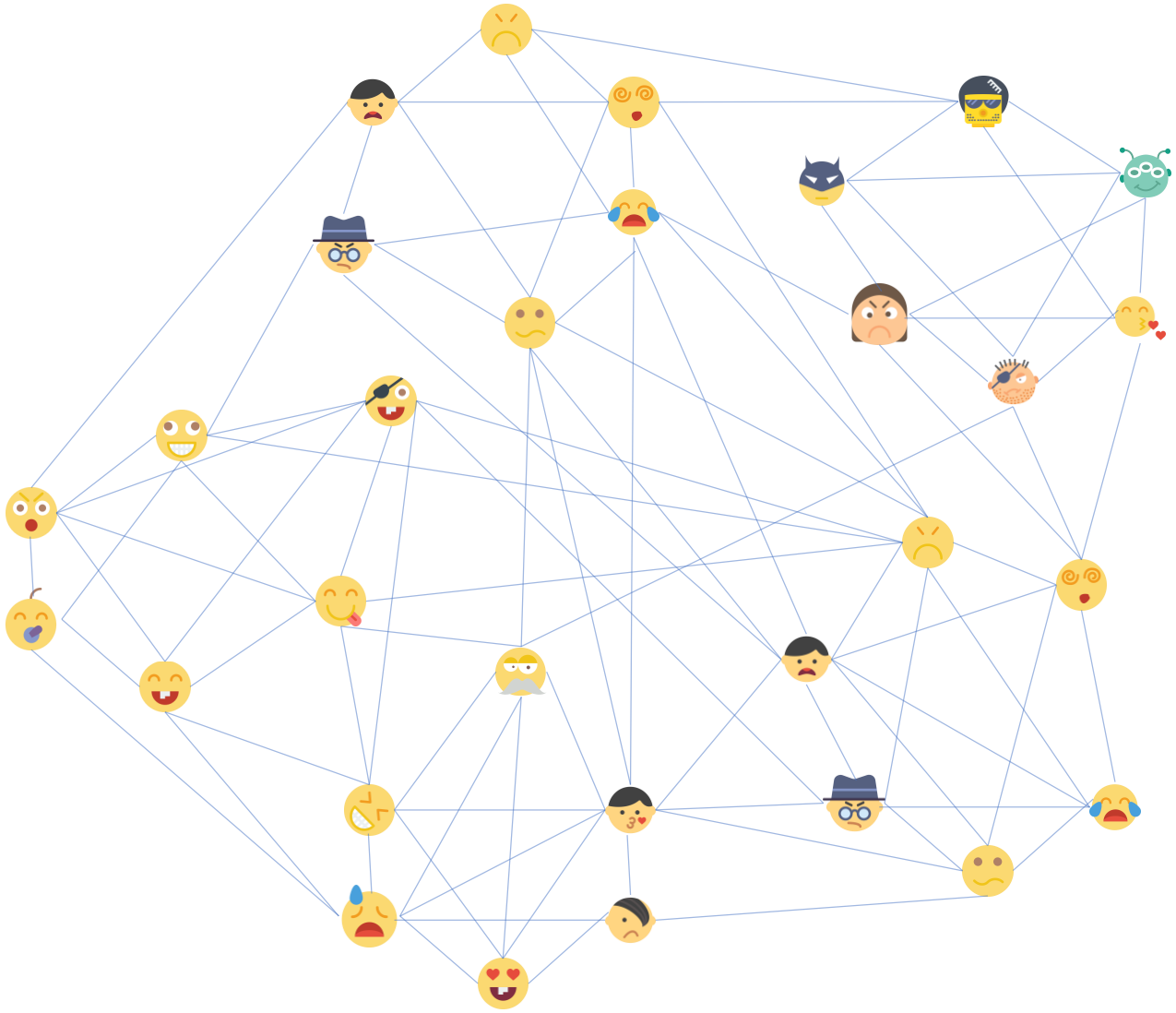

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Is there an asynchronous BA with $o(n^2)$ communication that tolerates $\theta(n)$ adaptive corruptions?

- Feasibility of asynch. $o(n^2)$ BA for $f < (1-\epsilon)\,{}^{n}/_{3}$ using a trusted dealer (alternately, with *amortized* $o(n^2)$ and without setup)

- Impossibility of asynch. $o(n^2)$ BA with $\theta(n)$ corruptions without setup

Related Work

Most previous subquadratic BA are synchronous or partially synchronous [KS06,KS10,M17,A+19,…]

Recent work by Cohen et al. [CKS20] give subquadratic asynchronous BA, but the adversary has restricted scheduling power

Feasibility of asynchronous $o(n^2)$ BA for $f < (1-\epsilon)\,{}^{n}/_{3}$ adaptive

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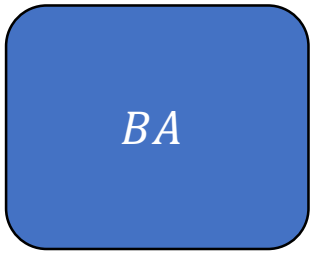

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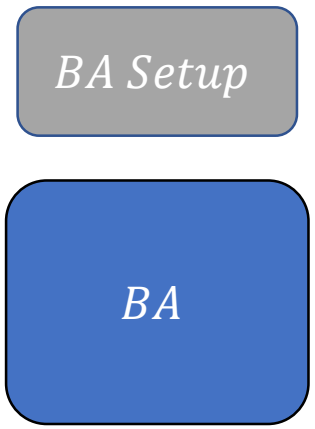

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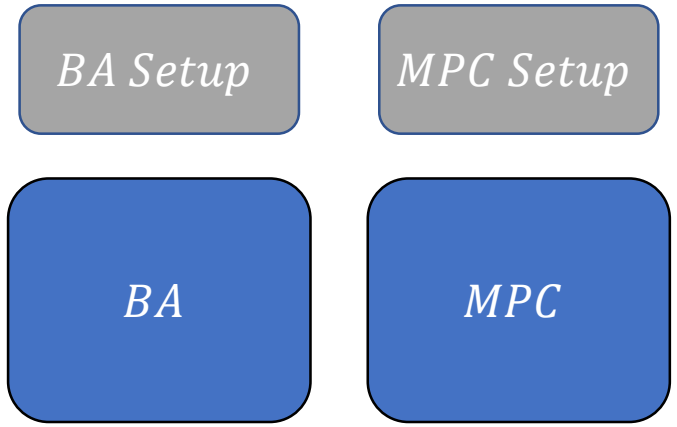

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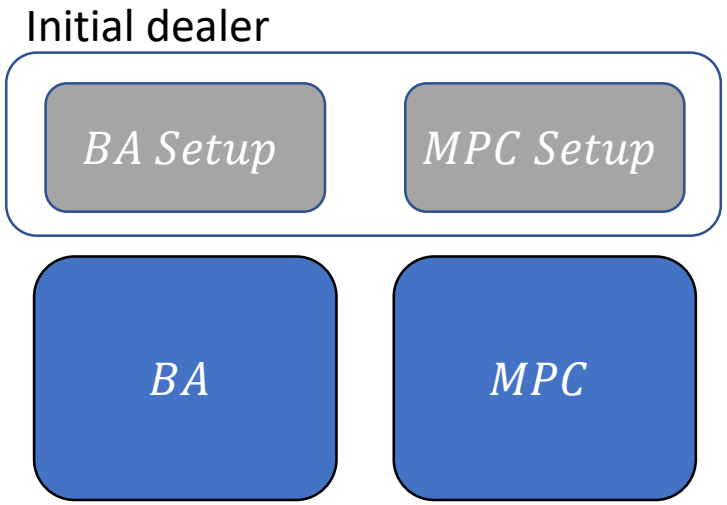

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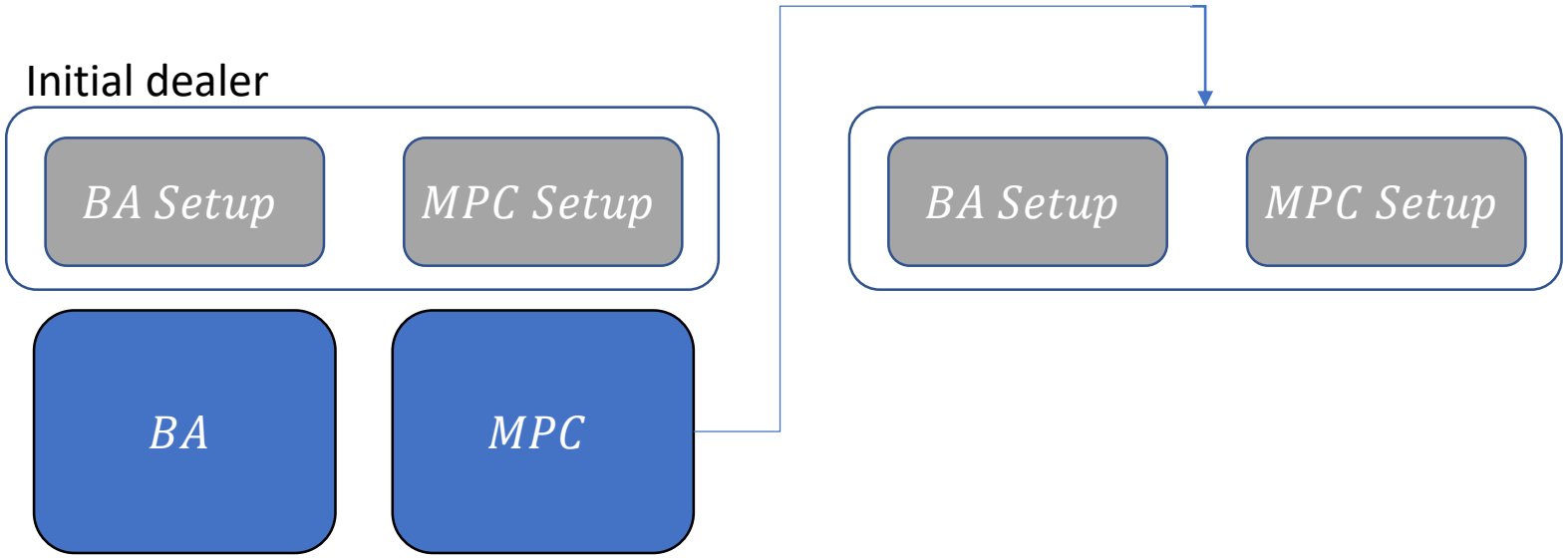

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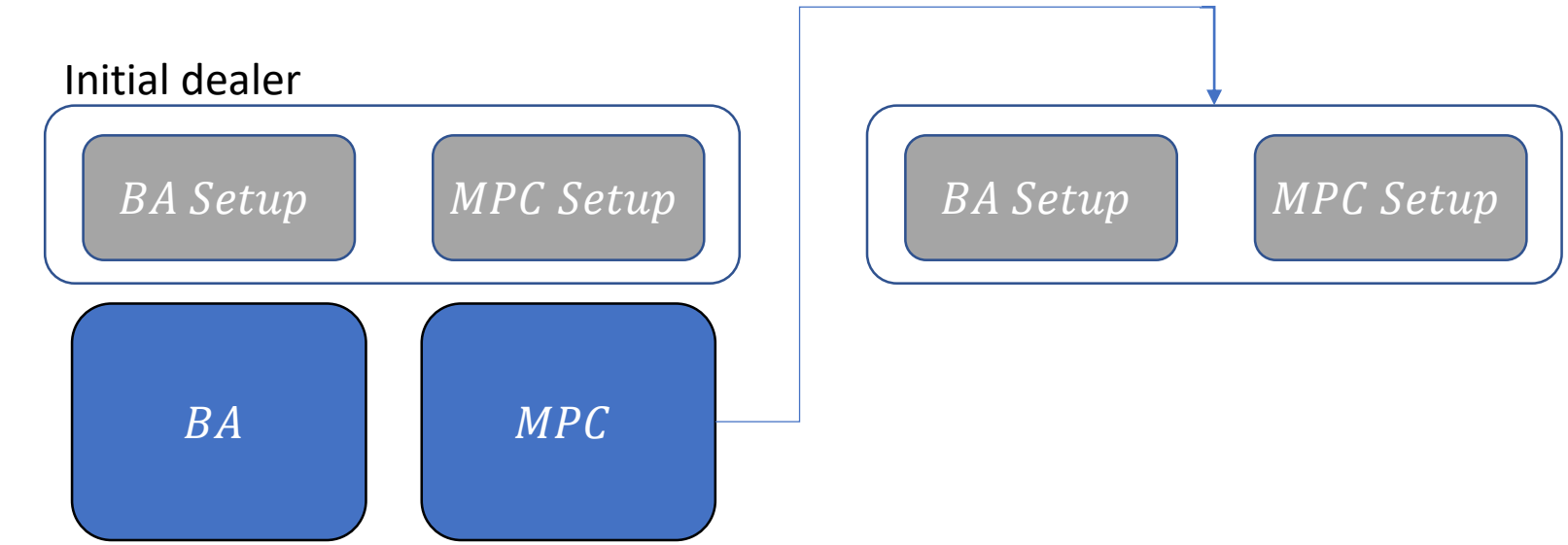

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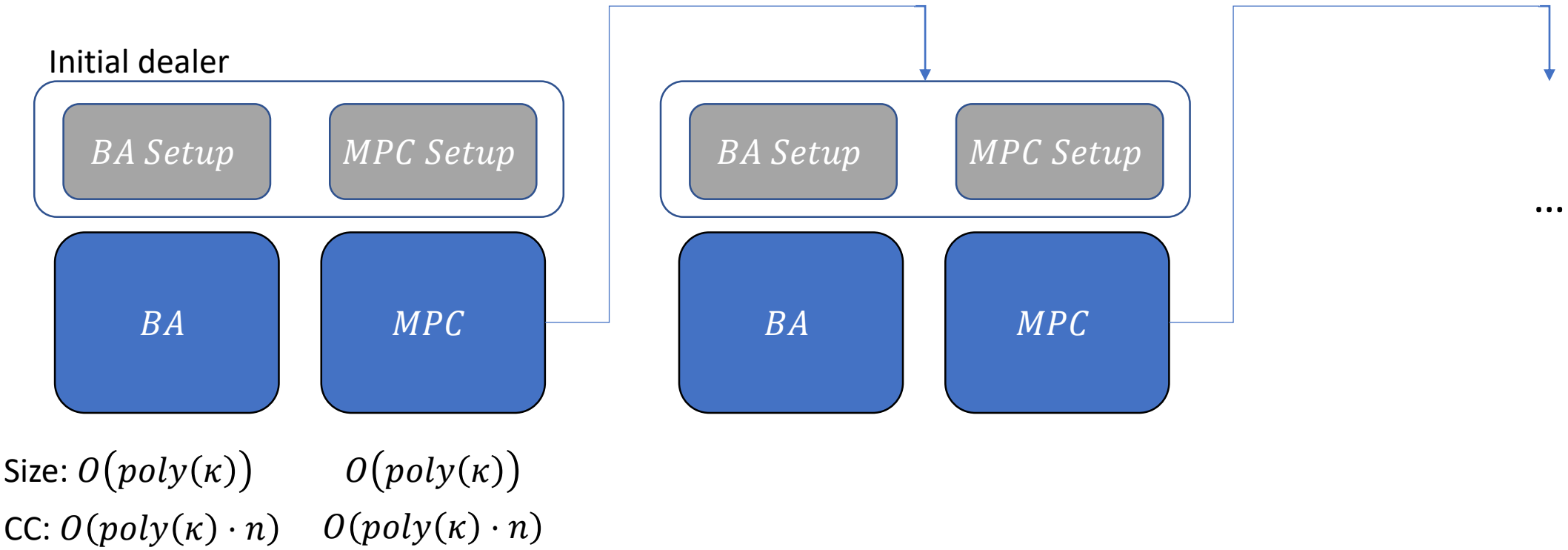

One-Time BA

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Graded Consensus [CR93]
Input x_i; Output (z_i, g_i)

If ∀ honest P_i $x_i = x$, then $(z_i, g_i) = (x, 1)$
If ∃ honest P_i $g_i = 1$, then $z_j = z_i$

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Coin-Flip
Each P_i obtains the same random bit c_i

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$\leq O(\kappa)$

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If $g_i = 0$: $x_i = c_i$
Else $x_i = z_i$

One-Time BA

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GC

Graded Consensus [CR93]
Input x_i; Output (z_i, g_i)

If $\forall$ honest P_i $x_i = x$, then $(z_i, g_i) = (x, 1)$
If $\exists$ honest P_i $g_i = 1$, then $z_j = z_i$

$Coin$

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Each P_i obtains the same random bit c_i

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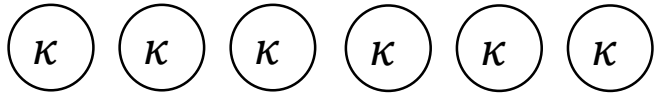
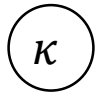
$BA\ Setup$



Each party in set can prove membership



Each party in set has a (signed) share of c_i

One-Time BA

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Communication $O(poly(\kappa) \cdot n)$
Setup size $O\big(poly(\kappa)\big)$

$BA\ Setup$

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MPC

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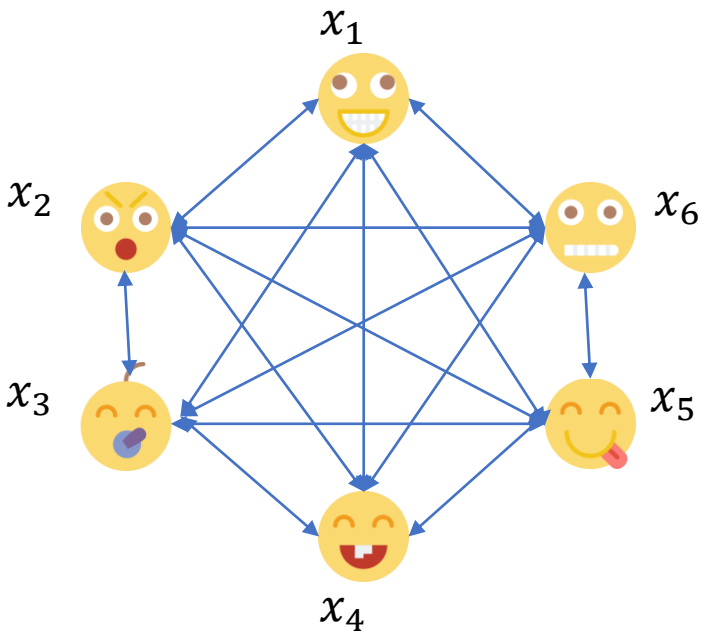
Multi-Party Computation with ℓ-output quality



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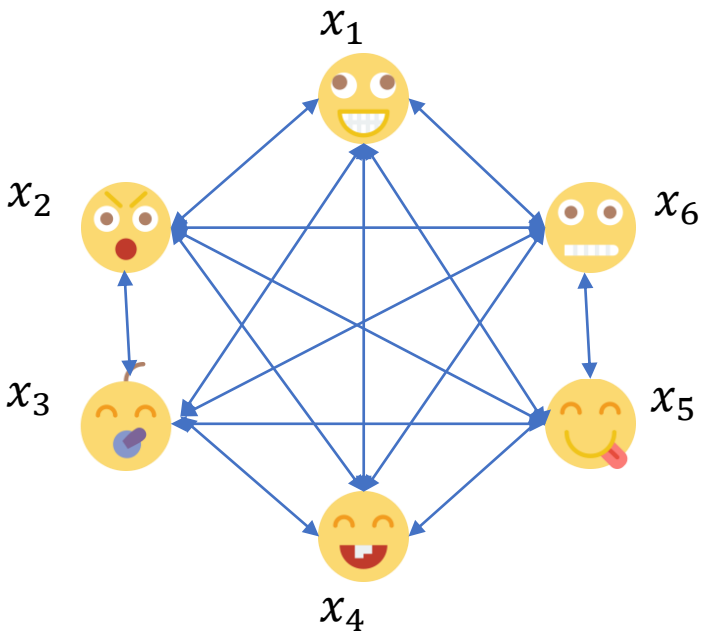


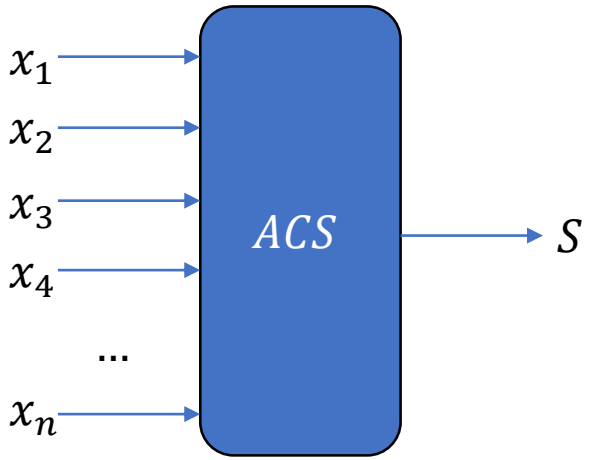
Adversary chooses S with size at least ℓ

$g(x_1', x_2', \ldots, x_n')$, where $x_i' = x_i$ if $P_i \in S$

$x_i' = \perp$ otherwise

MPC

Agreement on a Common Subset with ℓ-output quality



$|S| \geq \ell$ with $\ell - f$ honest inputs

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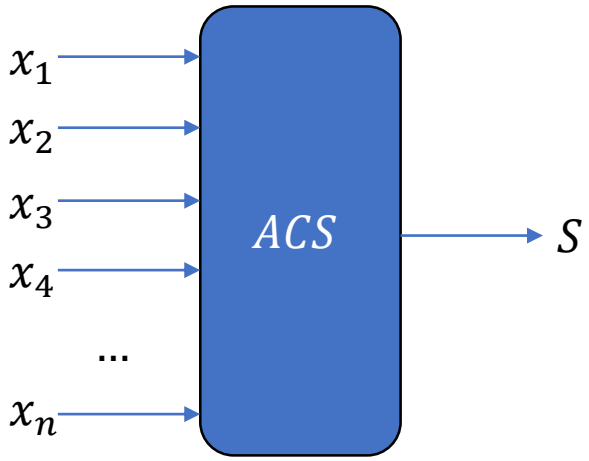

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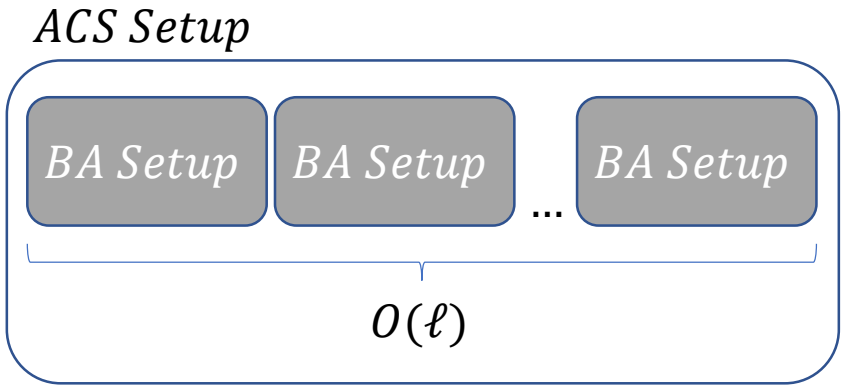

Communication $O(\ell \cdot \mathcal{I} \cdot poly(\kappa) \cdot n)$
Setup size $O\big(\ell \cdot poly(\kappa)\big)$

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Threshold Fully Homomorphic Encryption

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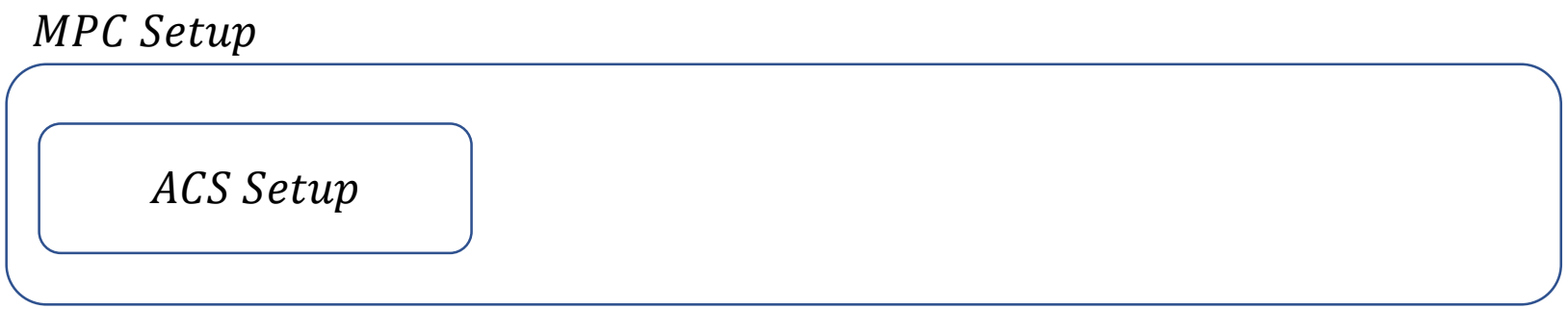

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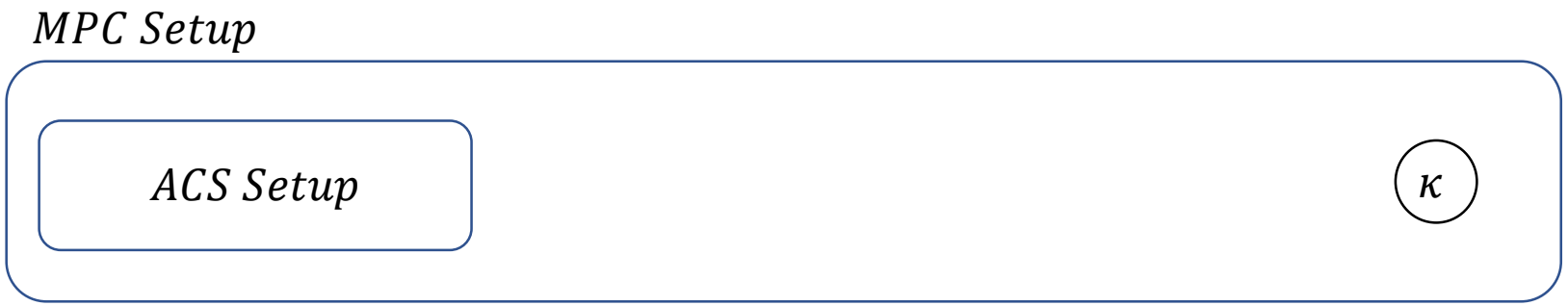

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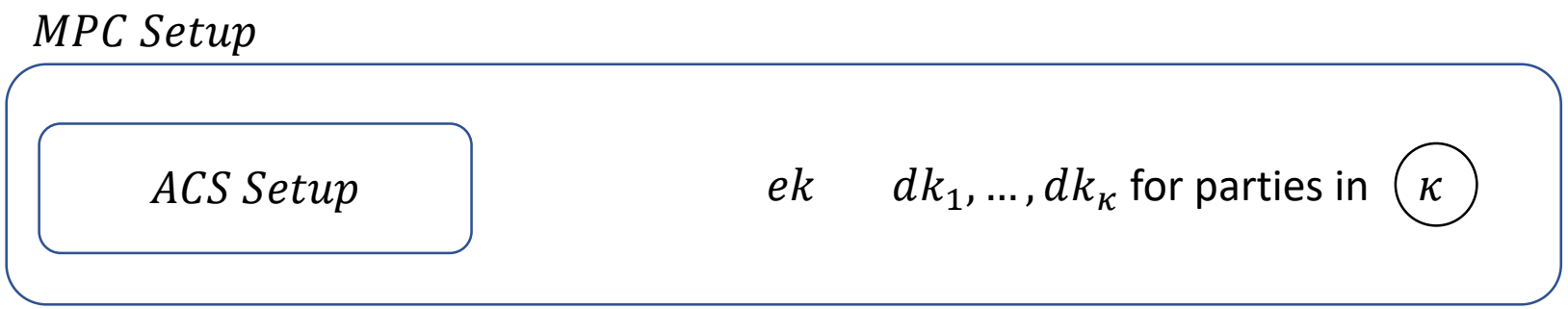

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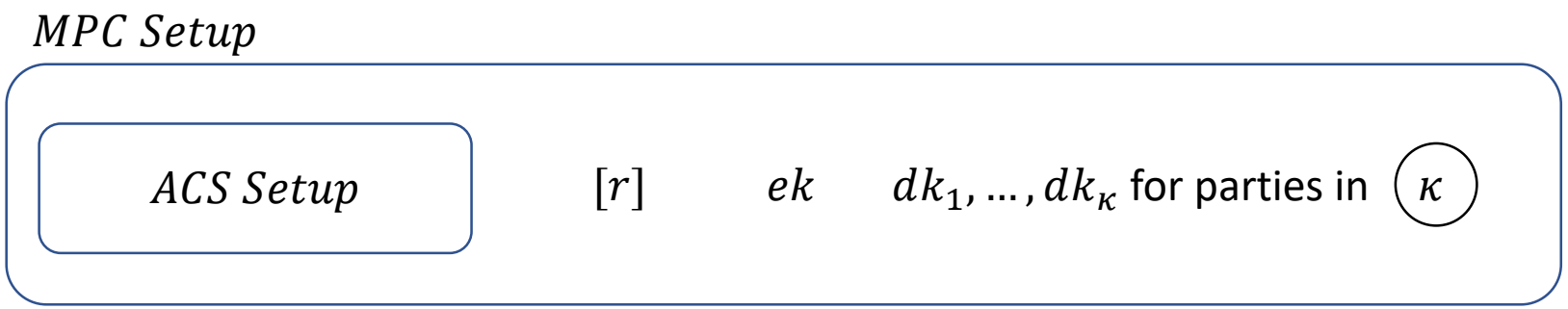

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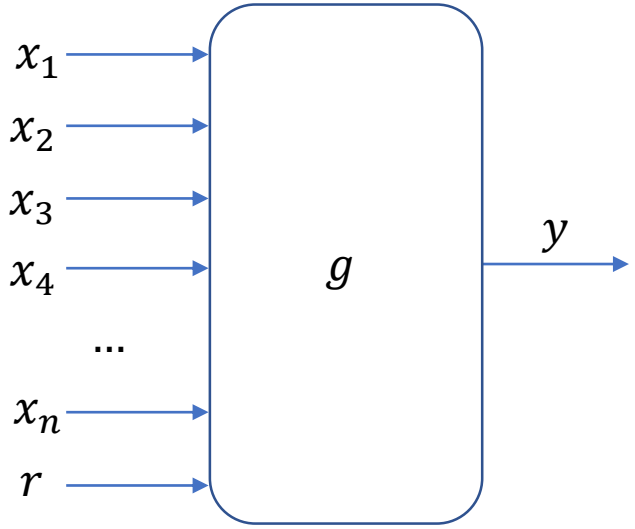

$MPC\ Setup$

$ACS\ Setup$ $[r]$ ek $dk_1, \ldots, dk_\kappa$ for parties in κ

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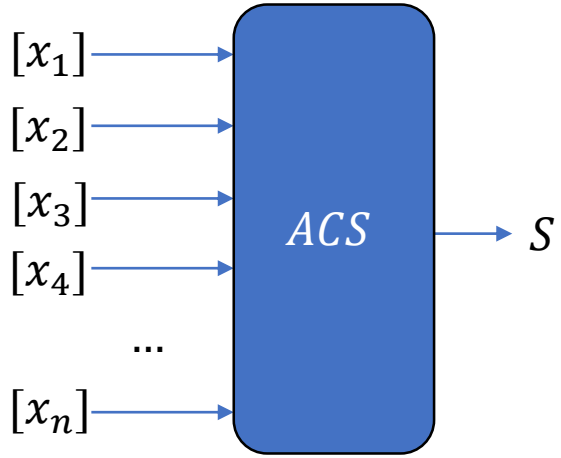

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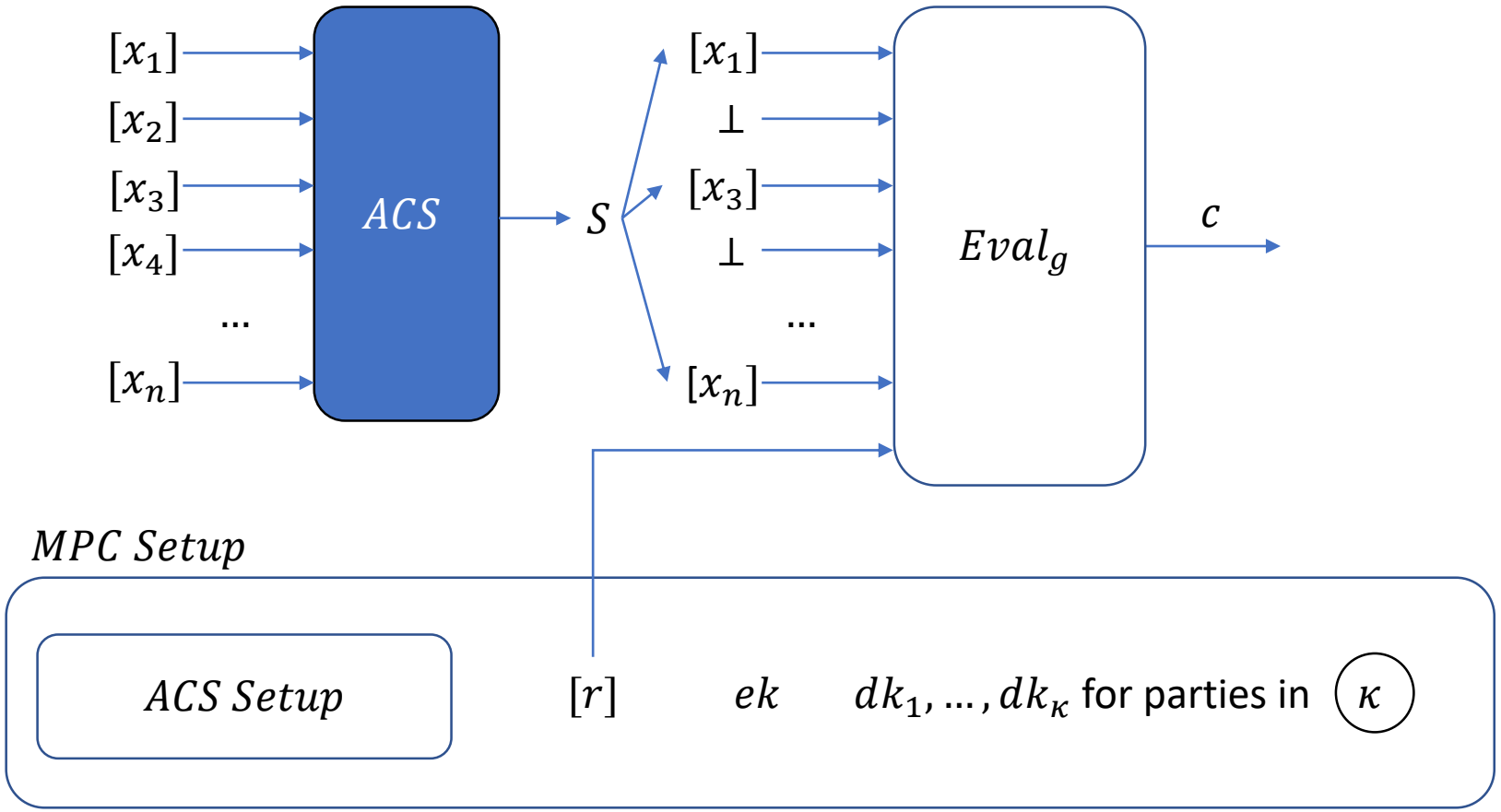

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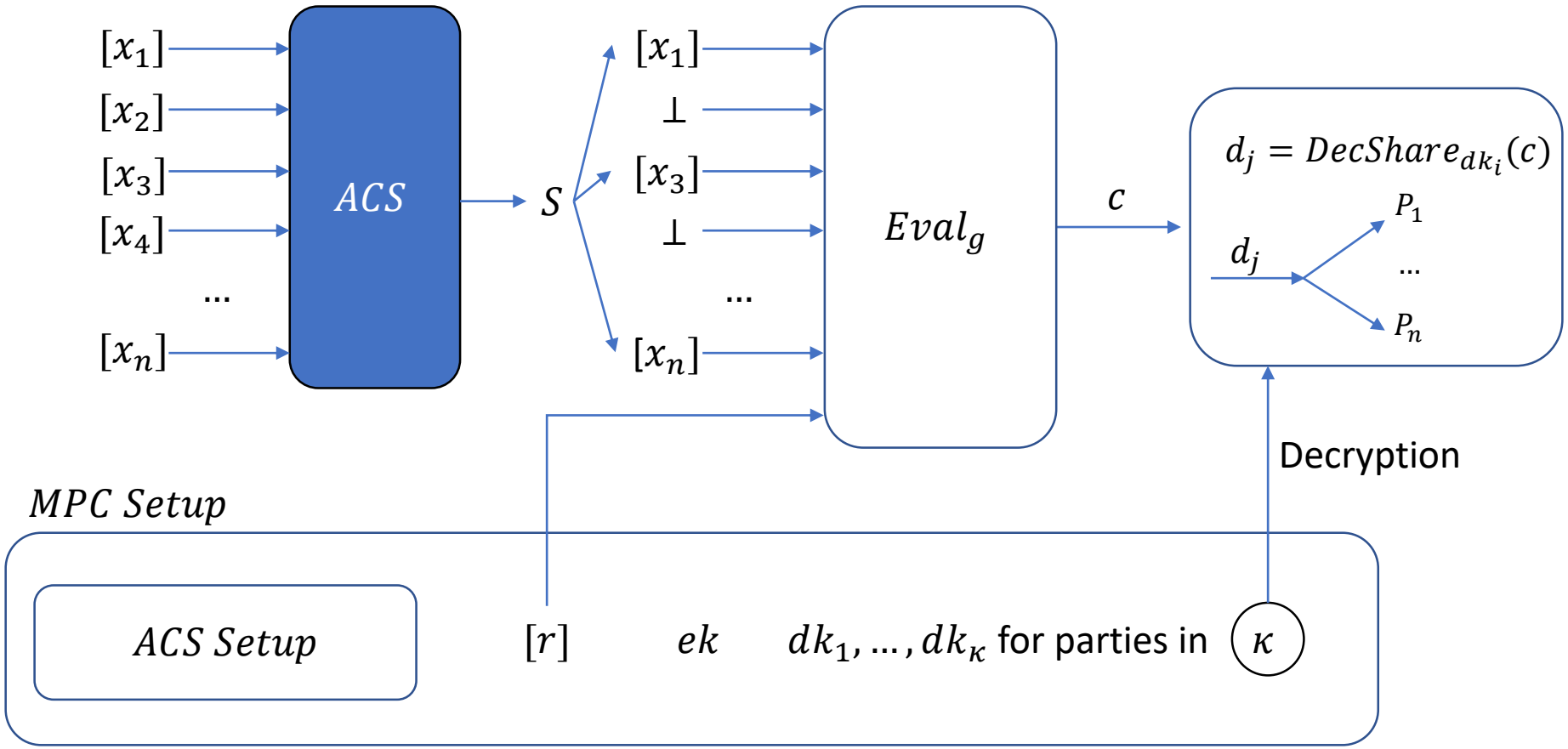

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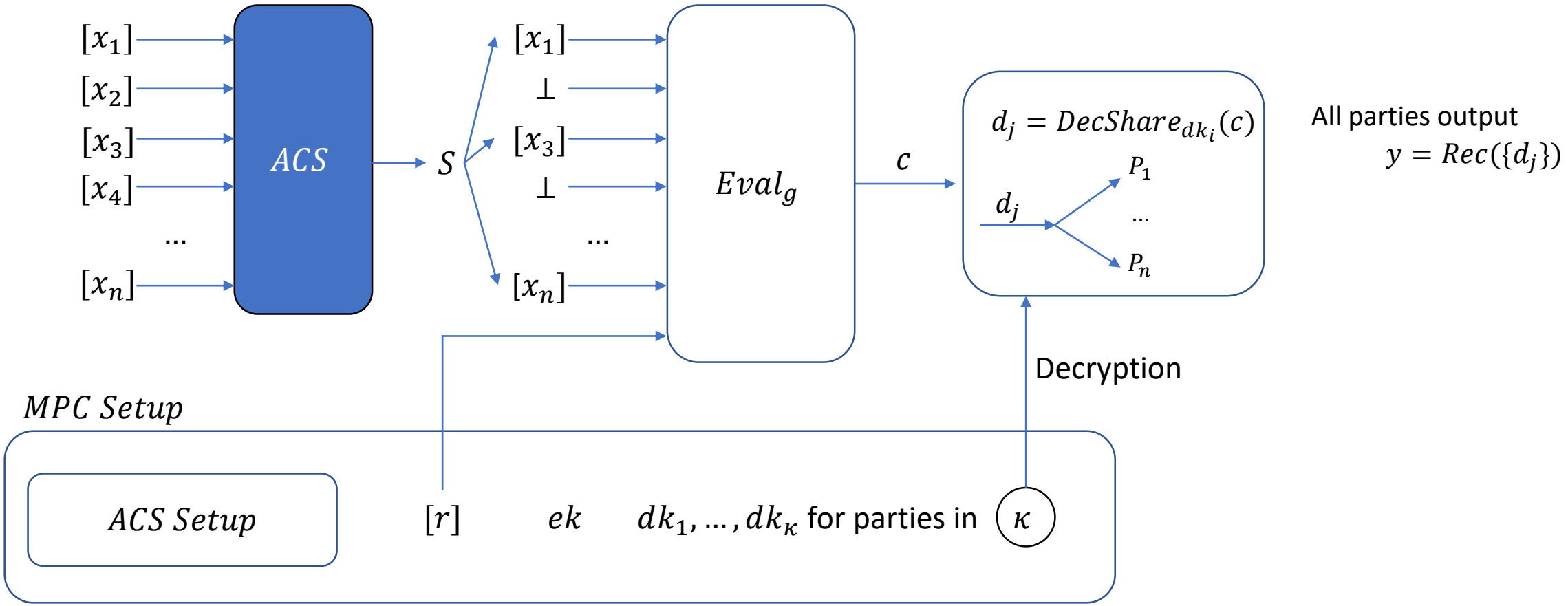

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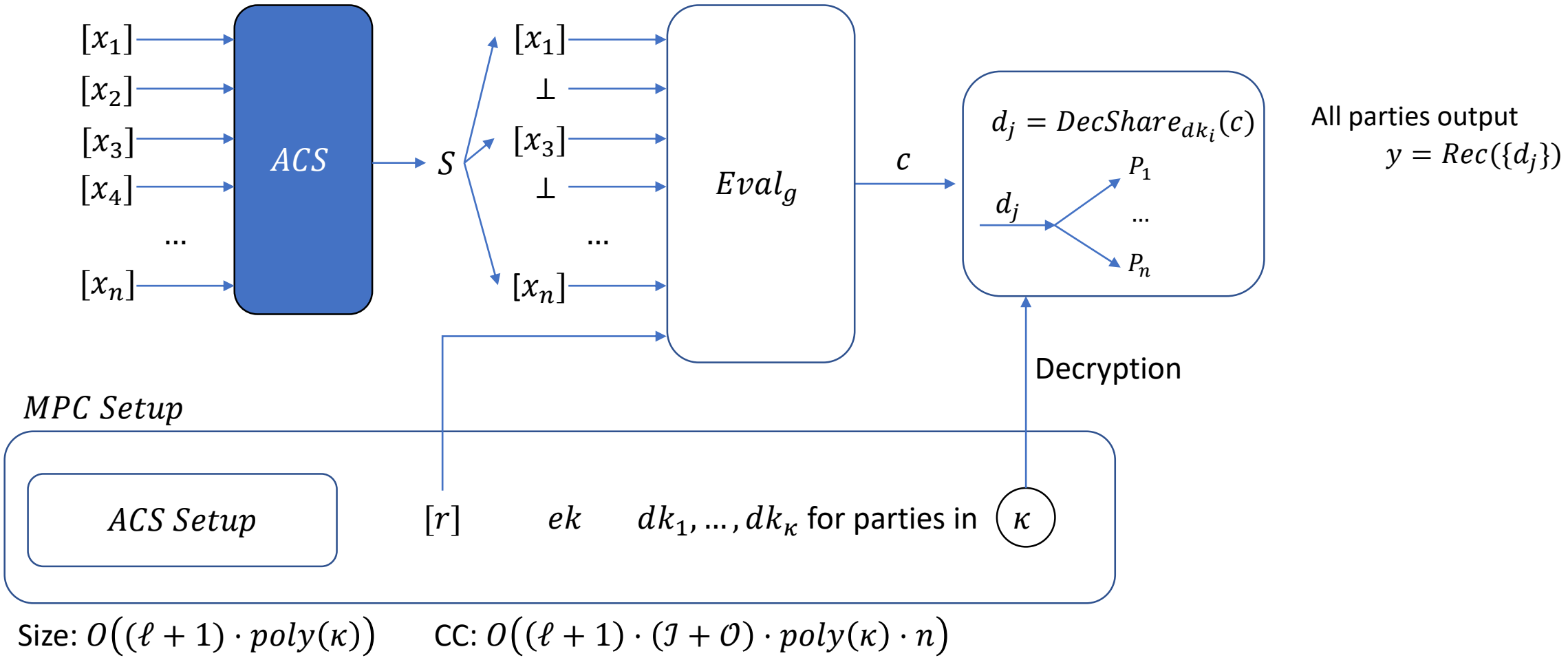
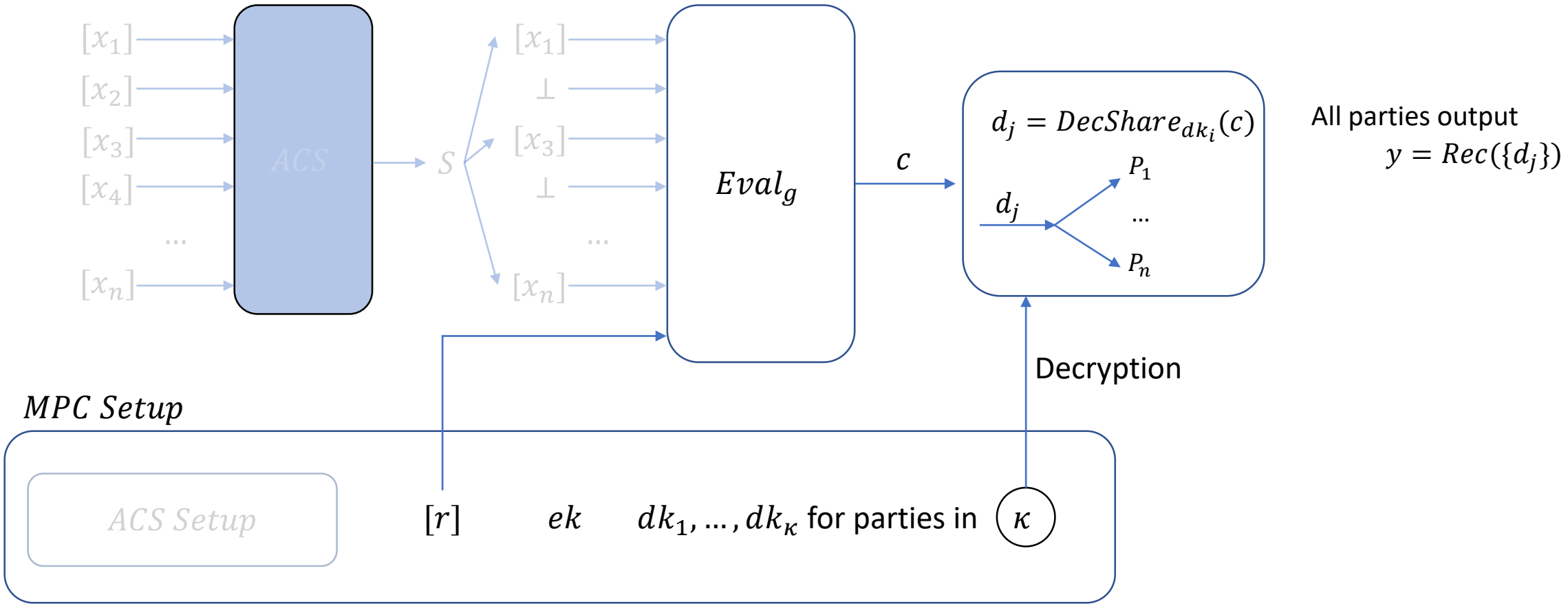


Size: $O\big((\ell + 1) \cdot poly(\kappa)\big)$ CC: $O\big((\ell + 1) \cdot (\mathcal{I} + \mathcal{O}) \cdot poly(\kappa) \cdot n\big)$

MPC for Trusted Dealer

Threshold Fully Homomorphic Encryption



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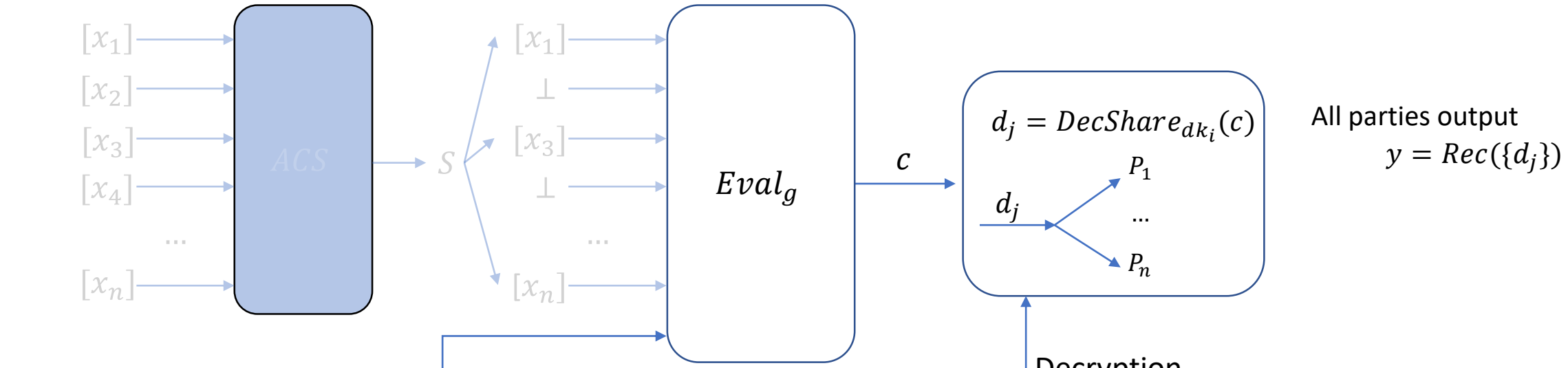

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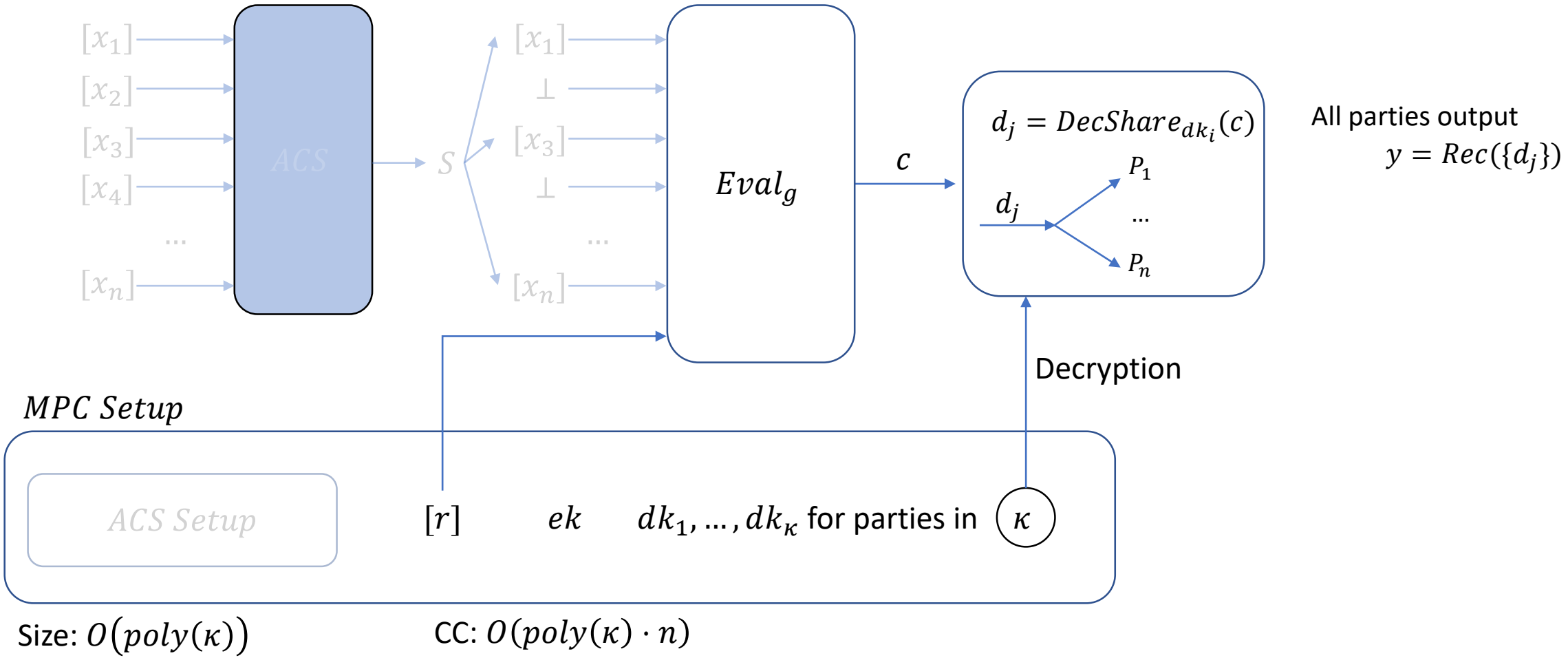


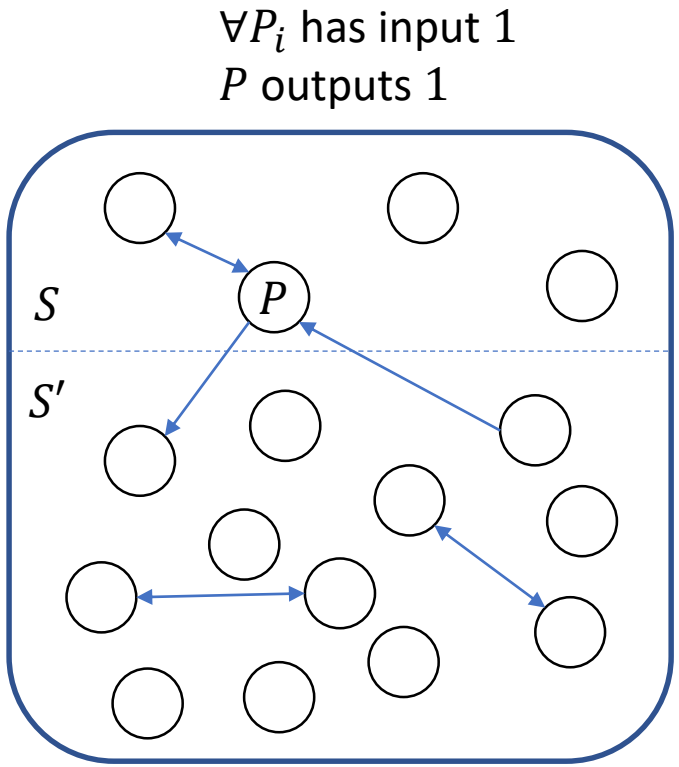
Impossibility of asynch. $o(n^2)$ BA with $\theta(n)$ adaptive corruptions and no setup

Other lower bounds:

[DR85, A+19] adversary can perform after-the-fact removal

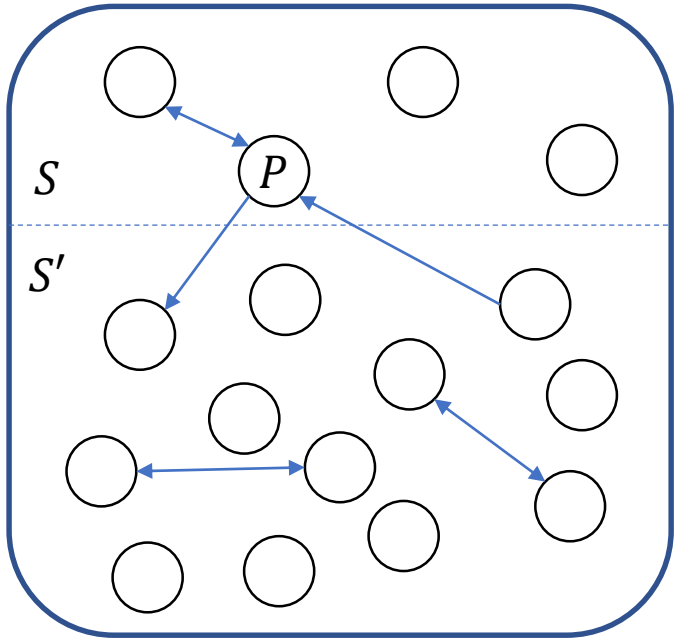
[R20] similar to our lower bound, but with idealized PKI

Impossibility of asynch. $o(n^2)$ BA with $\theta(n)$ adaptive corruptions and no setup

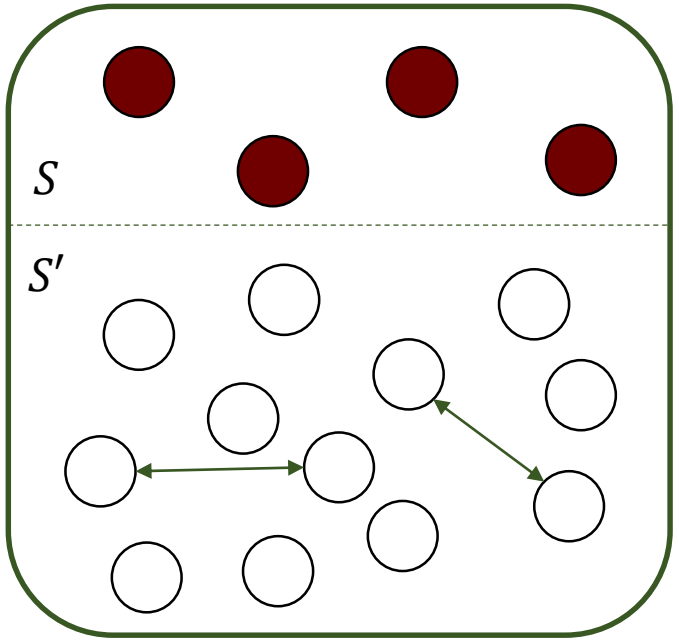


Impossibility of asynch. $o(n^2)$ BA with $\theta(n)$ adaptive corruptions and no setup

$\forall P_i$ has input 1
P outputs 1



$\forall P_i \in S'$ has input 0
$\forall P_i \in S'$ outputs 0



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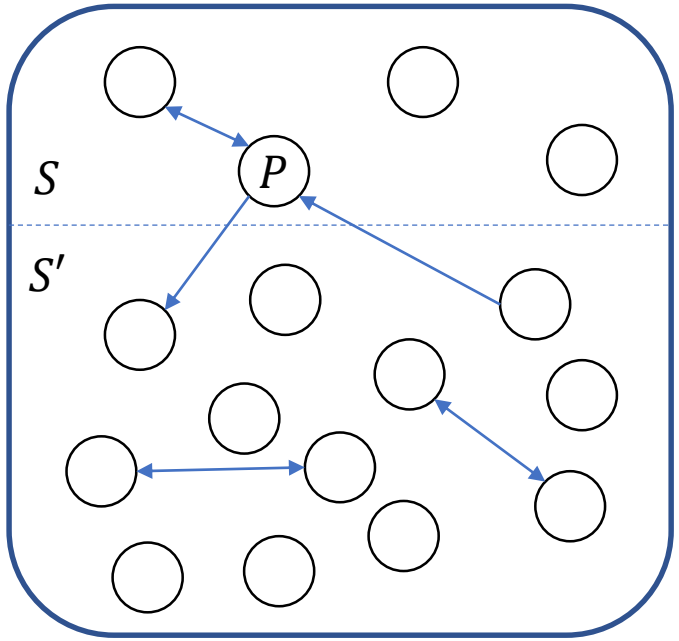

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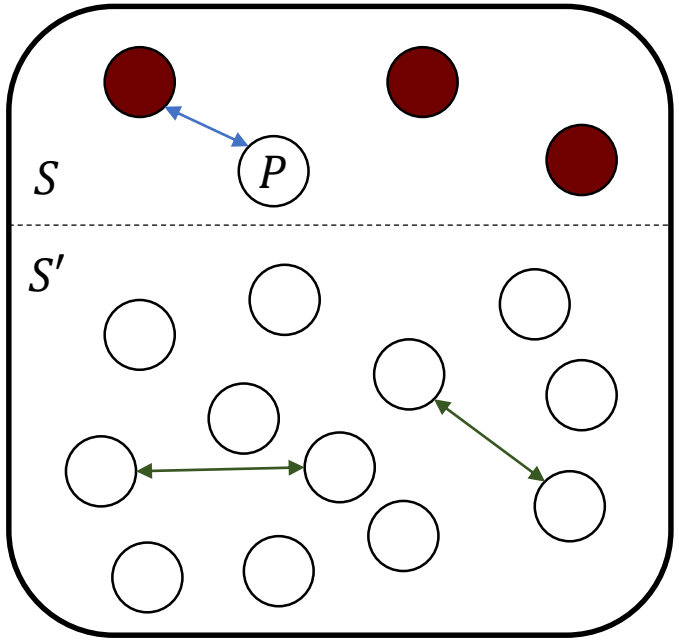

$\forall P_i \in S'$ has input 0
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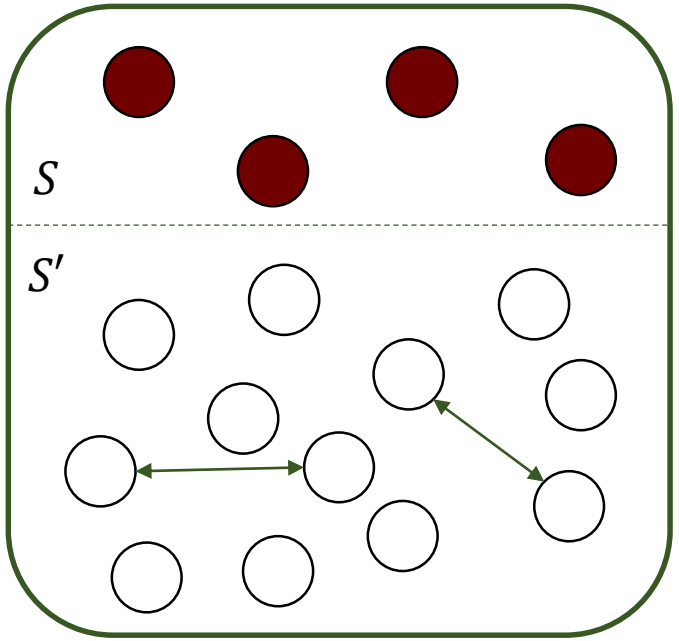

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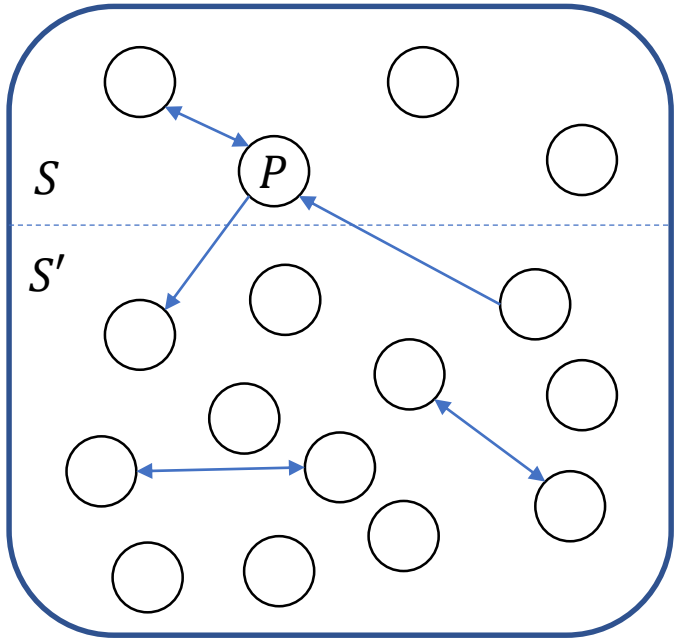

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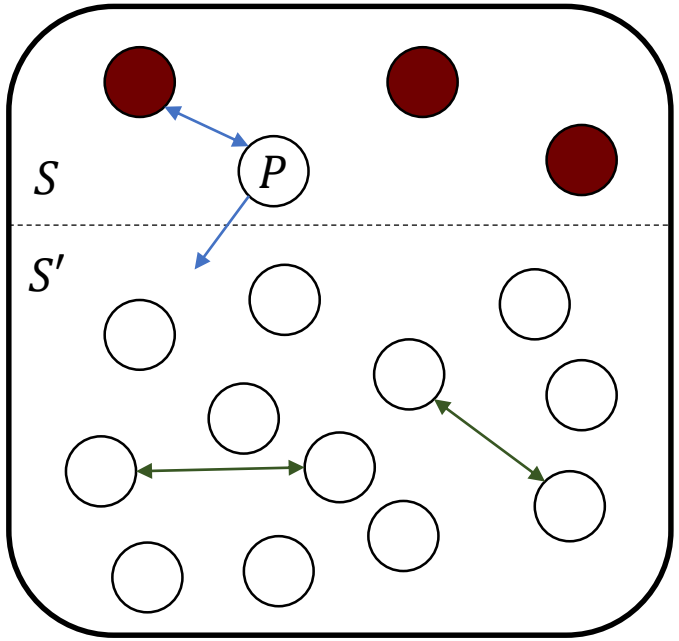

$\forall P_i \in S'$ has input 0
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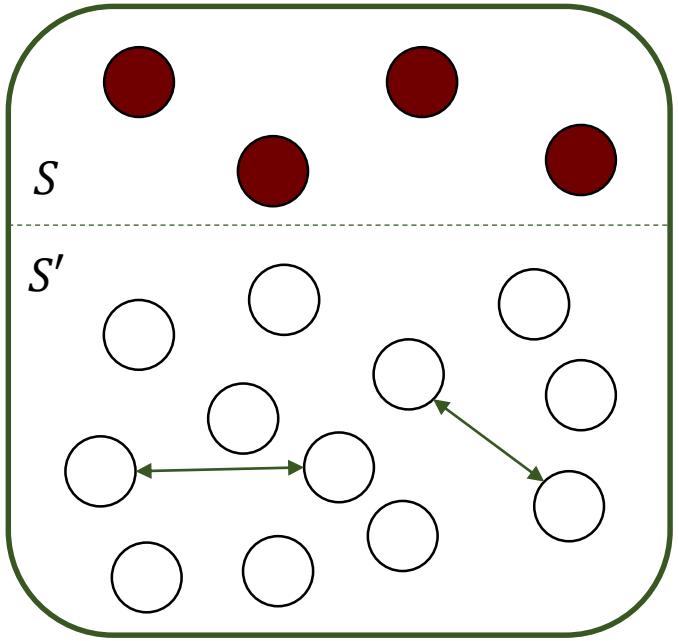

Impossibility of asynch. $o(n^2)$ BA with $\theta(n)$ adaptive corruptions and no setup

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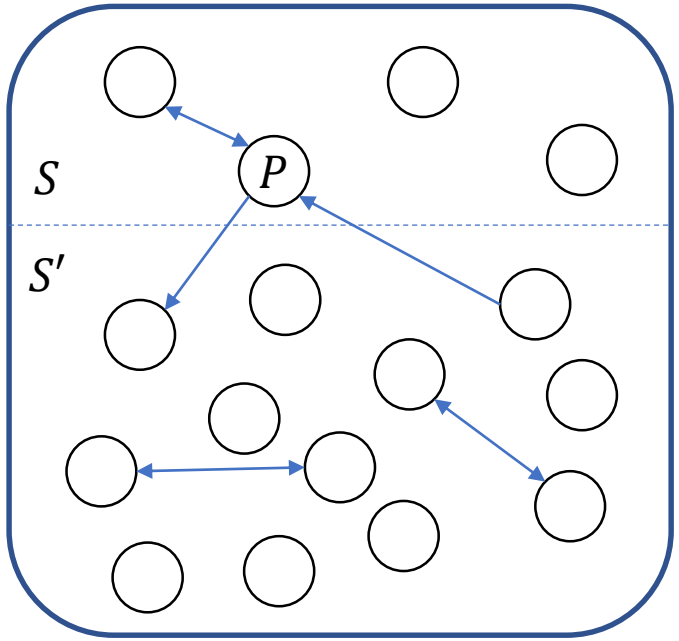
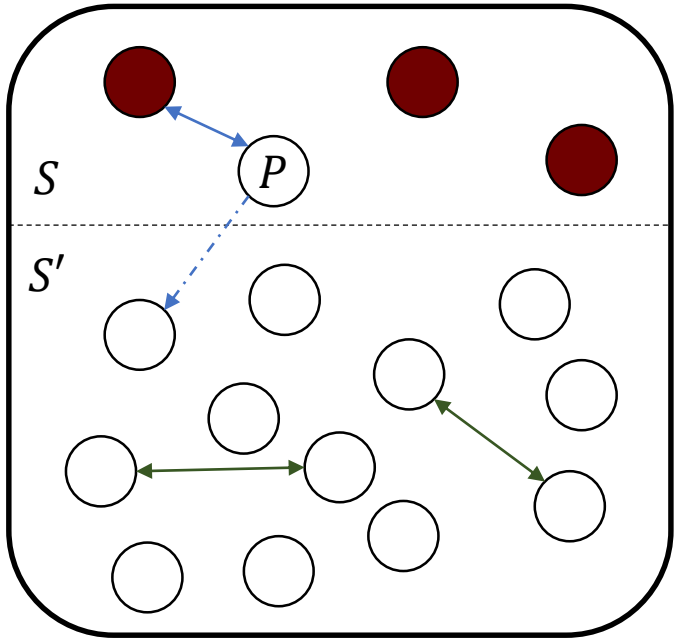
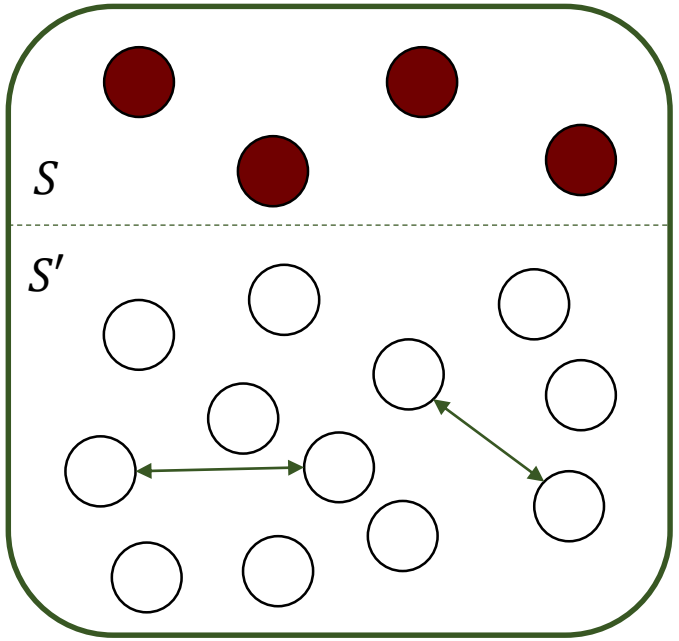


P has input 1; $\forall P_i \in S'$ has input 0
P outputs 1; $\forall P_i \in S'$ outputs 0



$\forall P_i \in S'$ has input 0
$\forall P_i \in S'$ outputs 0



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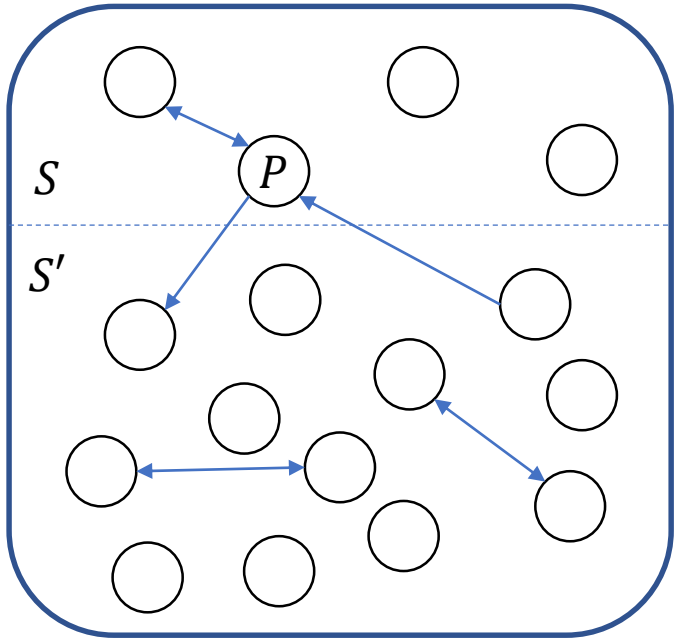

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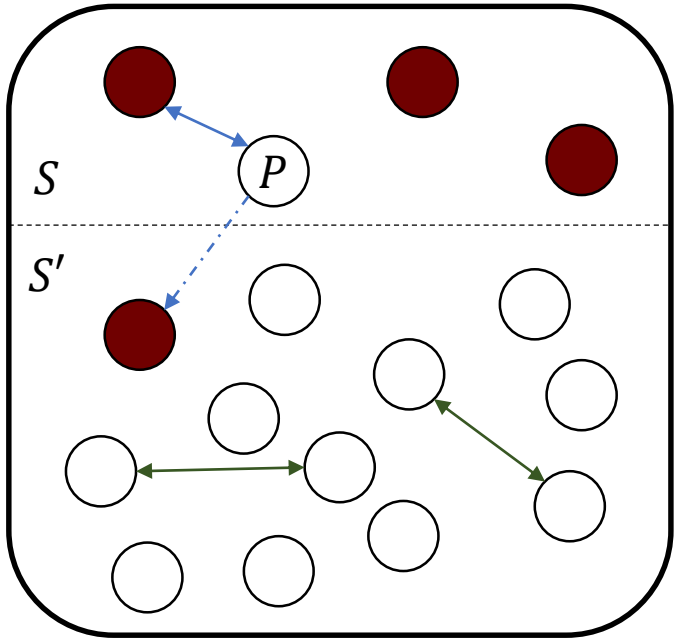

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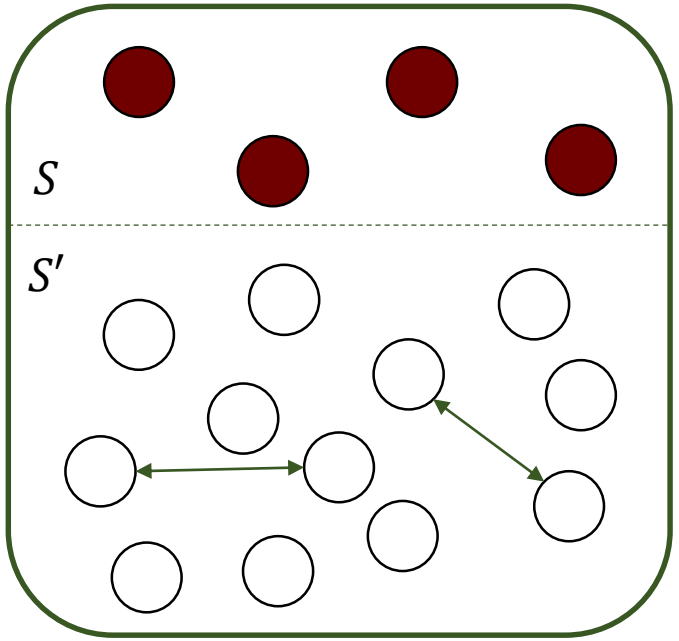

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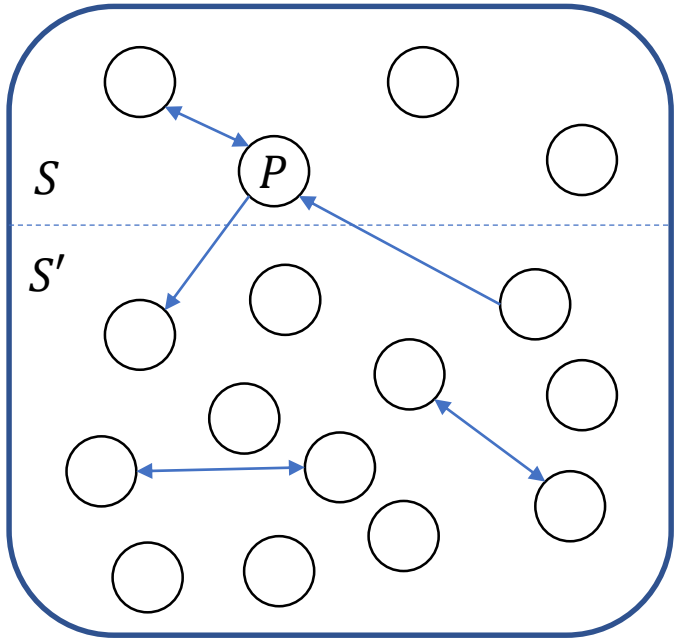

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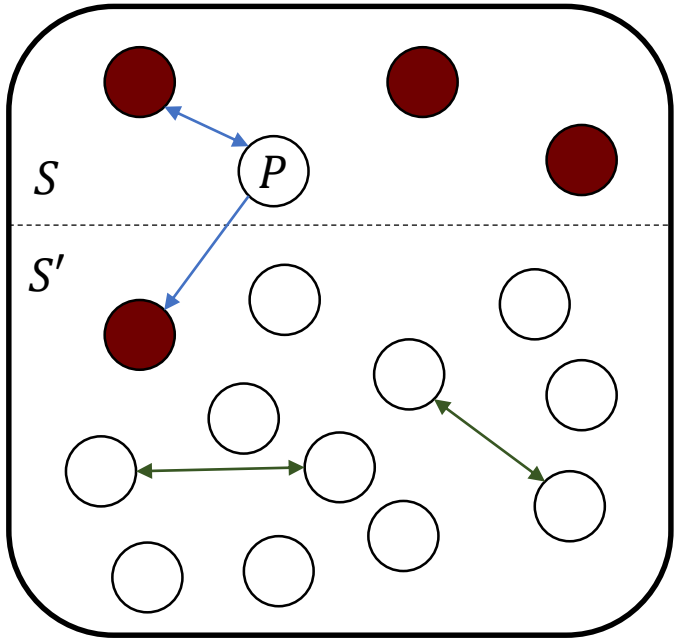

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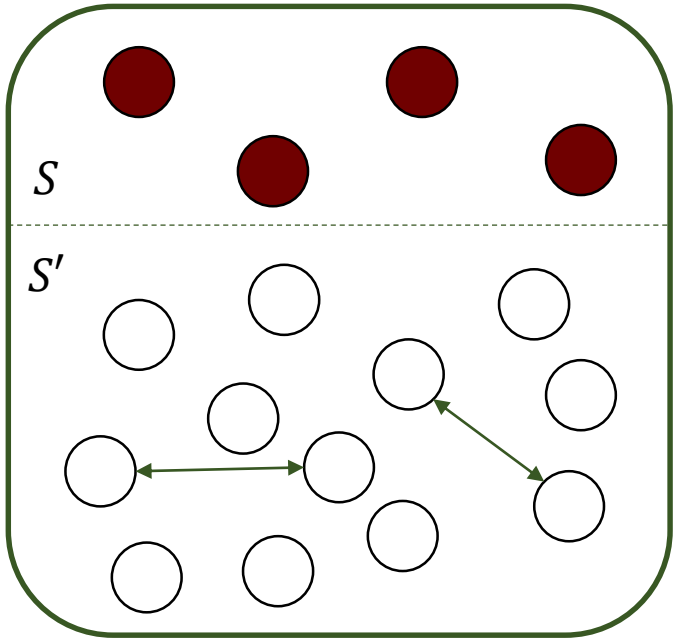

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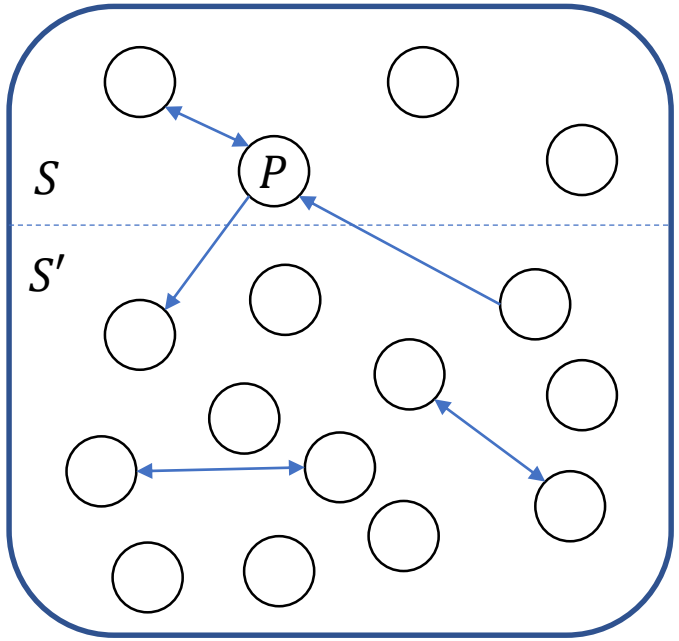

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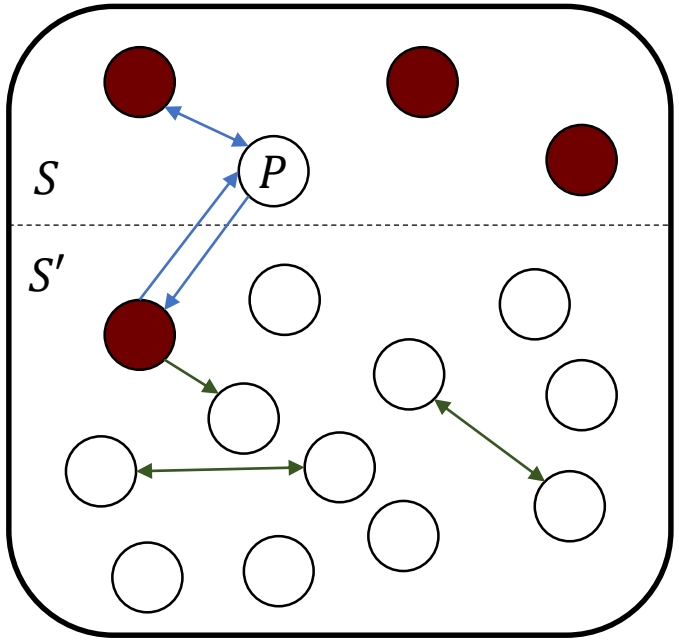

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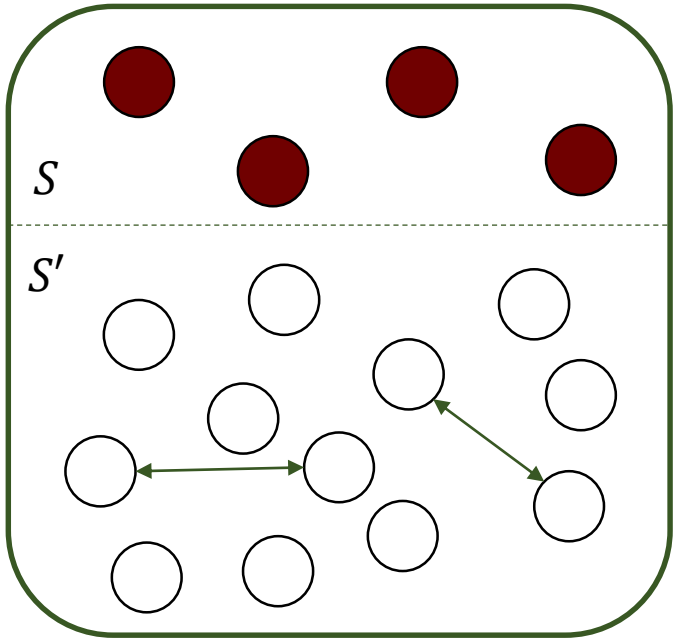

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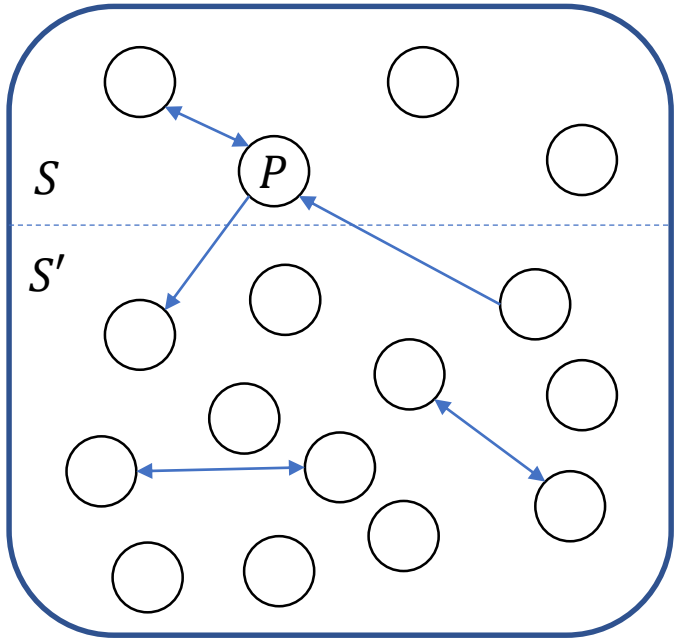

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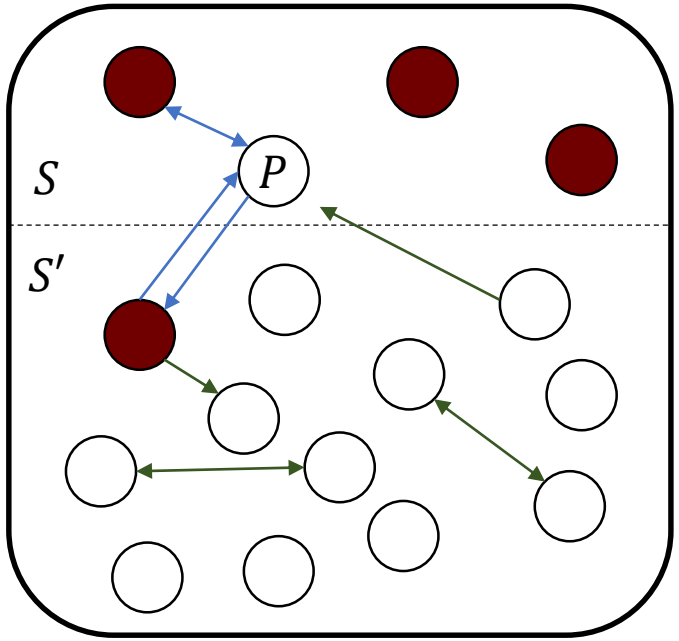

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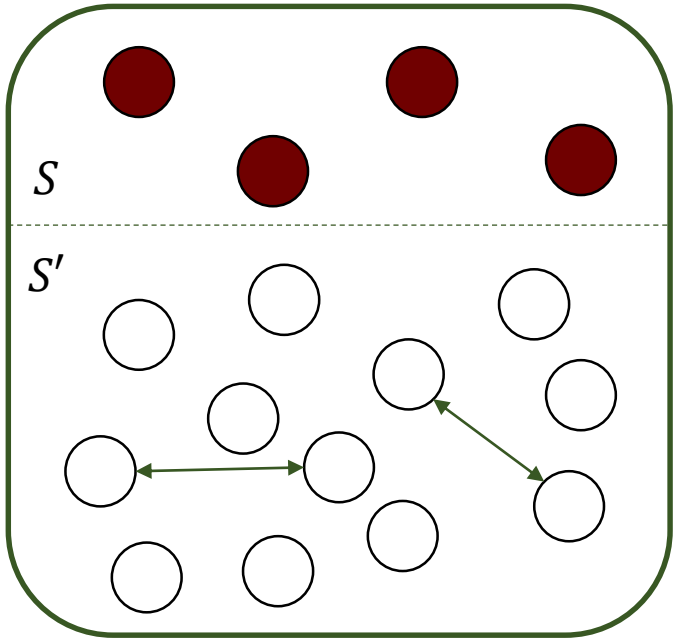

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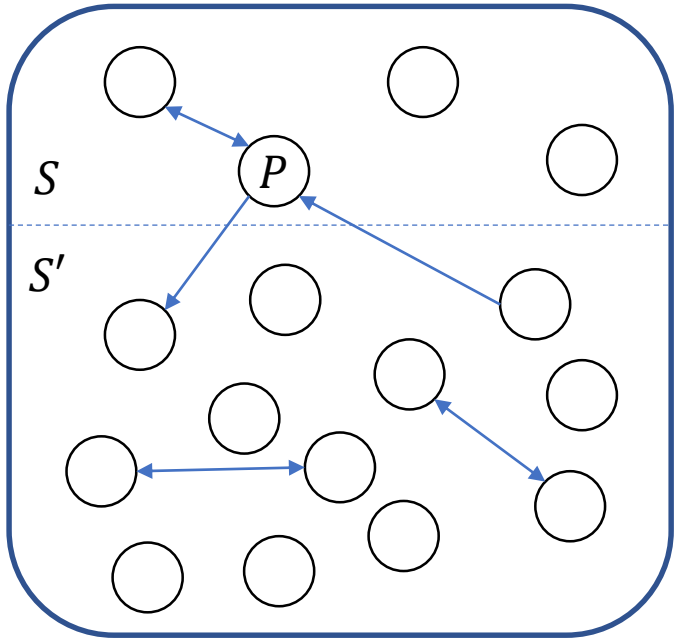

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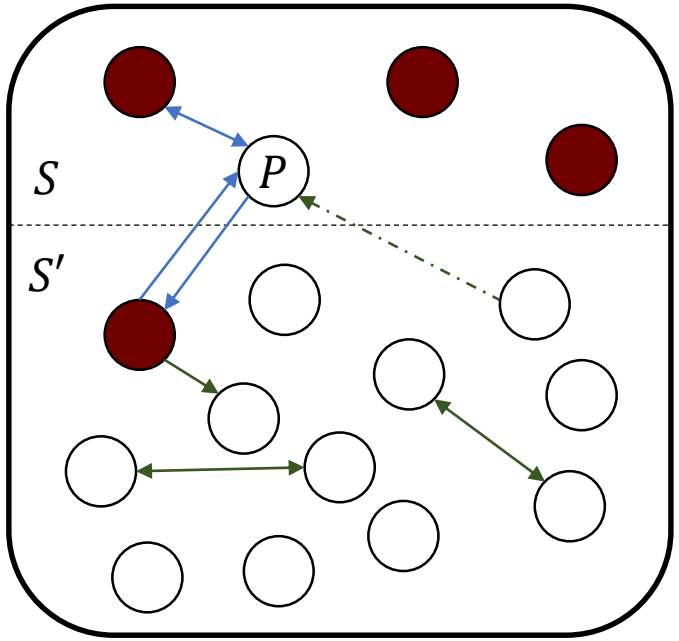

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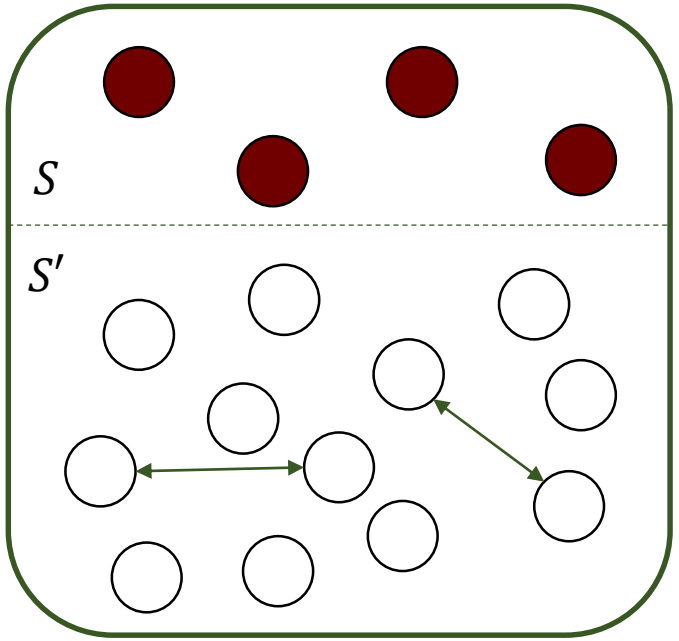

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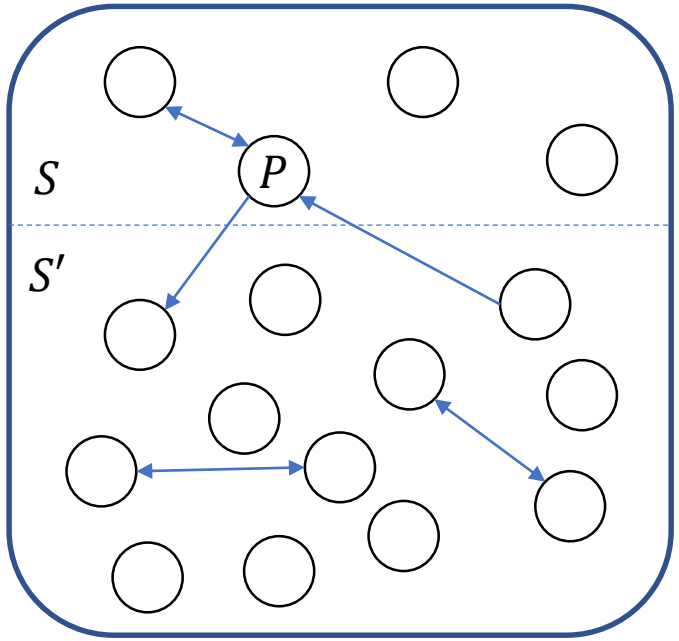

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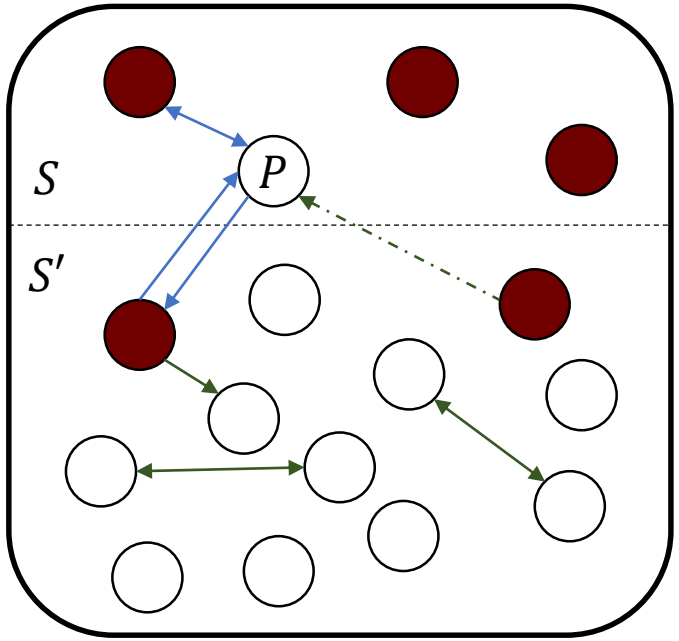

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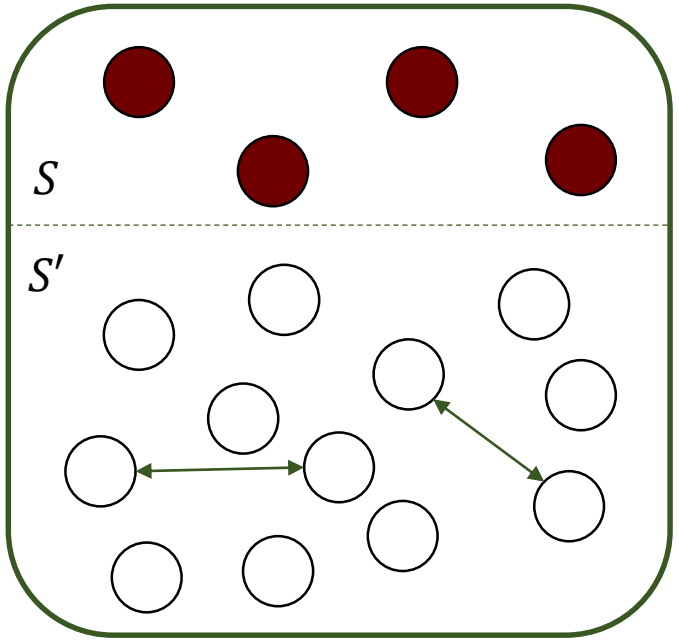

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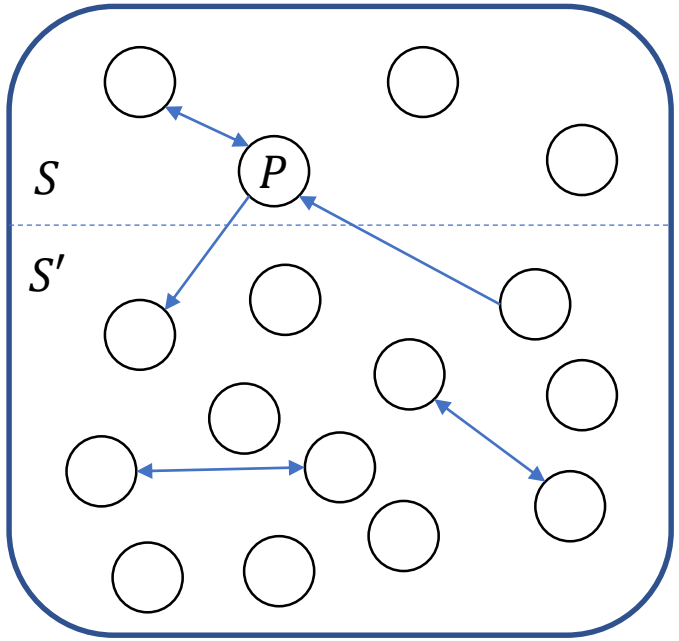

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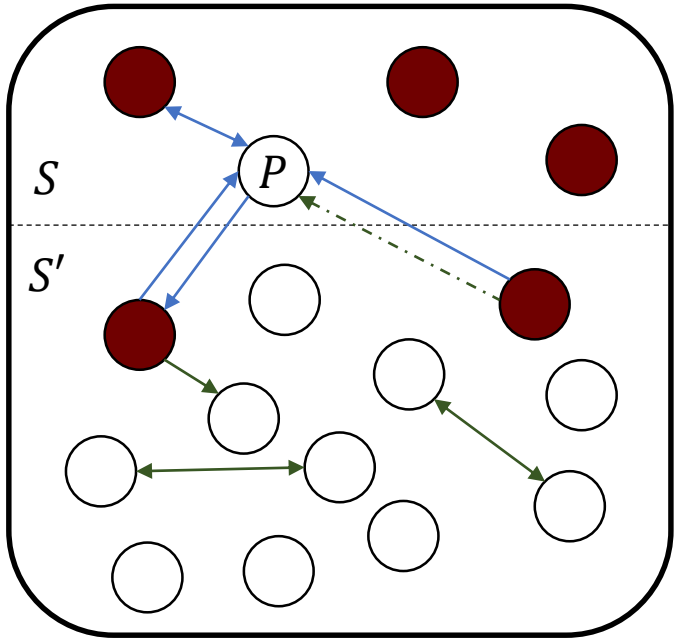

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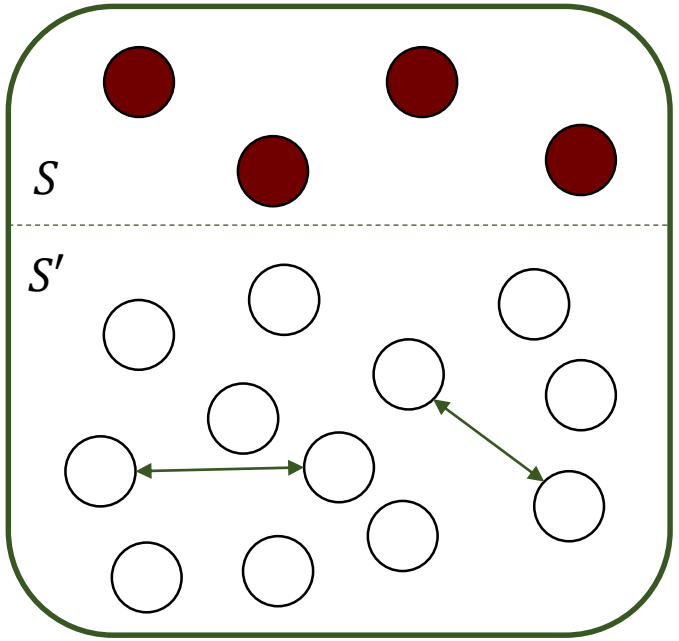

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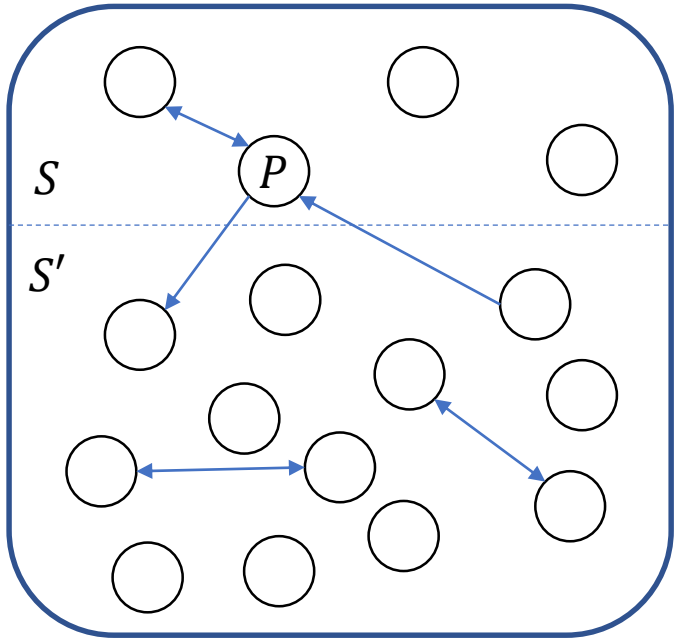

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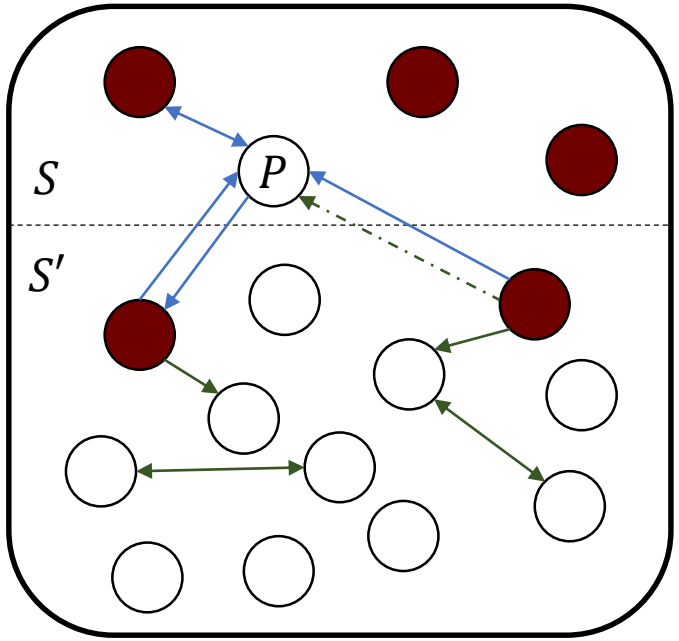

$\forall P_i \in S'$ has input 0
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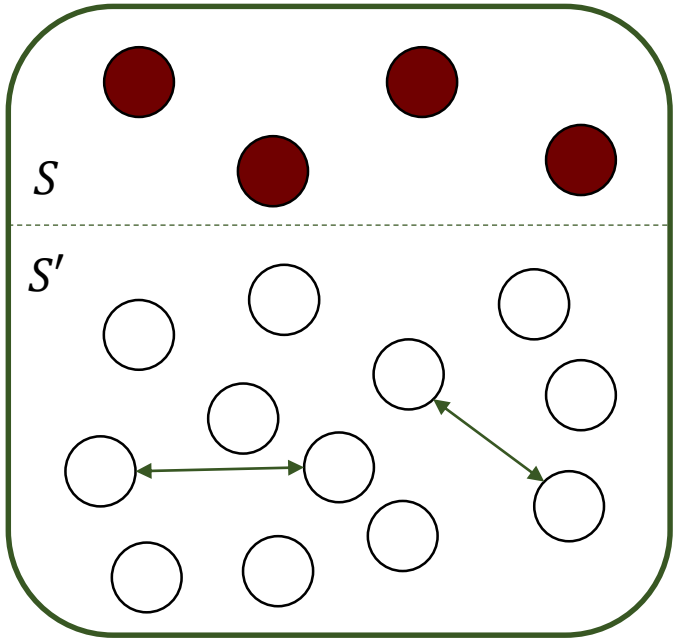

References and Credits

Full version: https://eprint.iacr.org/2020/851

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Credits:

Icons: https://www.flaticon.com/