Gossiping for Communication-Efficient Broadcast

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Broadcast

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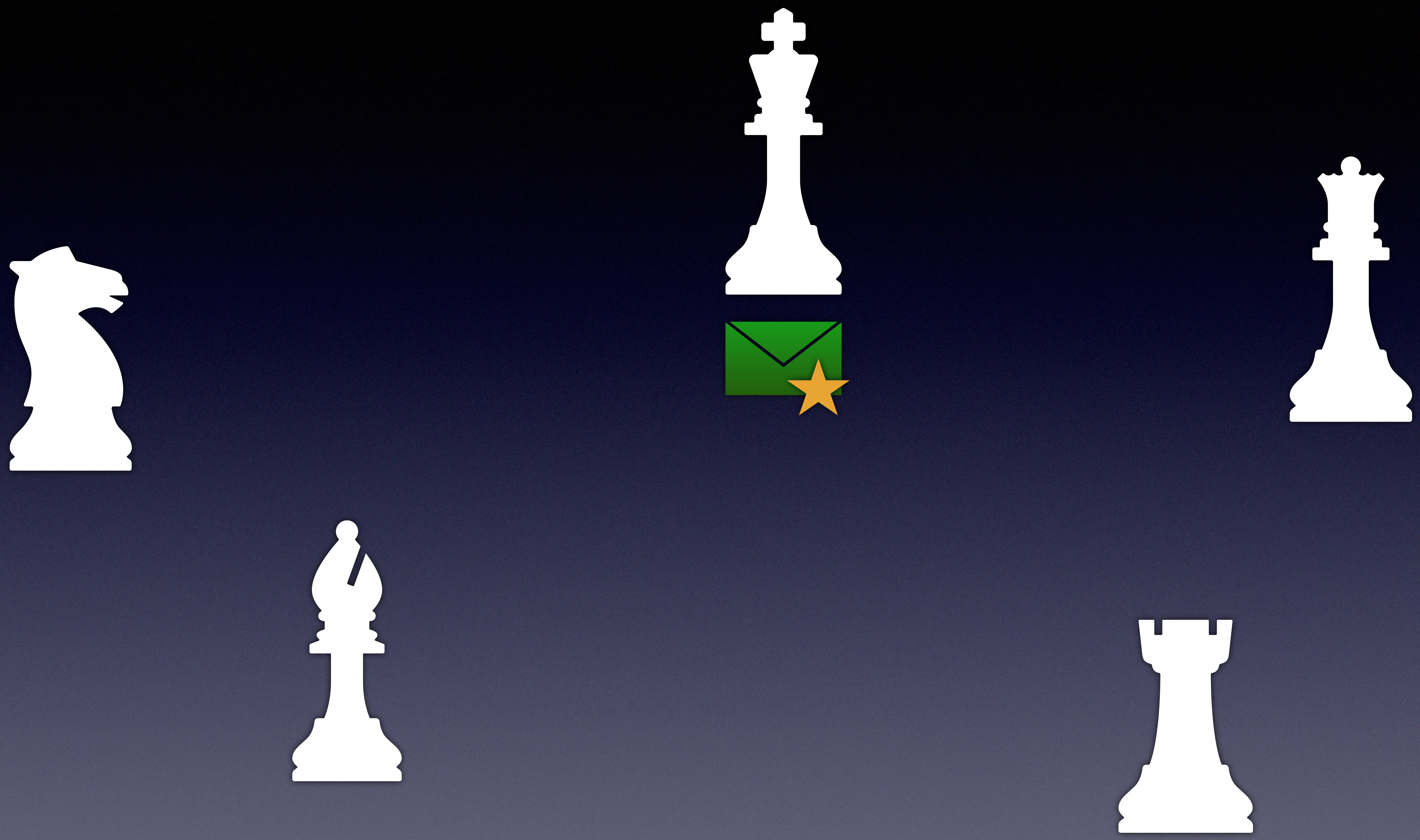
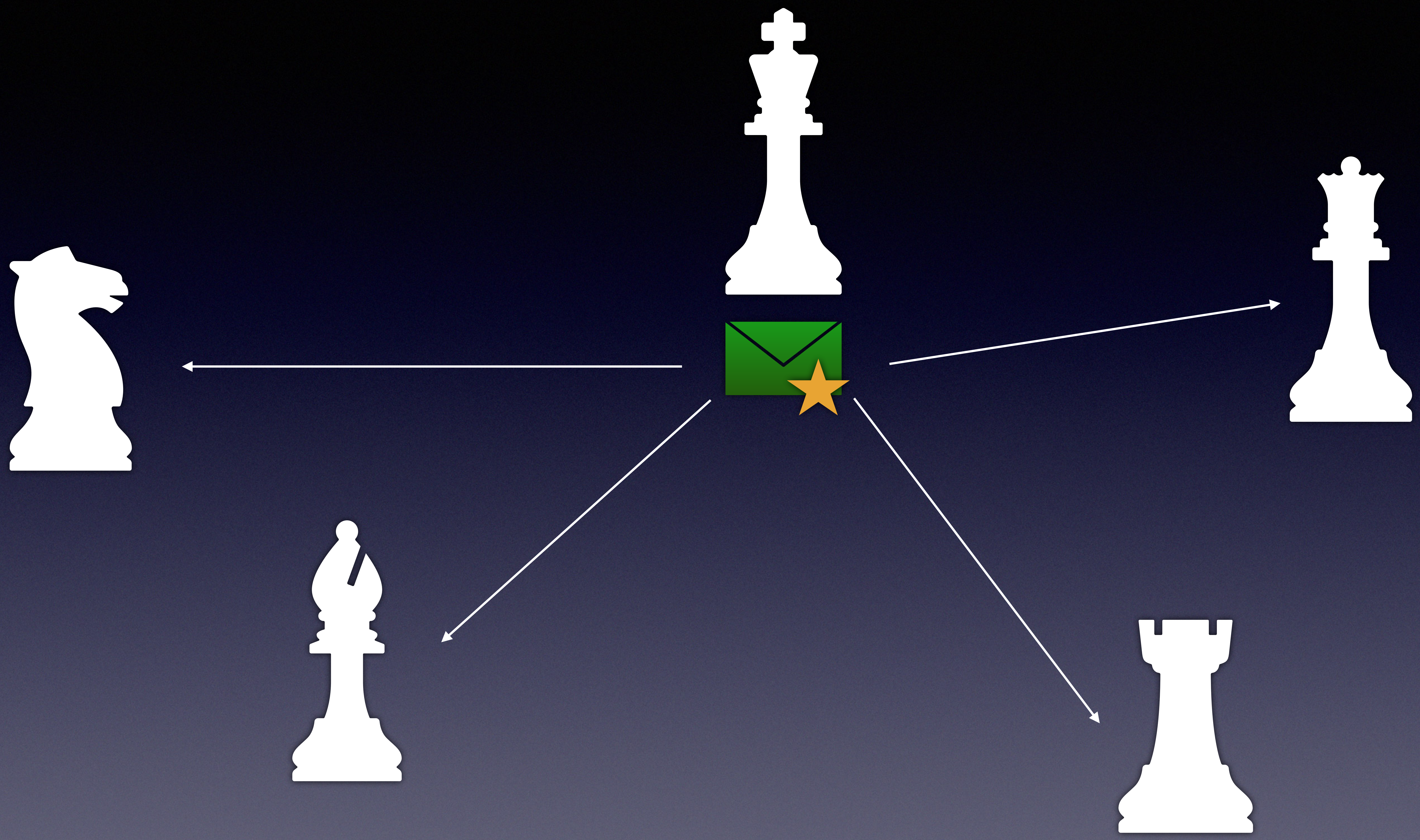
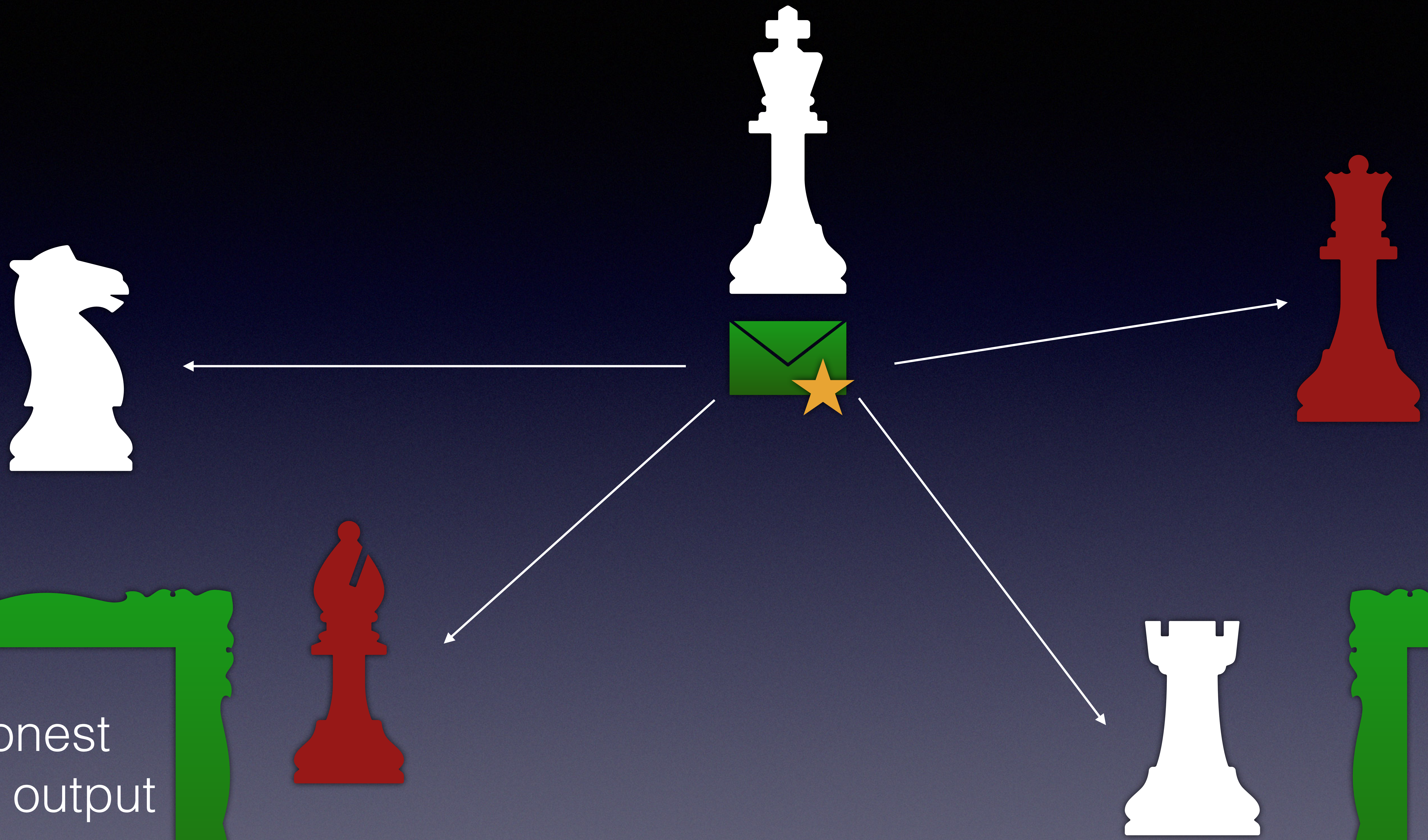
  - s might be dishonest
- Honest parties want to agree on the same value.

Authenticated Broadcast

- Authenticated Broadcast:
  - Broadcast **BUT** with Use of a Public Key Infrastructure (PKI)
    - Bulletin Board \ Trusted PKI
  - Each party can sign with a **signature** each message they send
    - P_i holds (pk_i, sk_i) and posts pk_i publicly







All honest parties output the same message

If S is honest, all honest parties output S's message

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  - static/adaptive Adversary

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  - Dolev-Strong protocol [DS'83] with $O(n^3)$ Communication

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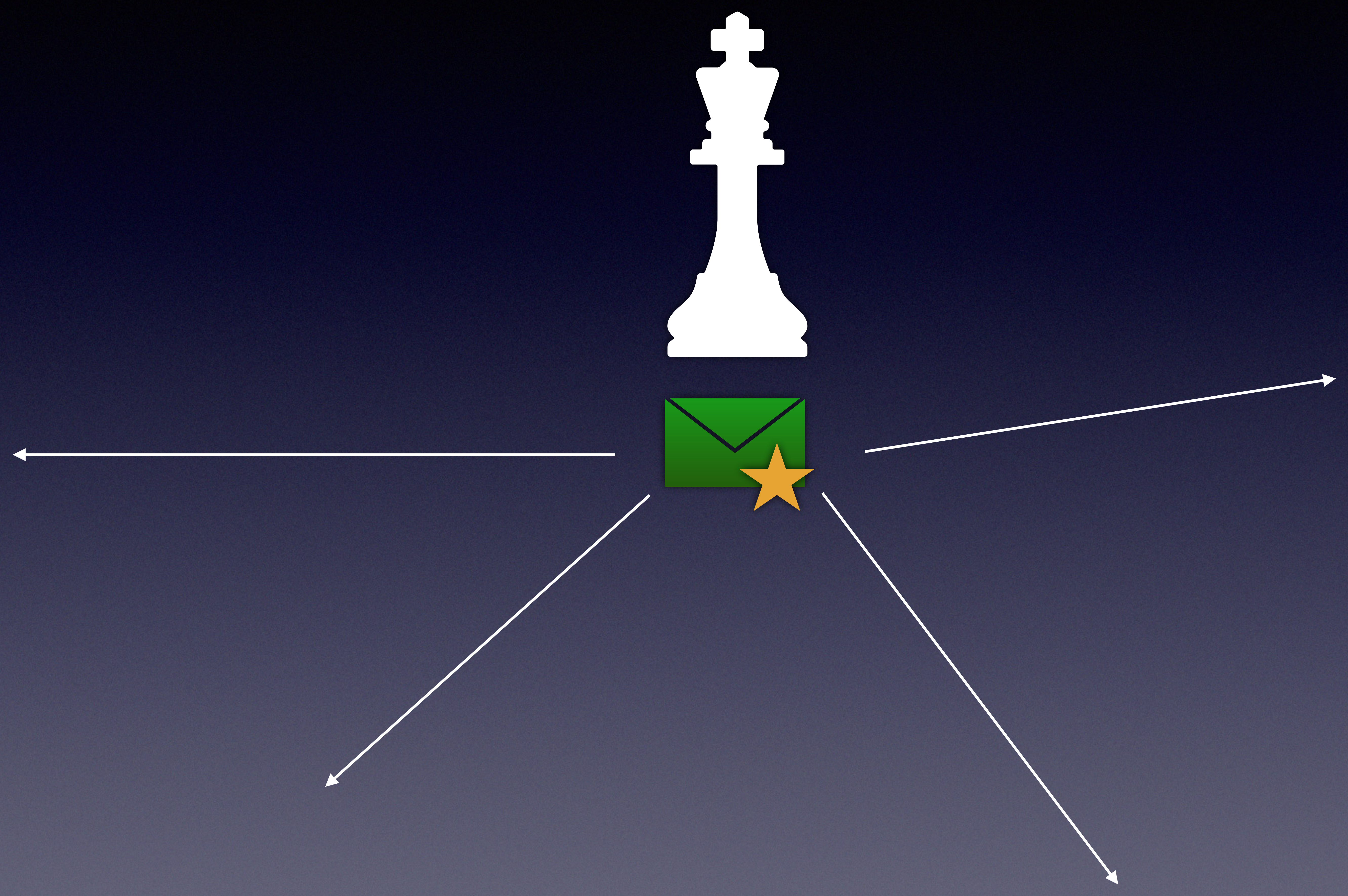
$\mathcal{O}(n^2)$ CC using **trusted PKI**, against $t < (1 - \epsilon)n$ **adaptive** corruptions.

Dolev-Strong

S sends ✉ with S's signature ★ to all parties



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Valid ✉ at round r:

At least r ★ from distinct parties. One is from S.

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If so, it adds its signature and sends … to all parties.

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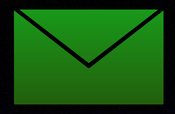
p checks if it received some new "valid" 

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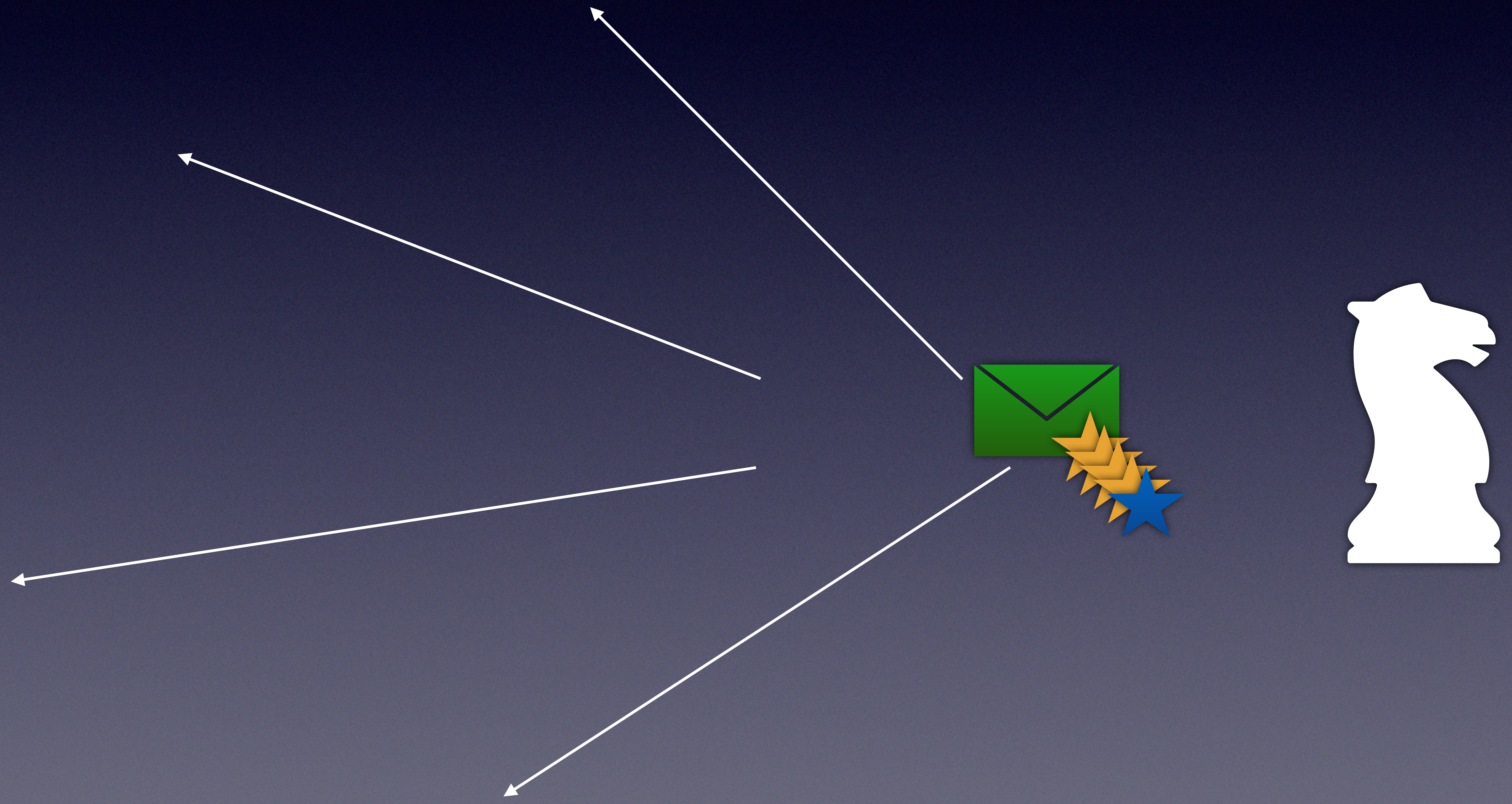

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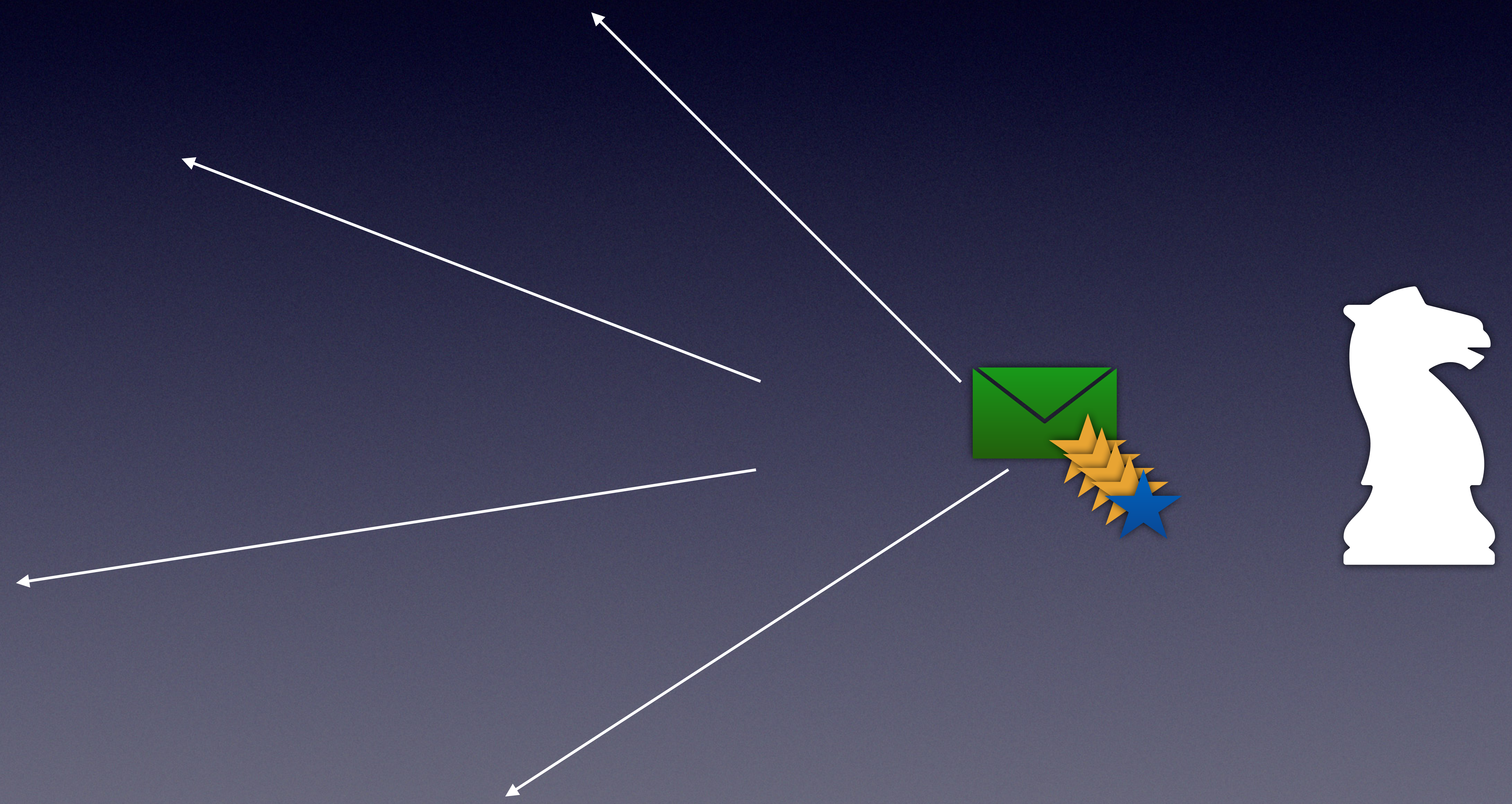

Our Observation

- What do parties want to achieve with sending?
  - Perhaps, sending to everyone takes more communication than what needed for the property.


"Do I send the message to party j?"

“Do I send the message to party j?”

Flip a coin with prob. m/n
If Heads, then I send, else I don’t

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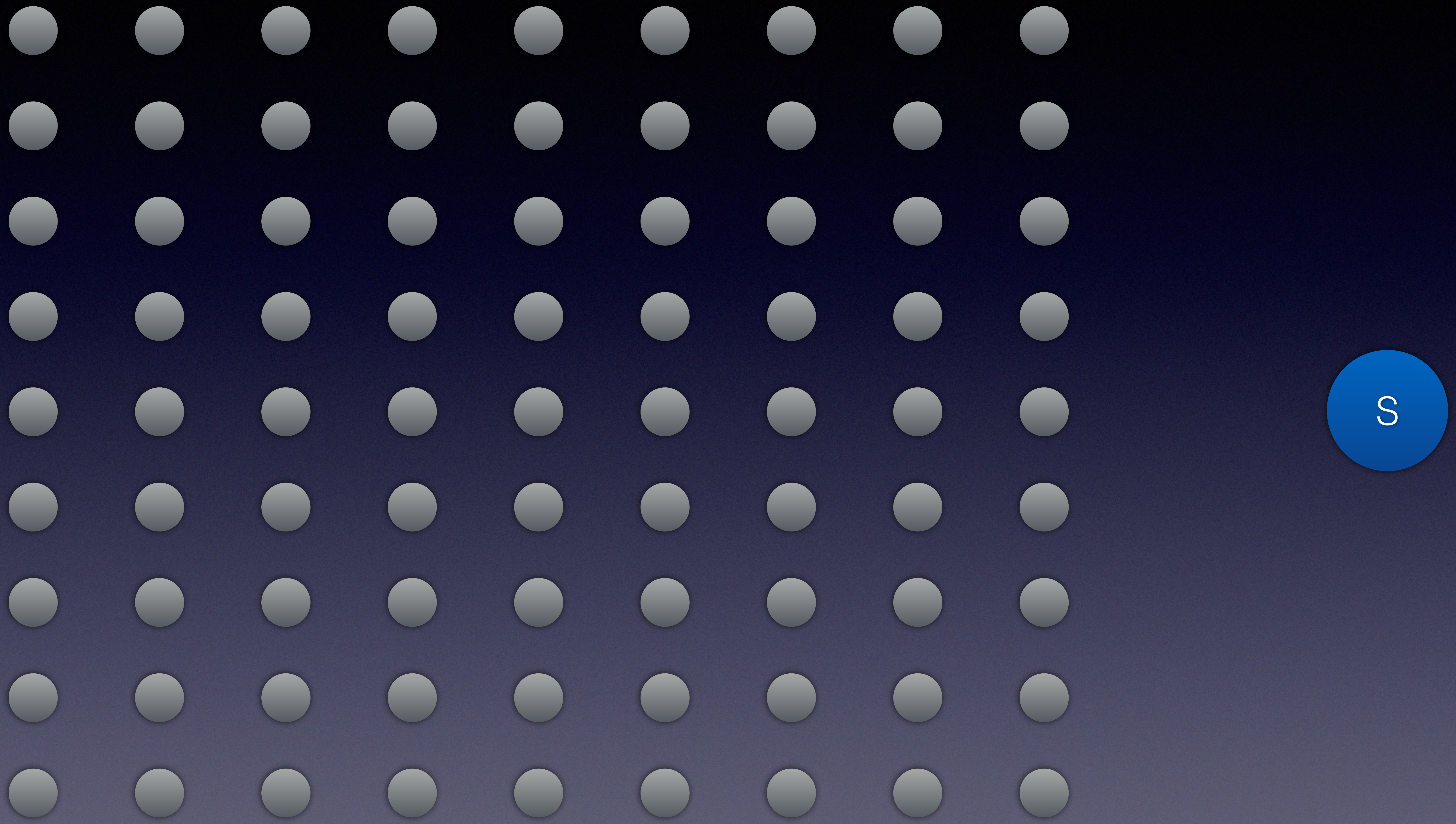
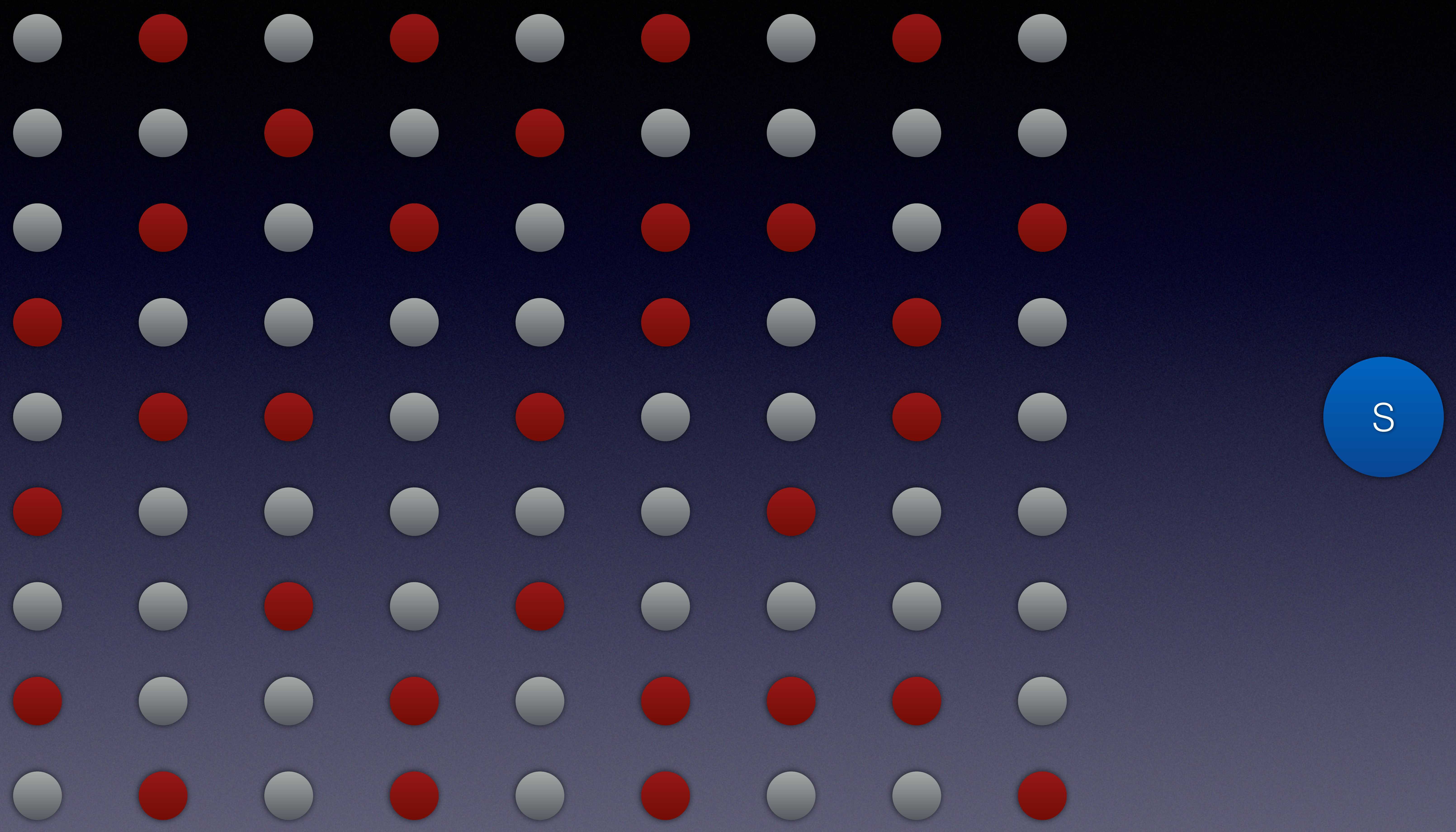

S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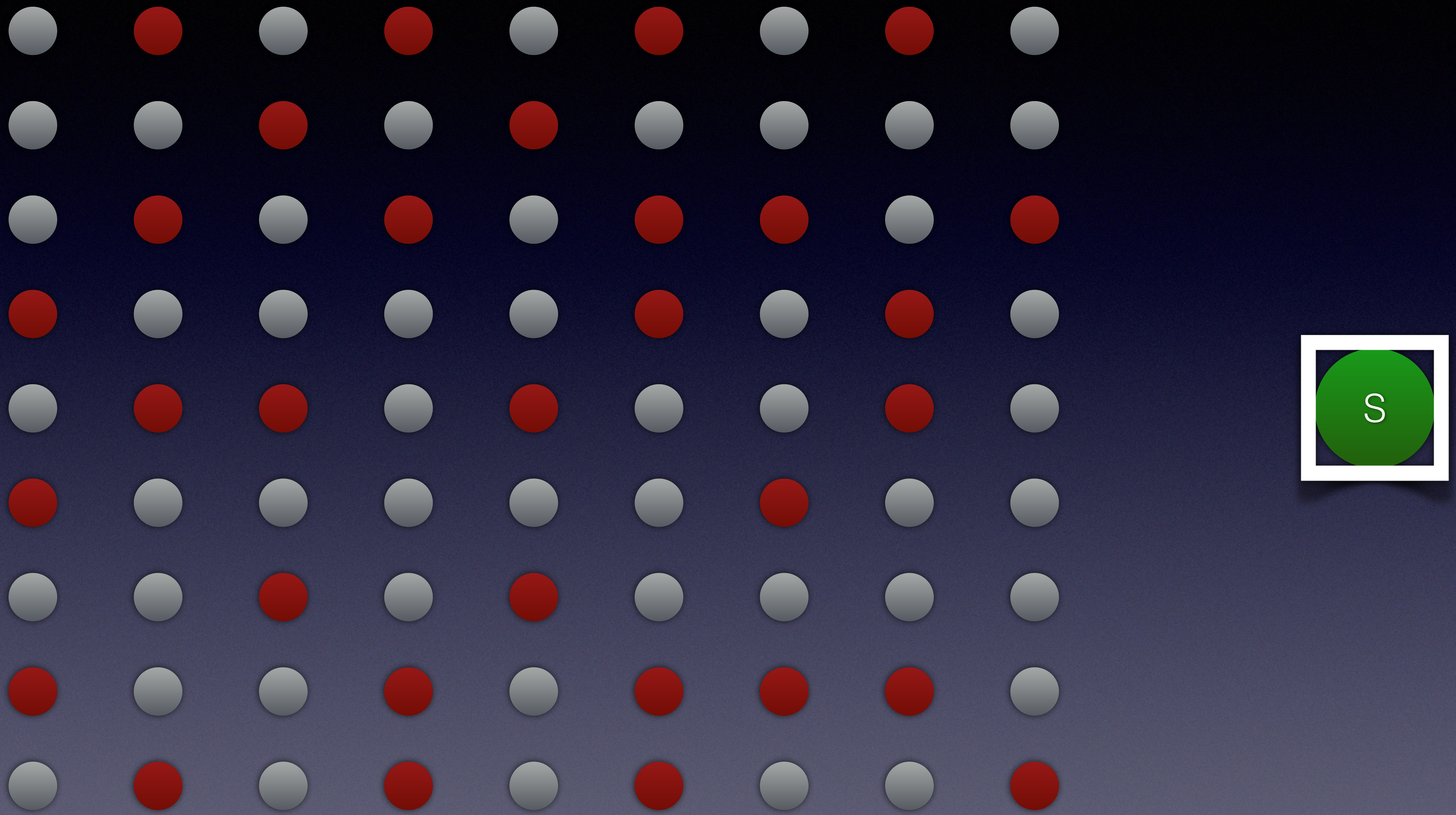
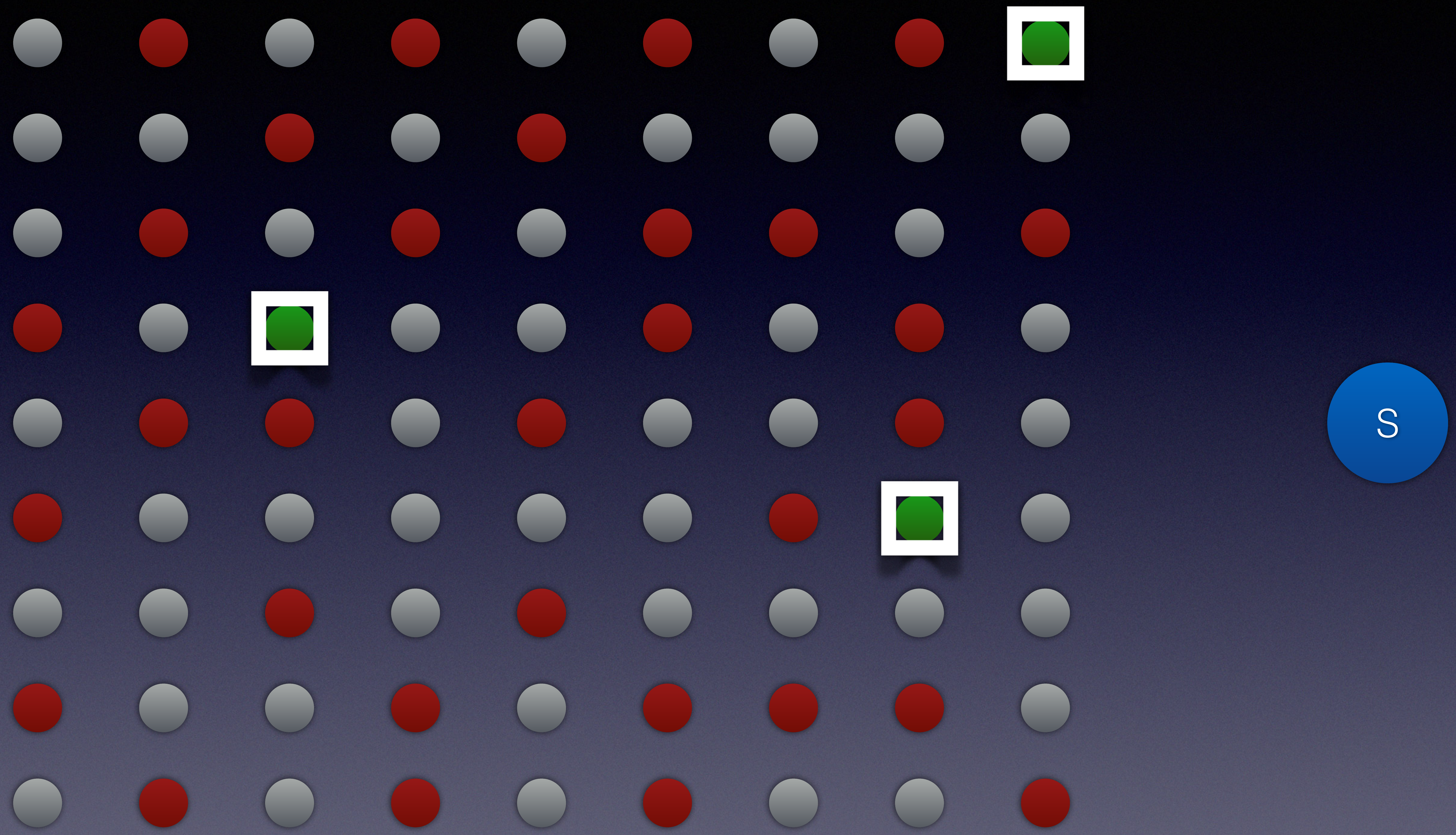
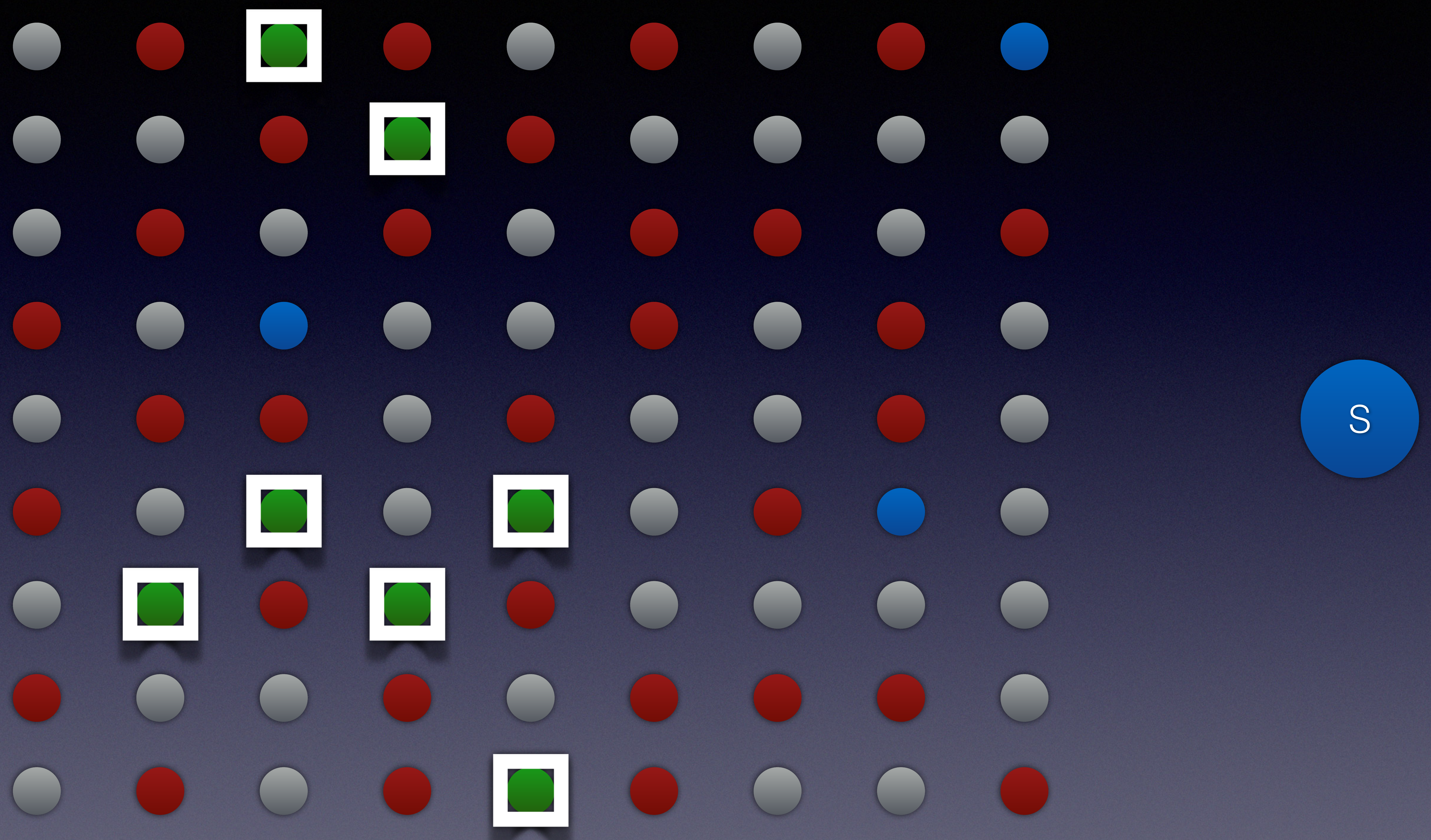
r=a<t+1



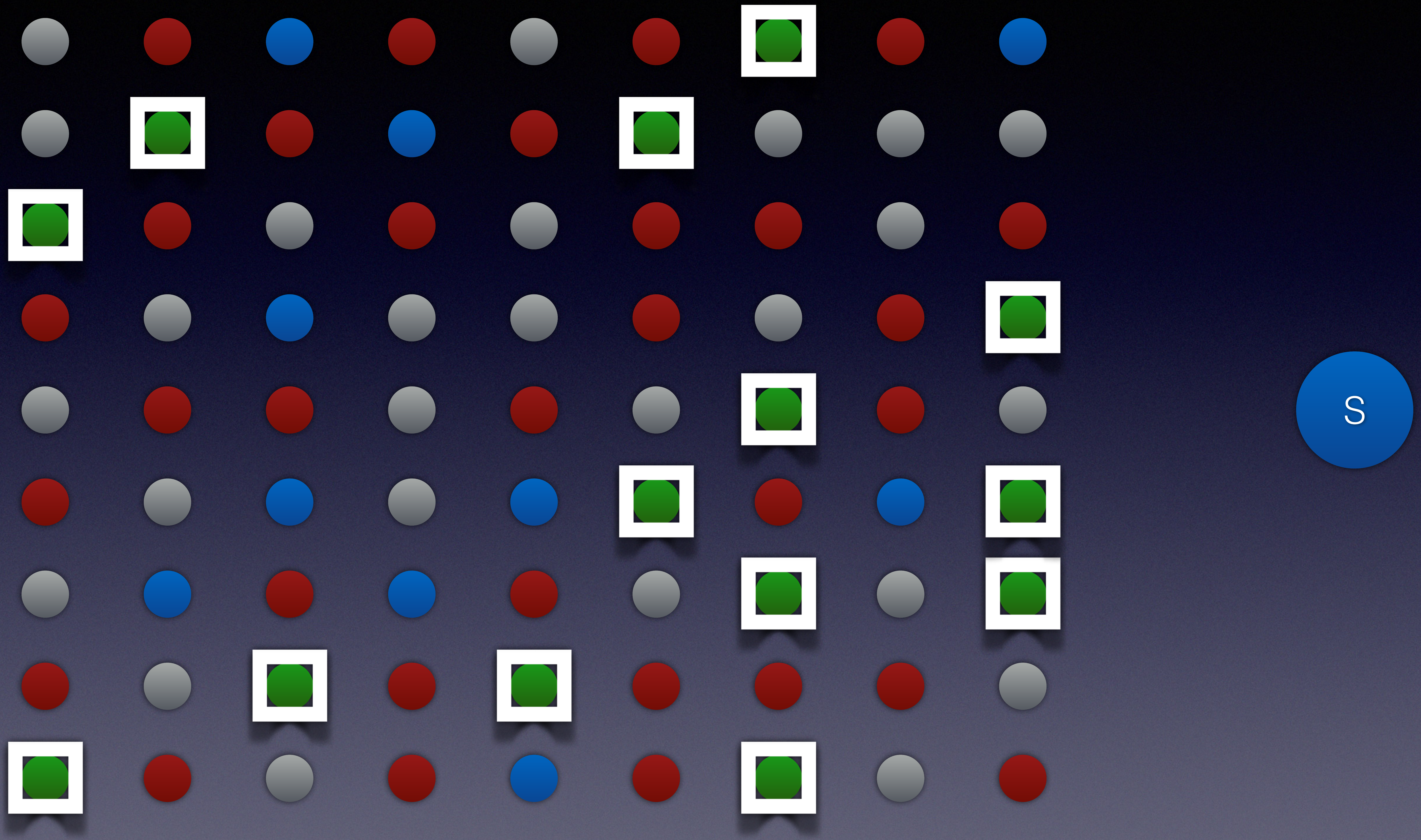
$r=a+1$



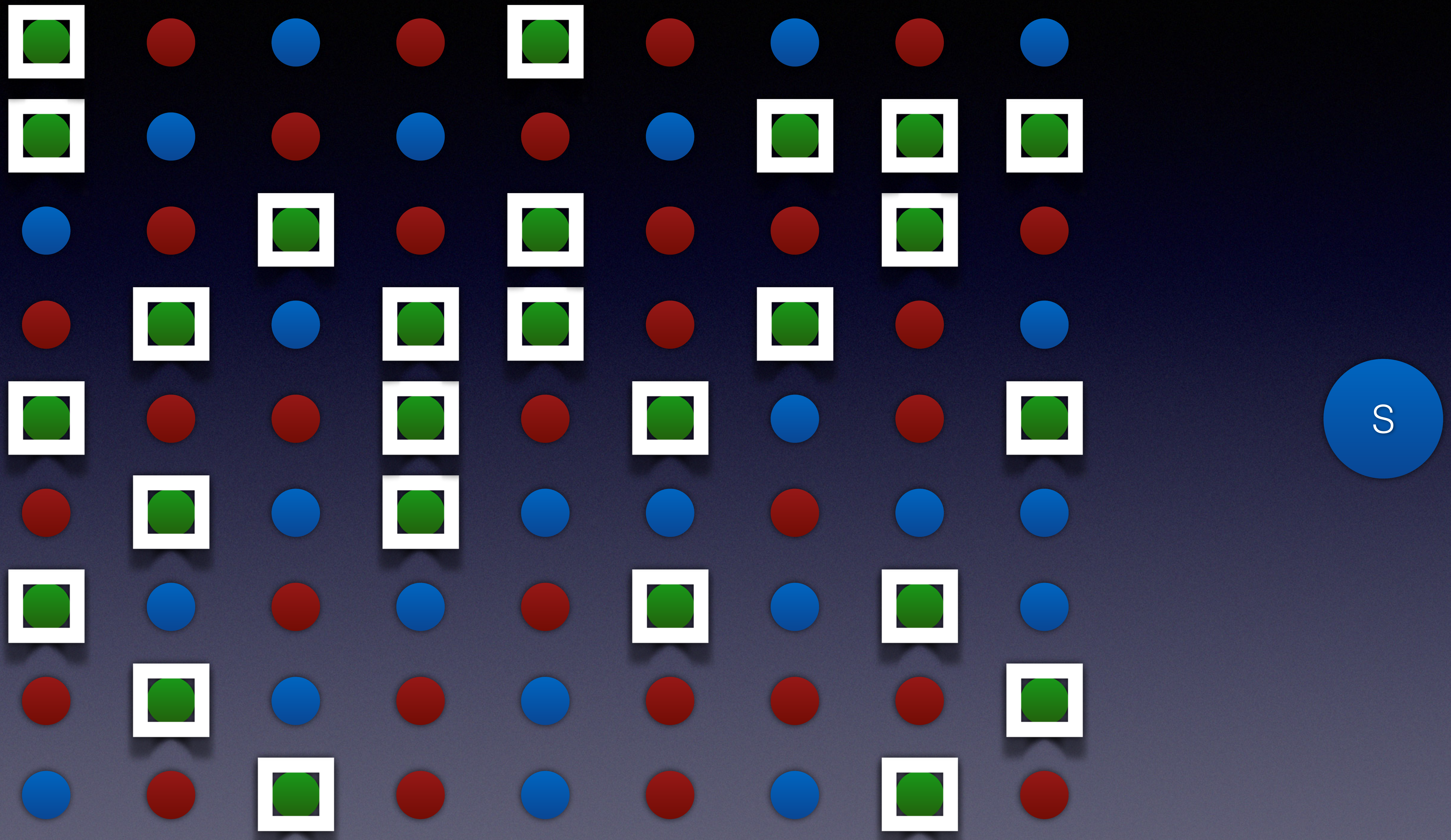
r=a+2



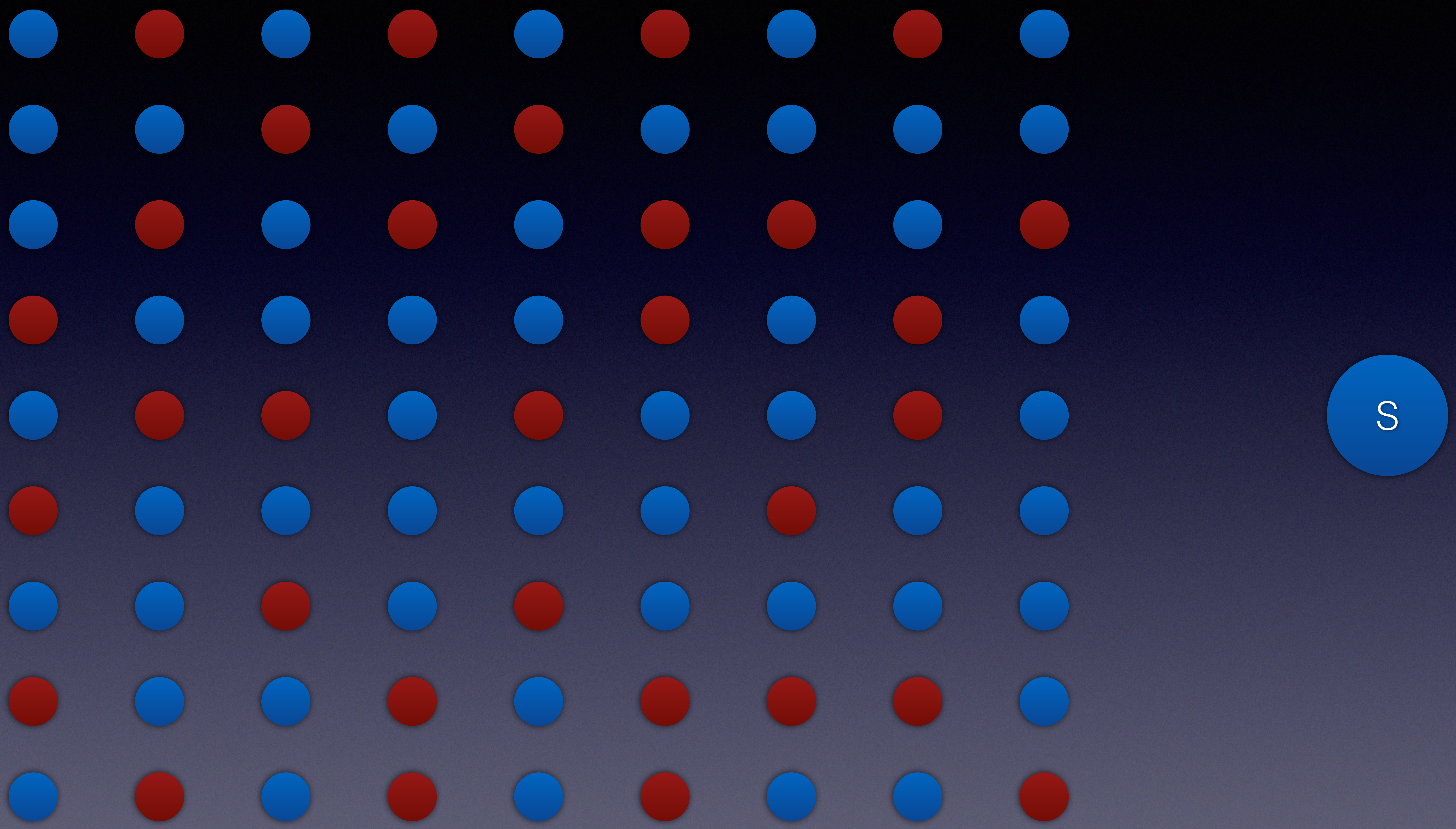
r=a+3



$r=a+4$



$r=a+5$



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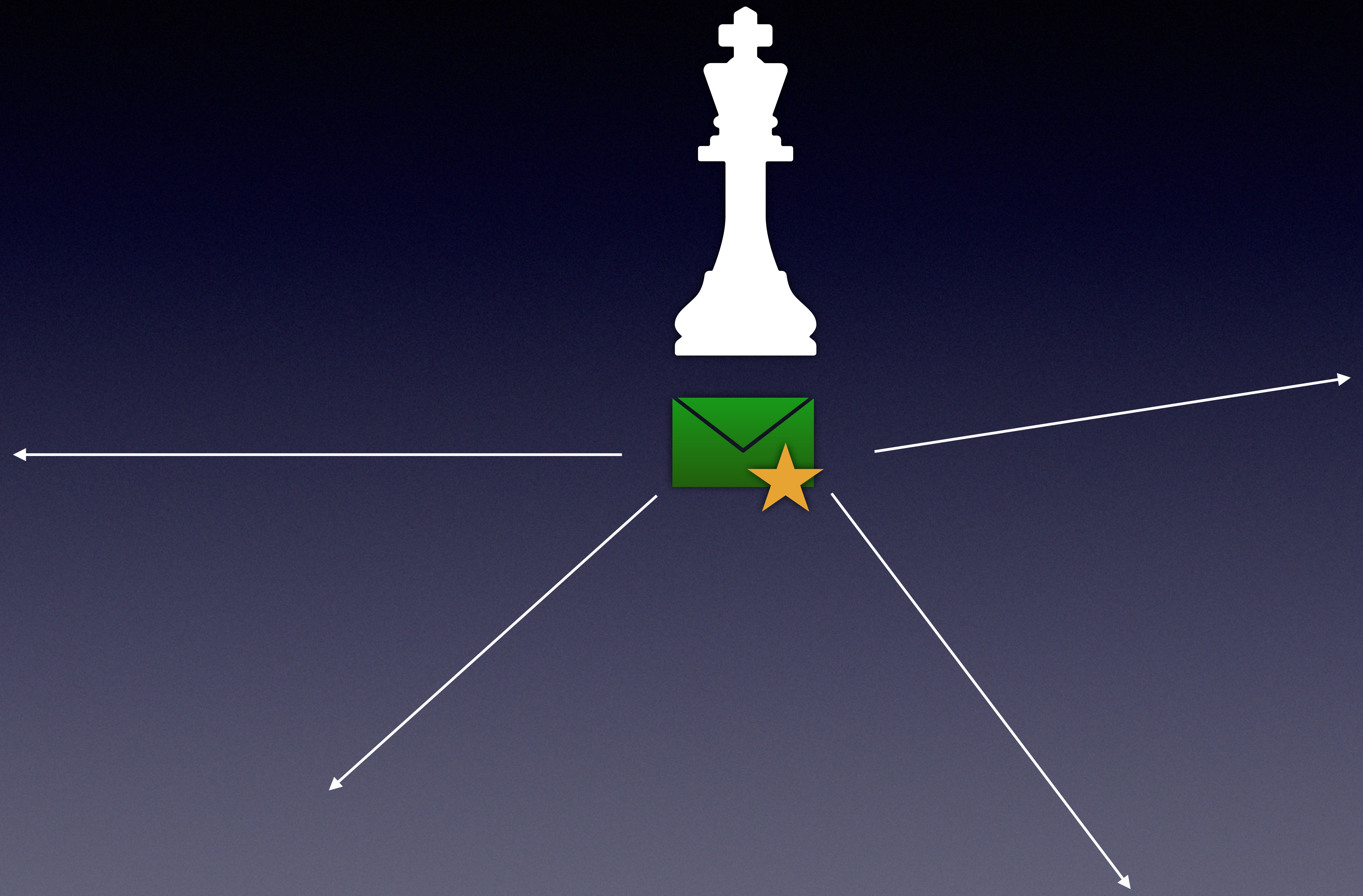

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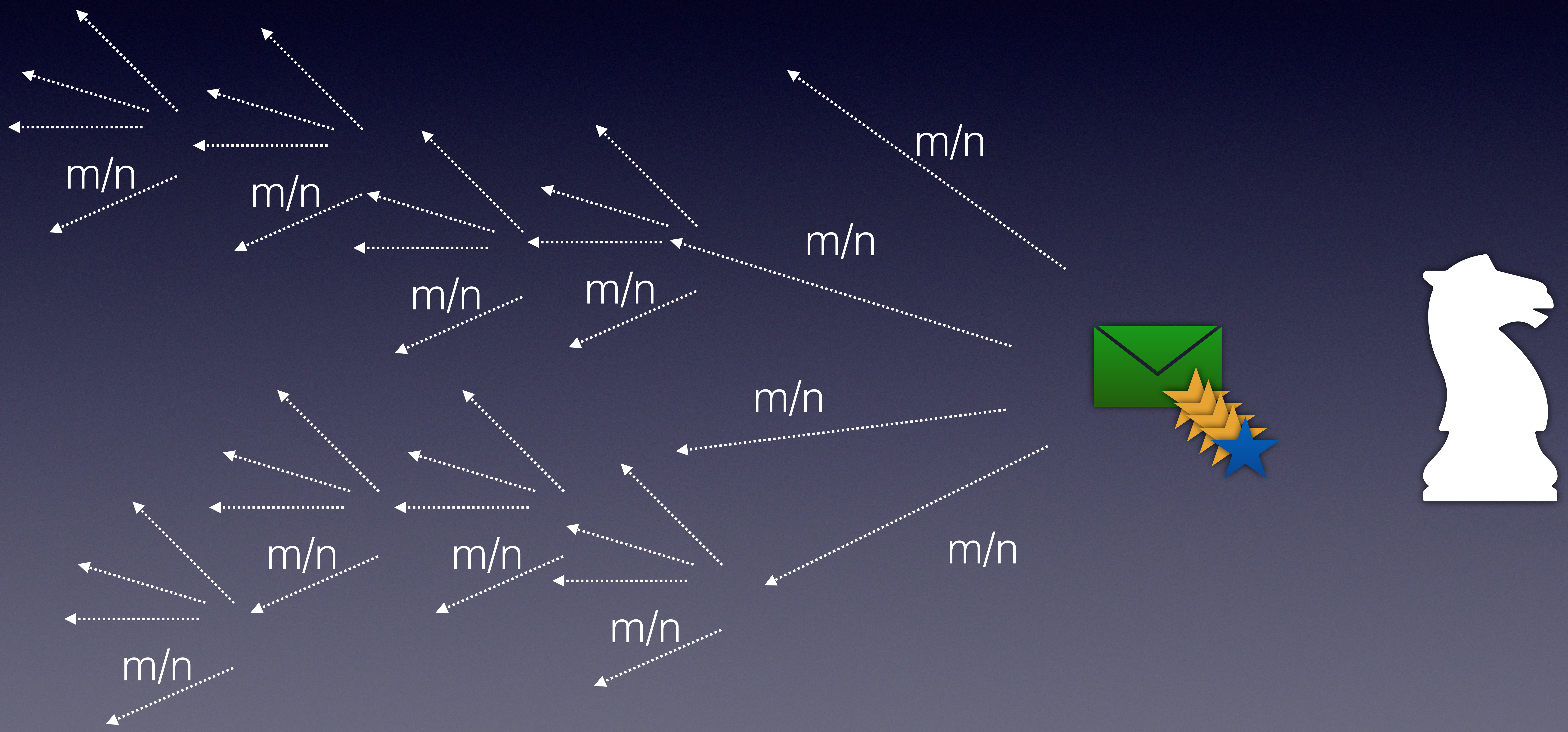

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Comparison

- Bulletin-Board PKI (**NO trusted setup**)
- State-of-the-art **Communication Complexity** for $t > n/2$

Protocol	Model	CC	RC	Adversary	Corruptions	Type
Dolev-Strong	Bulletin	$O(n^3\kappa)$	$O(n)$	Adaptive	$< n$	BC
BulletinBC	Bulletin	$\tilde{O}(n^2\kappa^2)$	$O(n)$	Static	$< (1-\epsilon)n$	BC
Abraham et al.	Trusted	$\tilde{O}(n\kappa)$	$O(1)$	Adaptive	$< n/2$	BC
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Limitations so far

- **Static** vs **Adaptive** adversary:
- An adaptive adversary can break the security of the process.
  - Any ideas how?

But… Broadcast?

- Back to our motivation:
  - Many times in practical uses of Broadcast, we require **all parties to broadcast** values.
    - (E.g. MPC, VSS applications)

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  - Consistency: For each slot s_i, all honest parties output the same bit

1. Caesar

5. Alexander

2. Washington

4. Napoleon

3. Charlemagne

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$[b_1, \mathsf{sig}_1(b_1)]$

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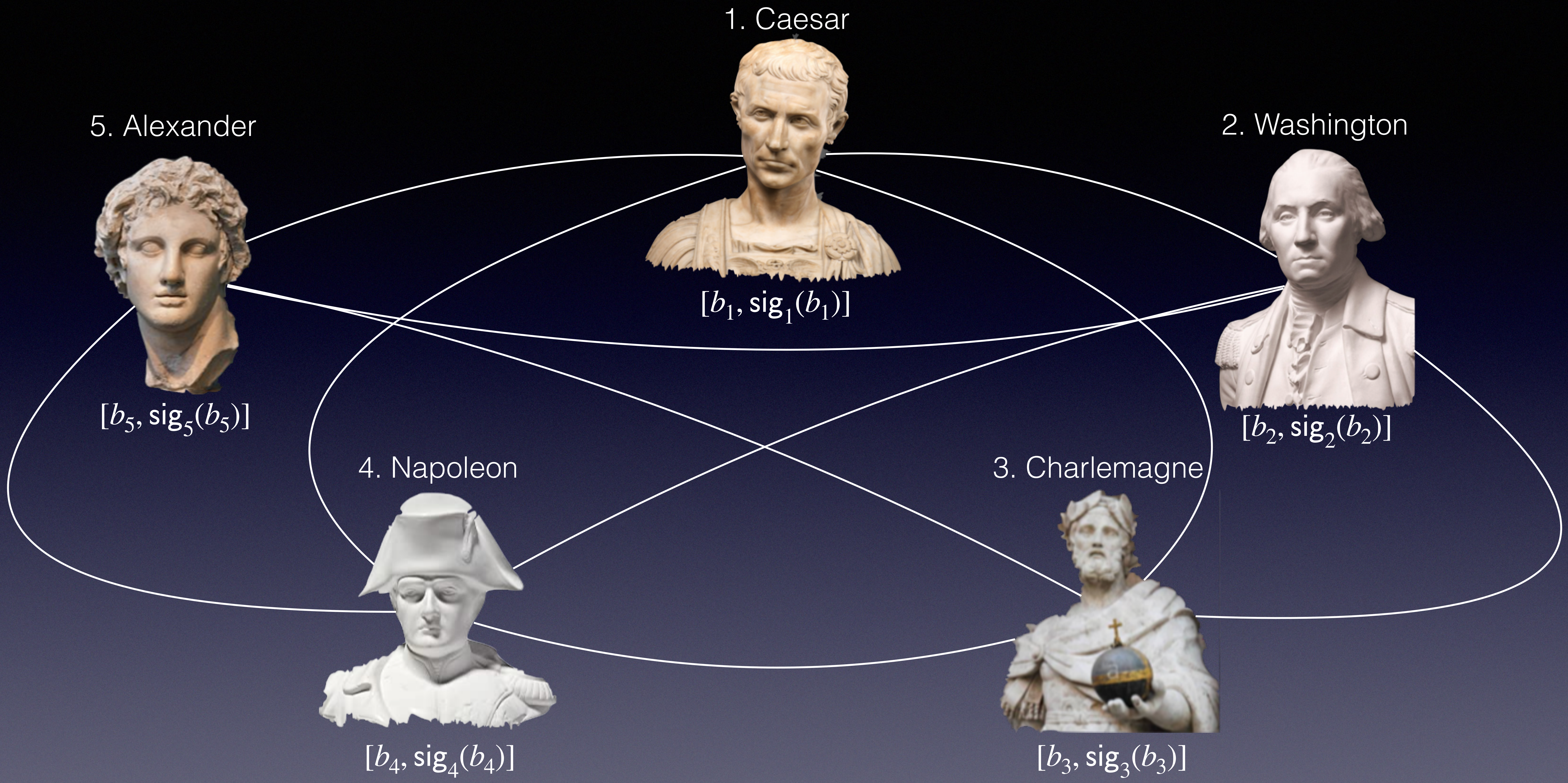
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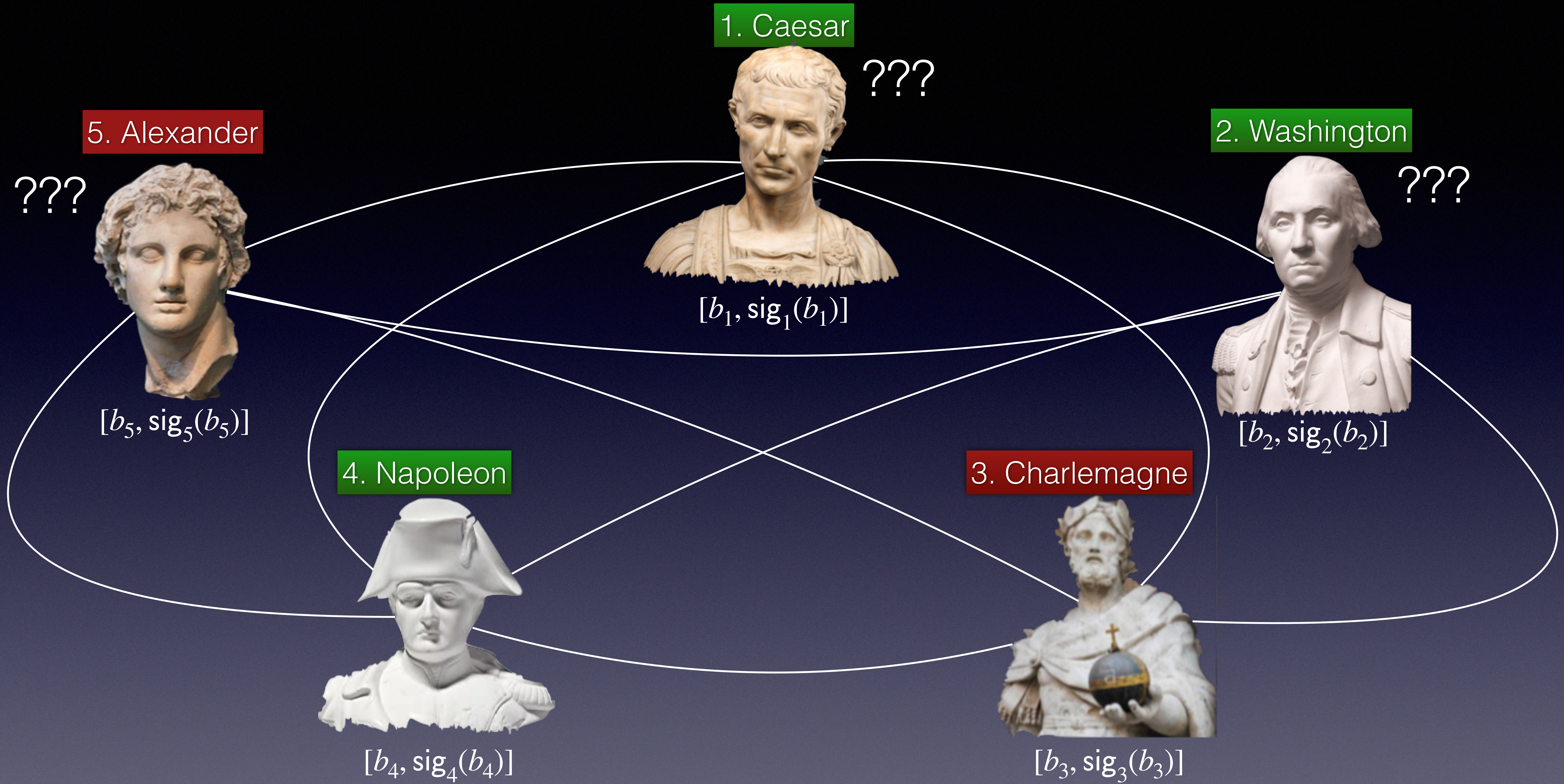
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  - If C is the Communication of the Broadcast protocol:
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- Can we do **better**?

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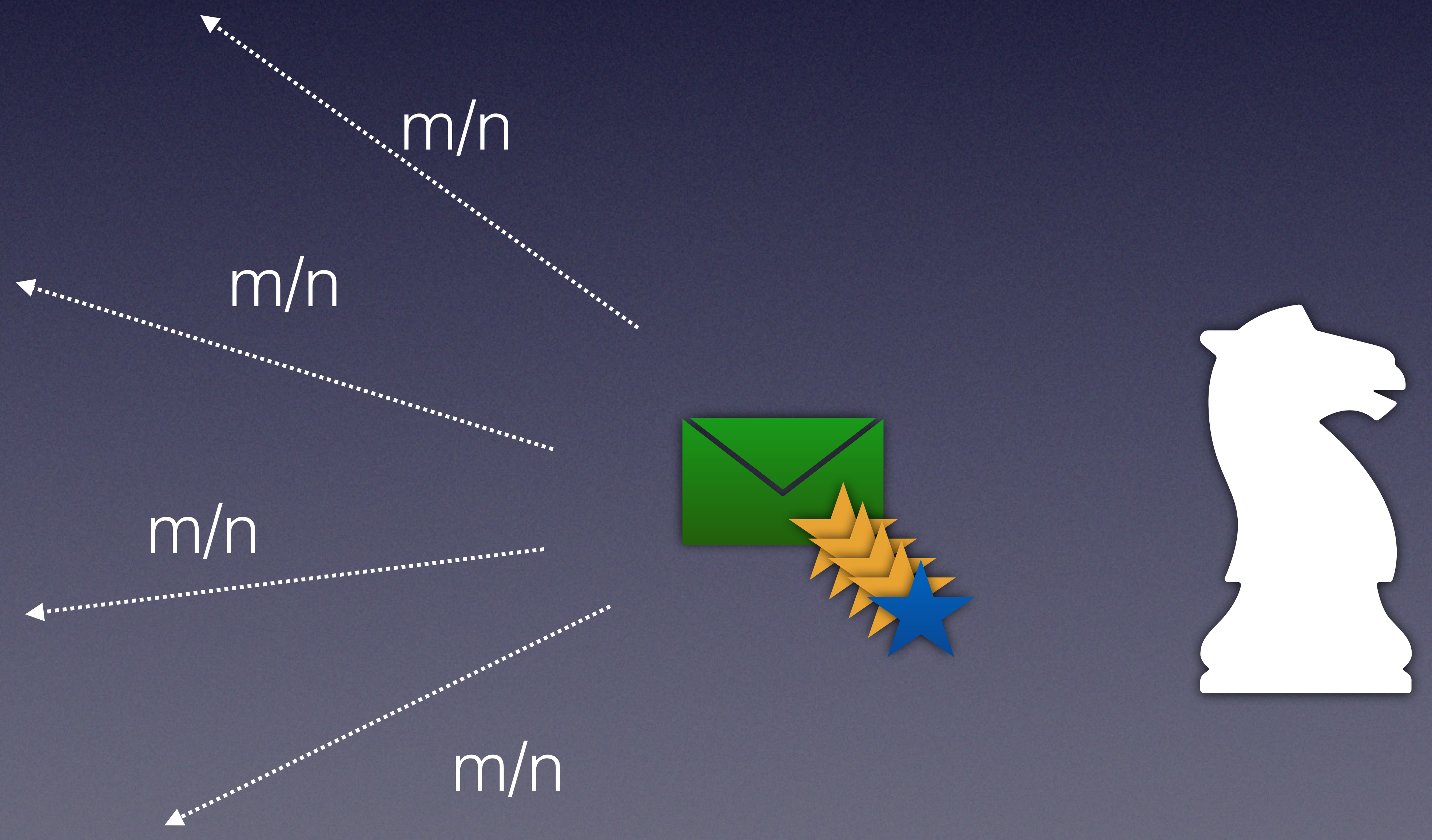
  - Against adaptive adversaries

Converge

- Before: Party gossips a specific message to a few other parties randomly



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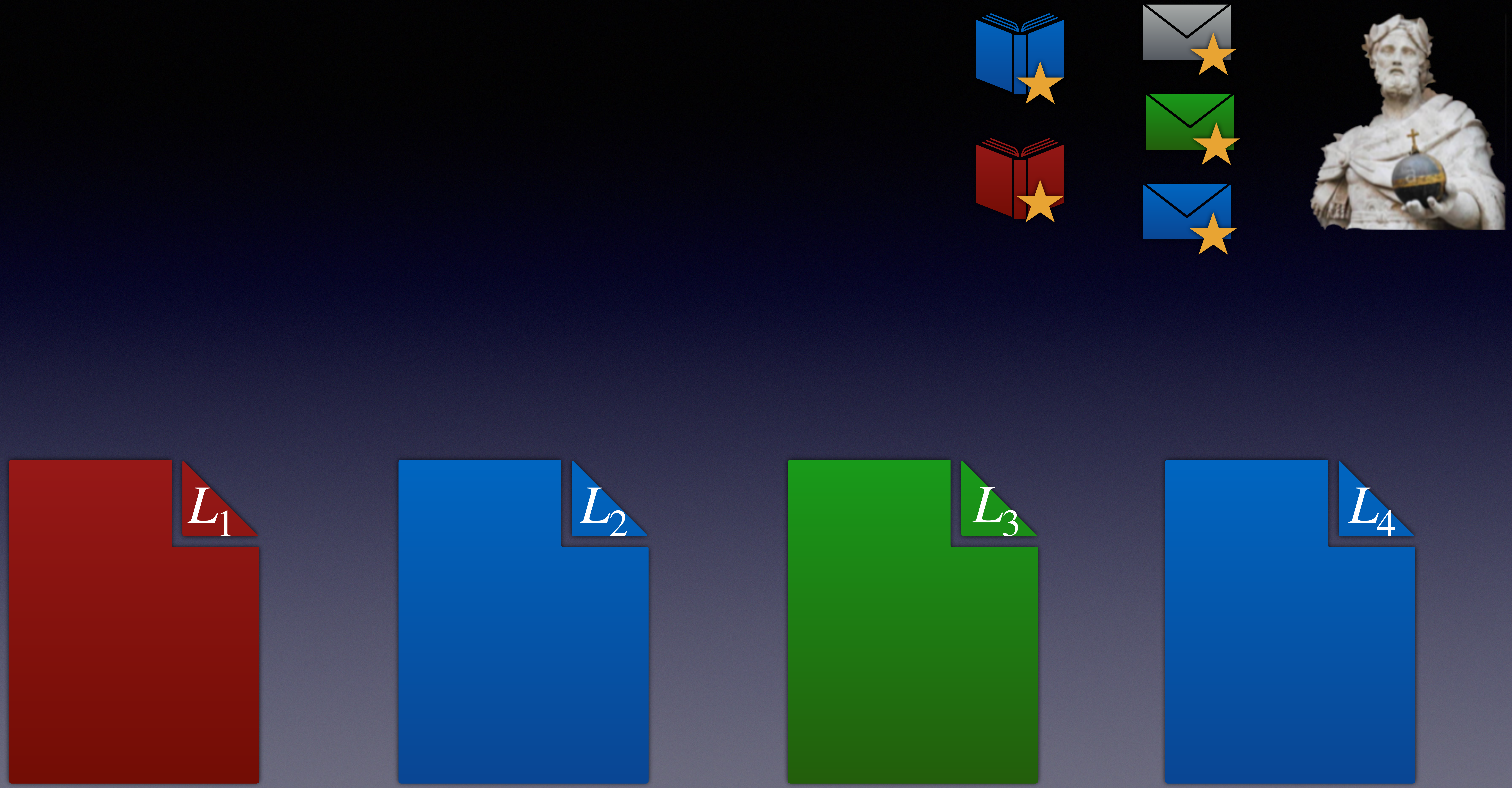
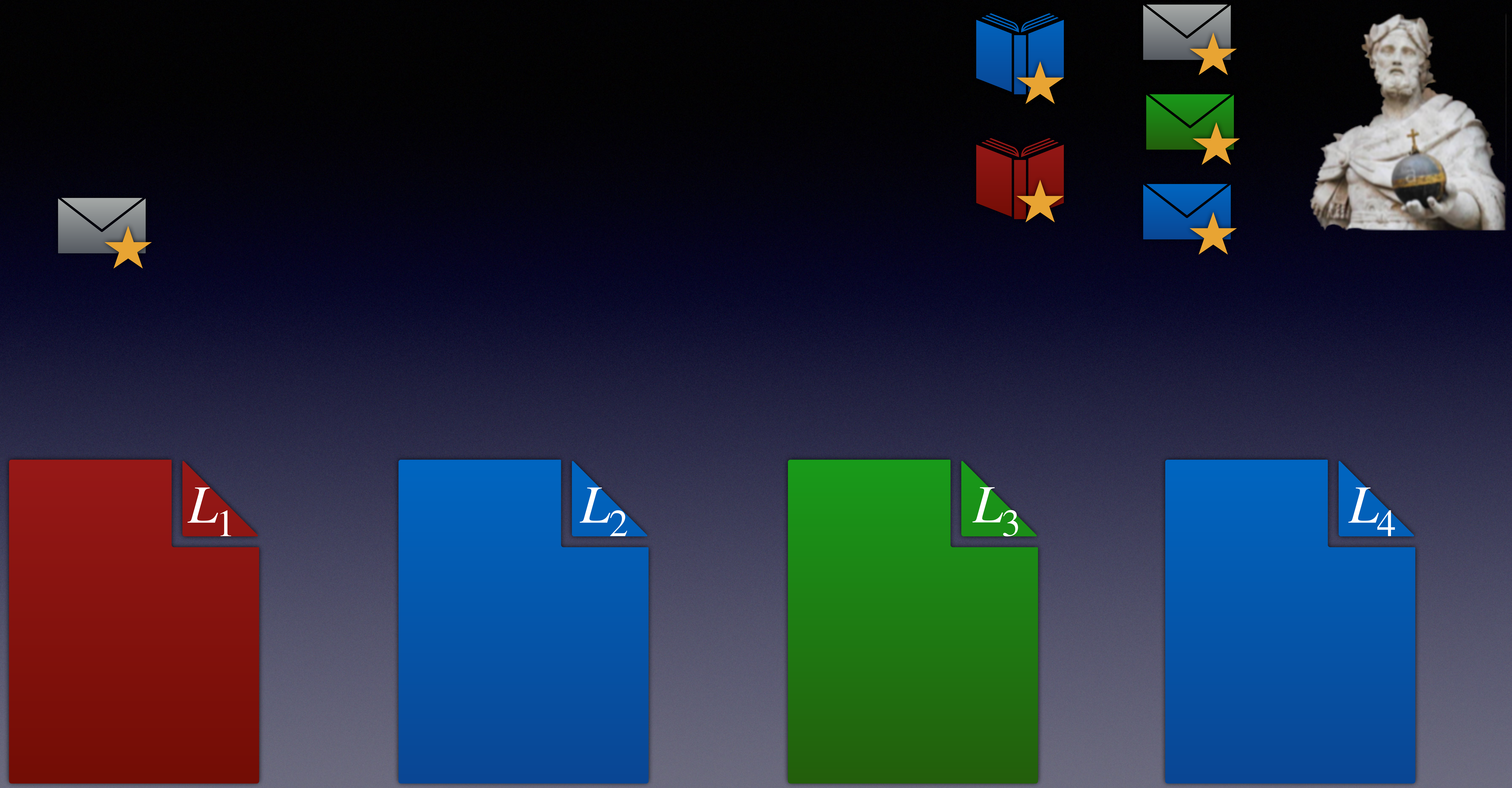
- With high prob. all parties receive ~ the same amount of messages
- The adversary doesn't gain any advantage by observing the execution of the protocol


L_1
L_2
L_3
L_4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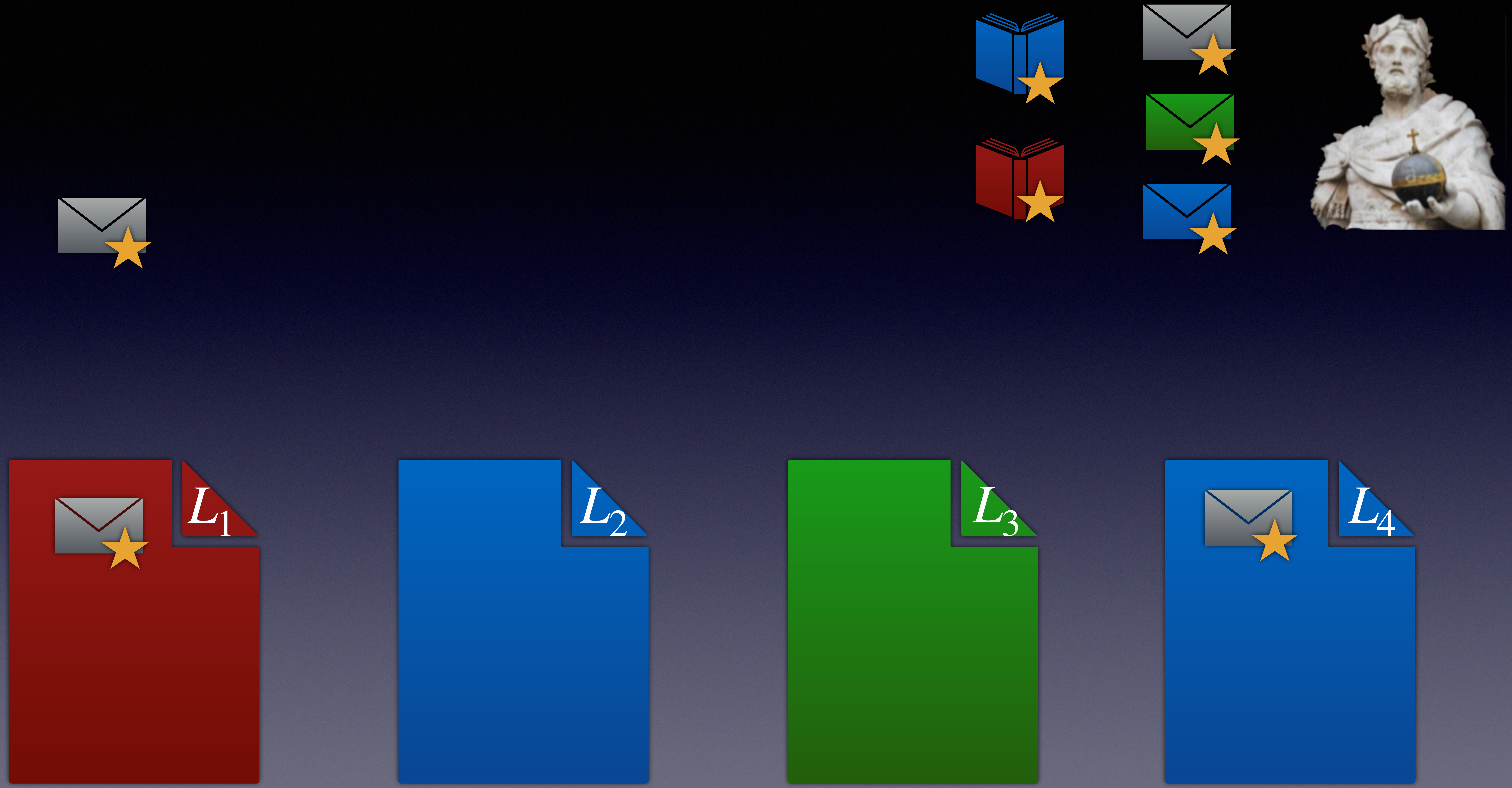
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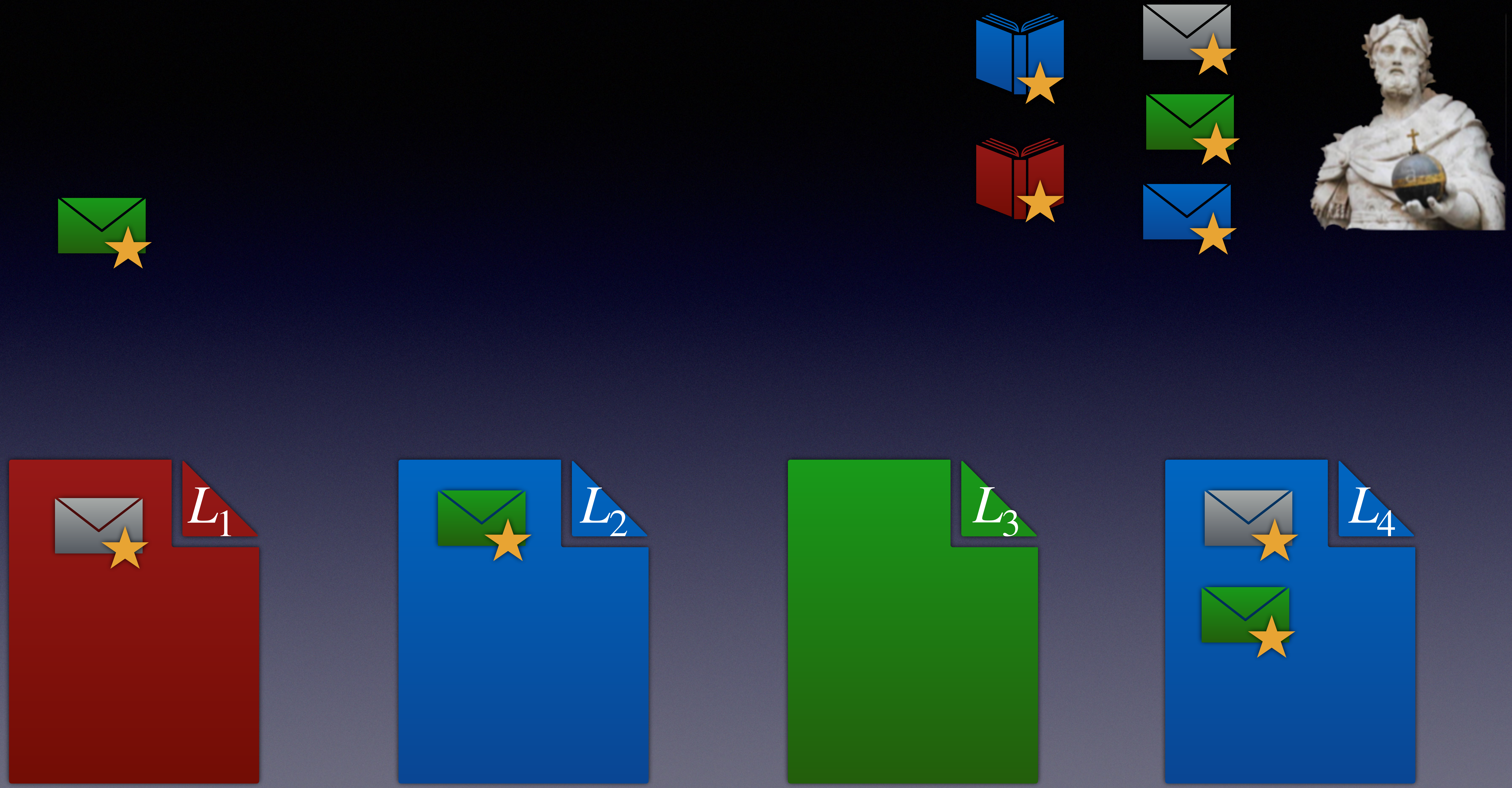
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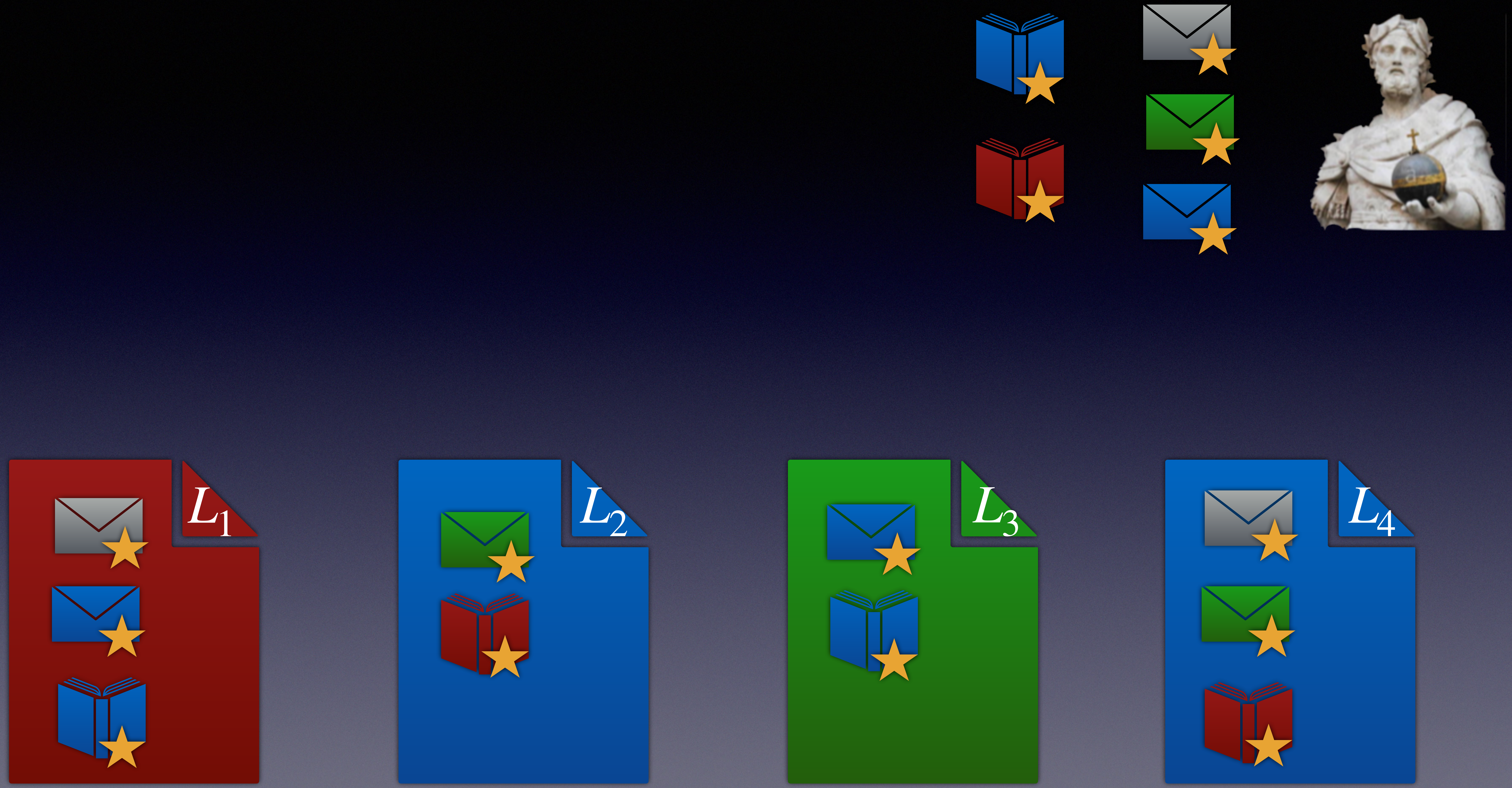
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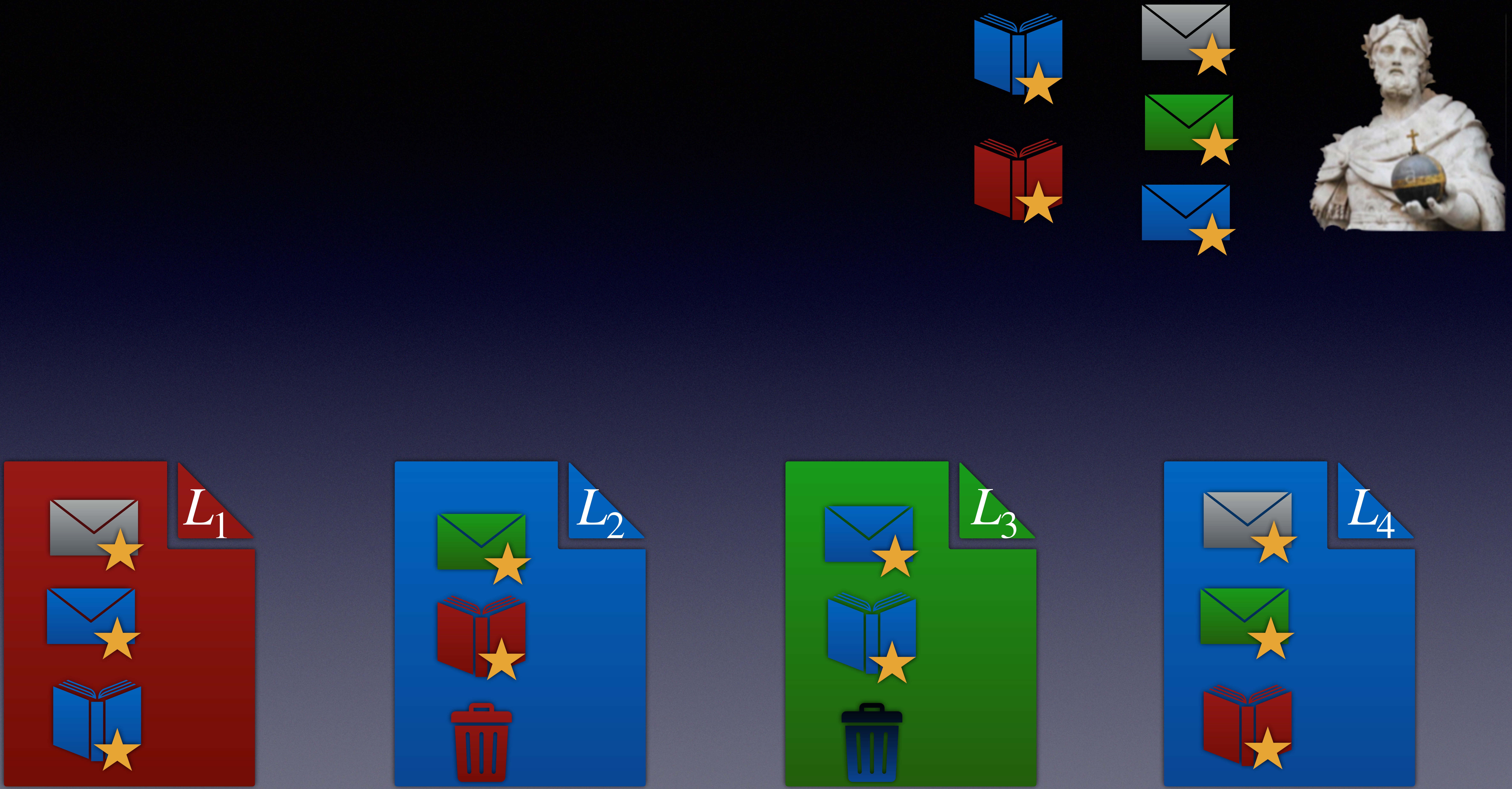
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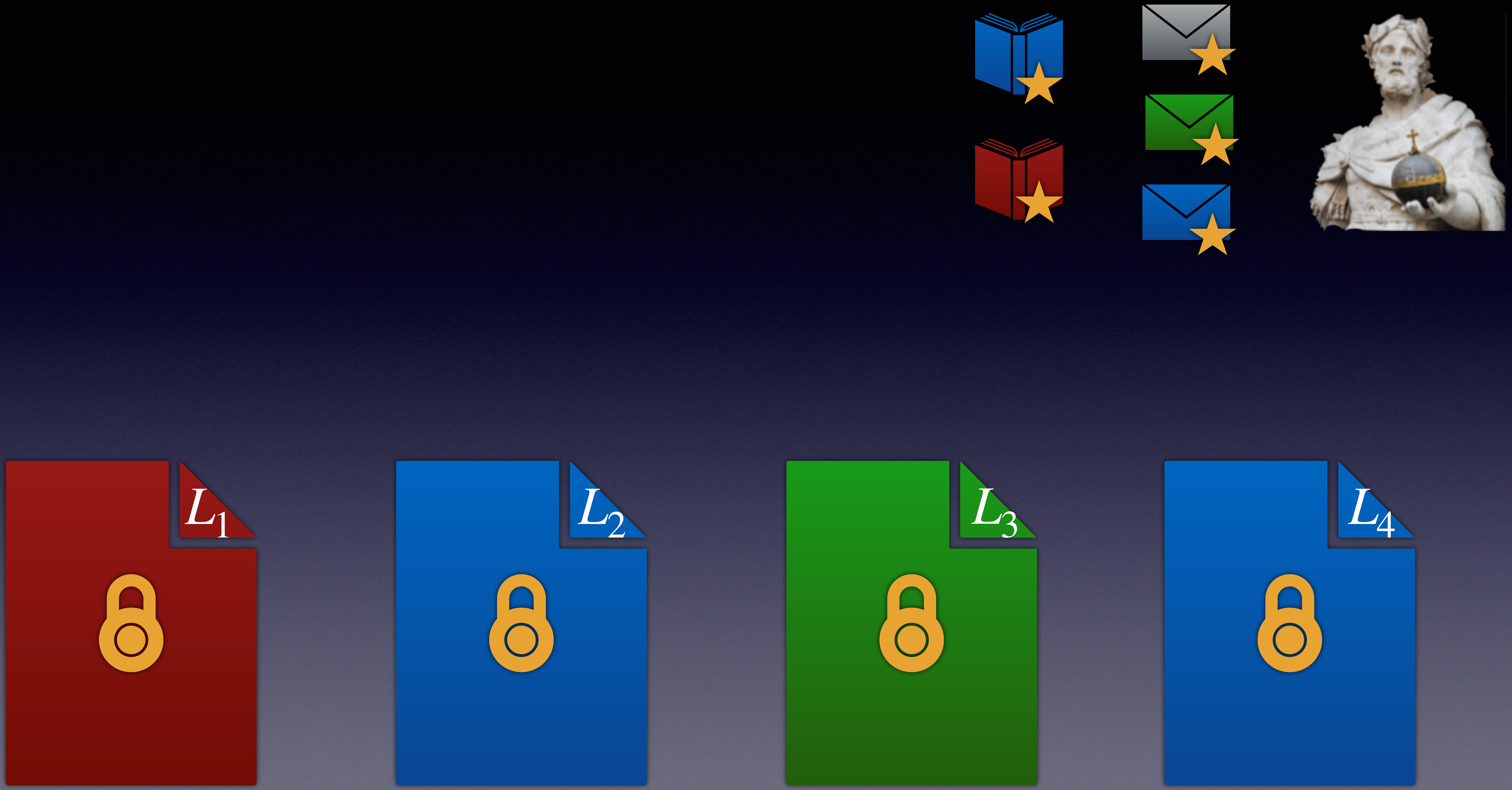
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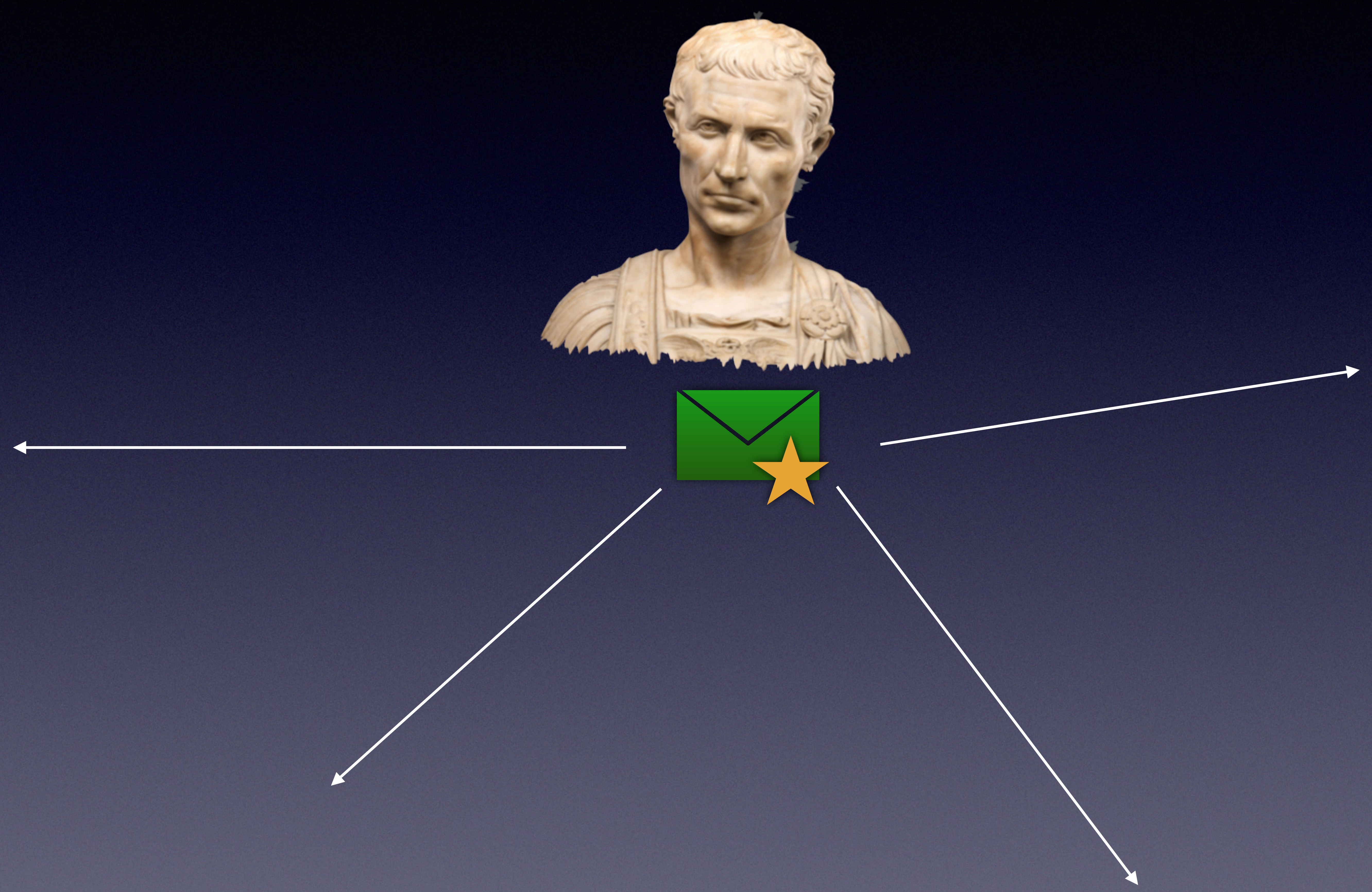

Stage 1:

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p checks if it received some new "**valid**" bit.
For such bit b and slot s, **add** $sig_p([b, s])$ ★.

Stage 1:

For each $r \leq t + 1$:
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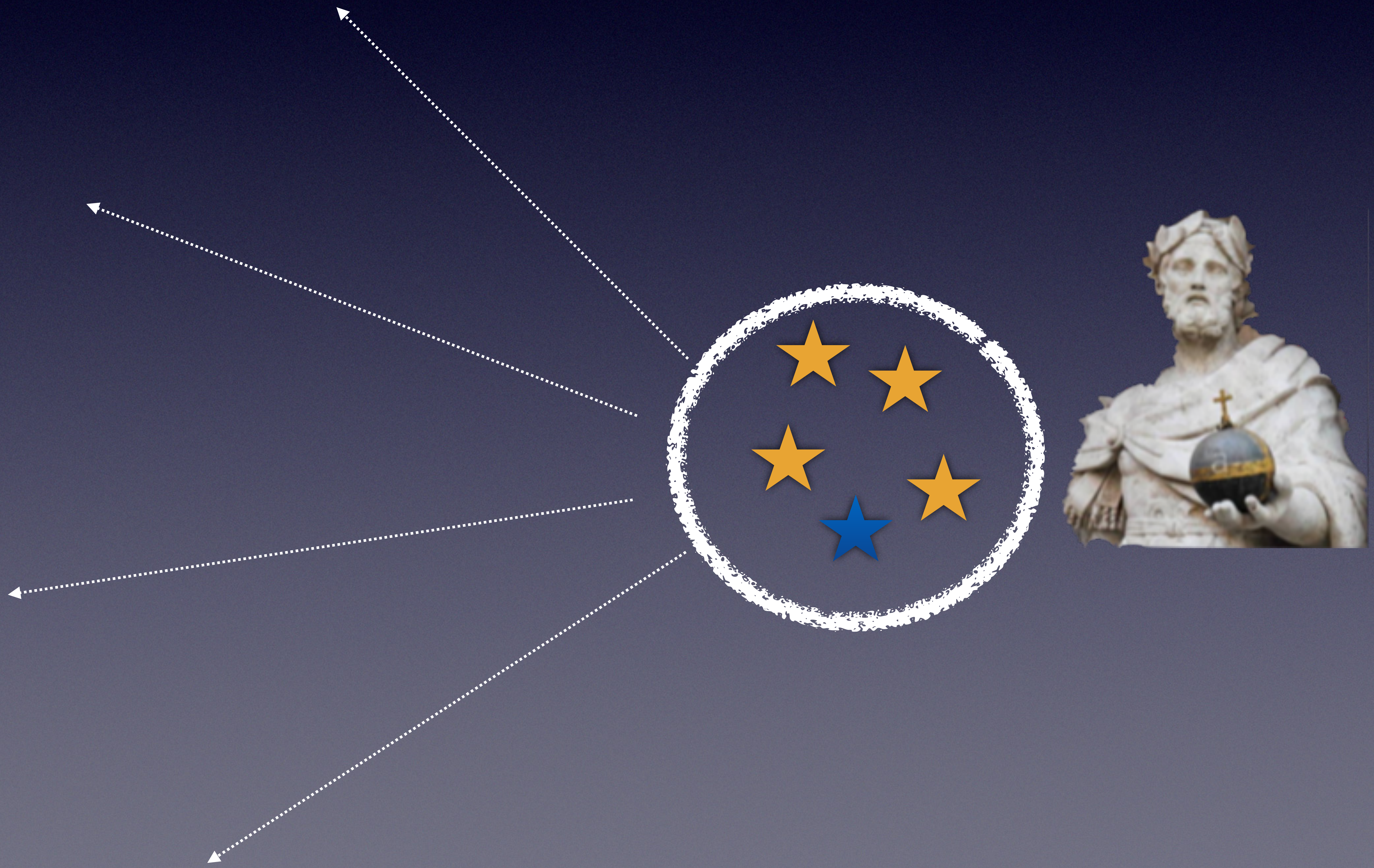
Valid bit at round r:

At least r distinct signatures, where one is from s.

Stage 2:

For each $r \leq t + 1$:

p calls **Converge** on M_p : received signatures



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- Total CC: $\tilde{O}(n^3)$ (Amortized $\tilde{O}(n^2)$ per broadcast)

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Comparison

Protocol	Model	CC	RC	Adversary	Corruptions	Type
Dolev-Strong	Bulletin	$O(n^3\kappa)$	$O(n)$	Adaptive	$< n$	BC
BulletinBC	Bulletin	$\tilde{O}(n^2\kappa^2)$	$O(n)$	Static	$< (1-\epsilon)n$	BC
Abraham et al.	Trusted	$\tilde{O}(n\kappa)$	$O(1)$	Adaptive	$< n/2$	BC
Chan et al.	Trusted	$O(n^2\kappa^2)$	$O(\kappa)$	Adaptive	$< (1-\epsilon)n$	BC
Momose and Ren	Bulletin	$\tilde{O}(n^2\kappa)$	$O(n)$	Adaptive	$< n/2$	BC
BulletinPBC	Bulletin	$\tilde{O}(n^2\kappa^2)*$	$O(n \log n)$	Adaptive	$< (1-\epsilon)n$	PBC
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