# CUCKOO COMMITMENTS: REGISTRATION-BASED ENCRYPTION & KEY-VALUE MAP COMMITMENTS FOR LARGE SPACES

WORK BY DARIO FIORE [1], DIMITRIS KOLONELOS [1, 2] & PAOLA DE PERTHUIS [3,4]

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PRESENTATION BY PAOLA DE PERTHUIS

1: institute imdea software
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3: cosmian
4: ENS ÉCOLE NORMALE SUPÉRIEURE

# REGISTRATION-BASED ENCRYPTION

MOTIVATIONS

# REGISTRATION-BASED ENCRYPTION (RBE)

**Stemming from [TCC:Garg-Hajiabadi-Mahmoody-Rahimi-18]**

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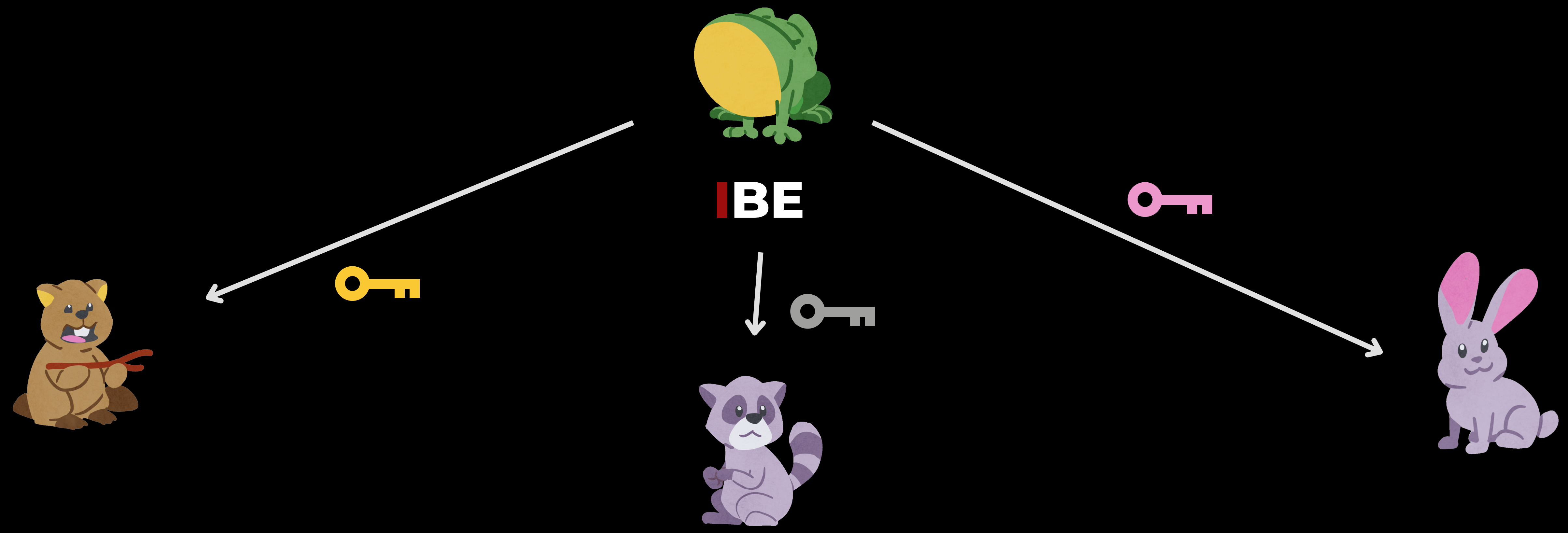

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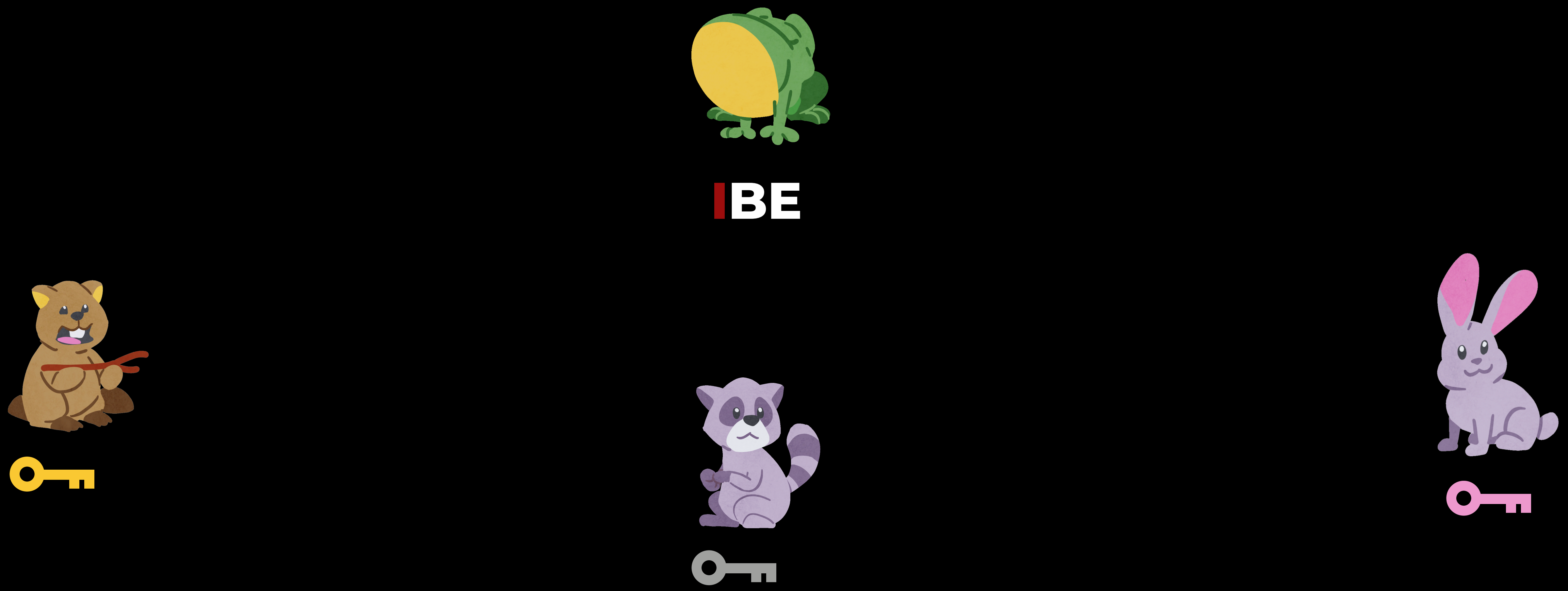

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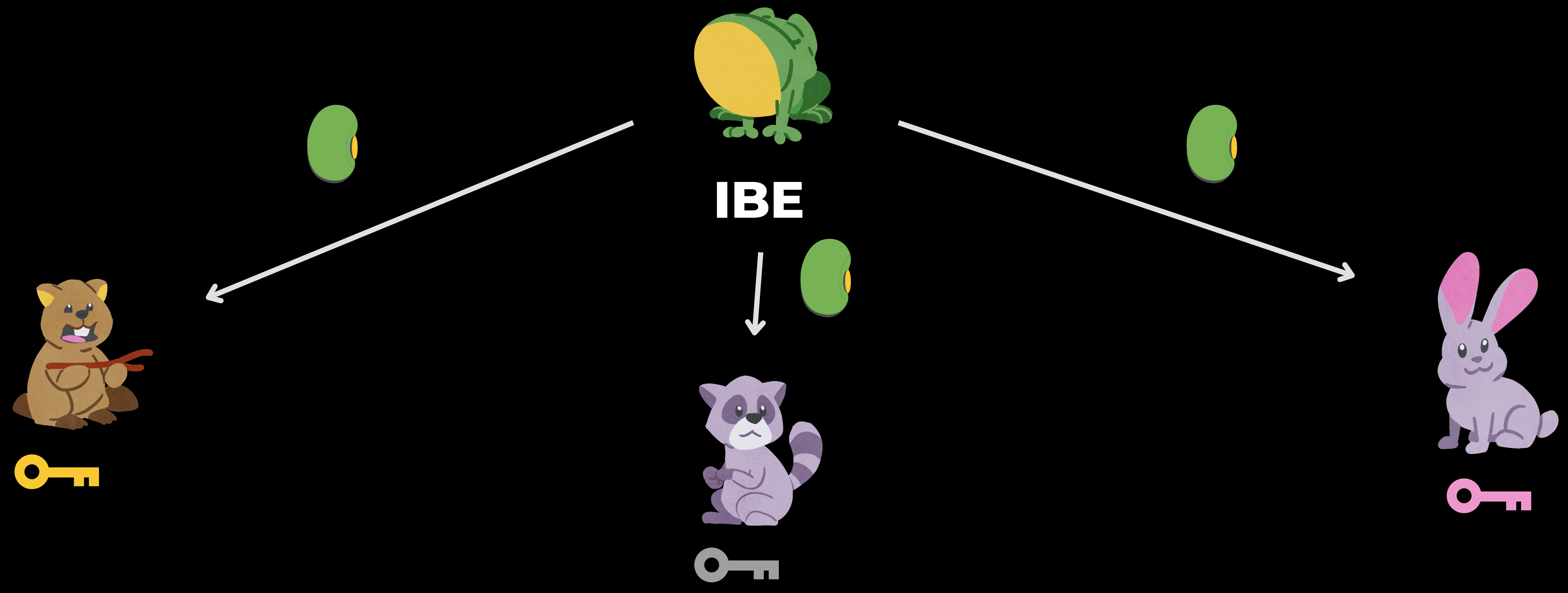

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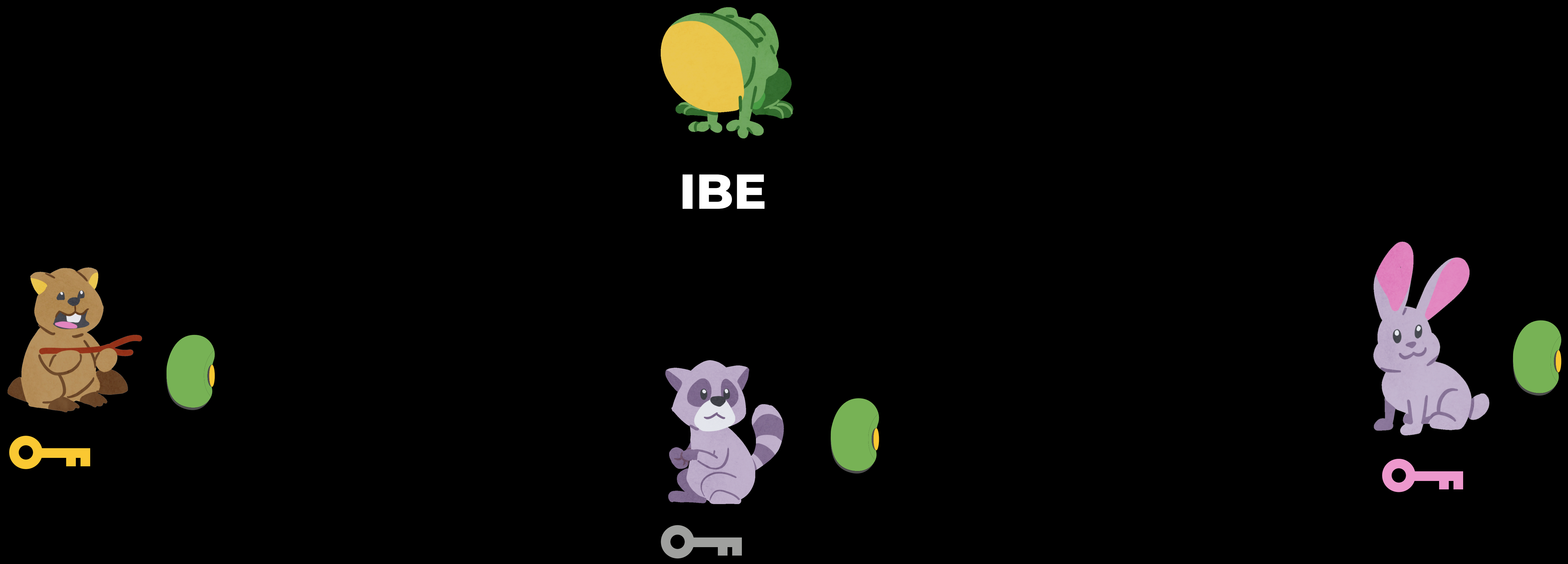

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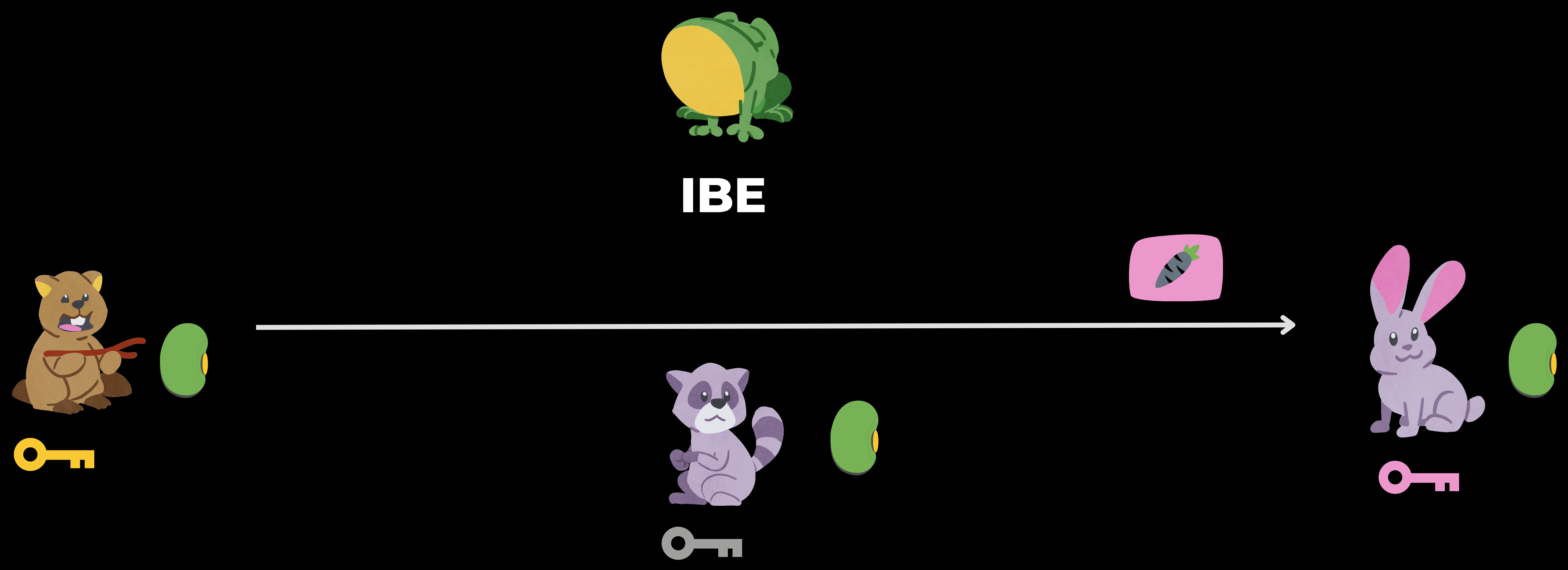

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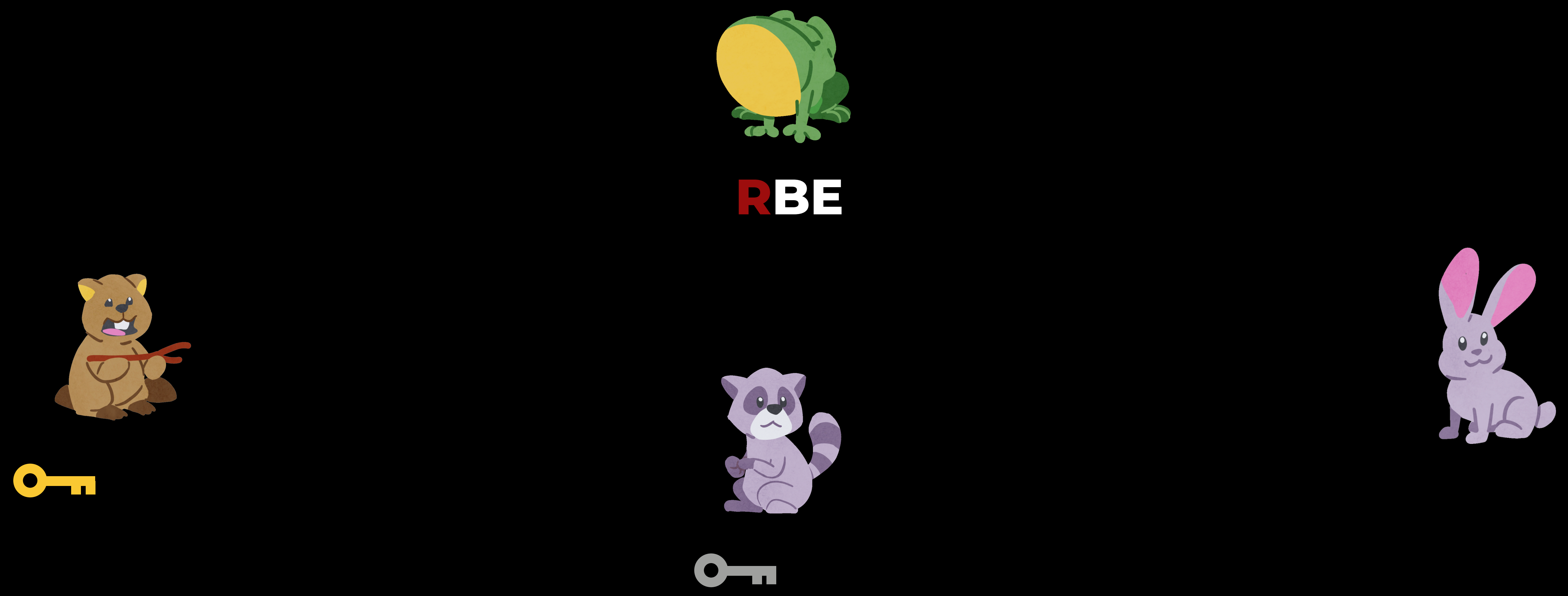

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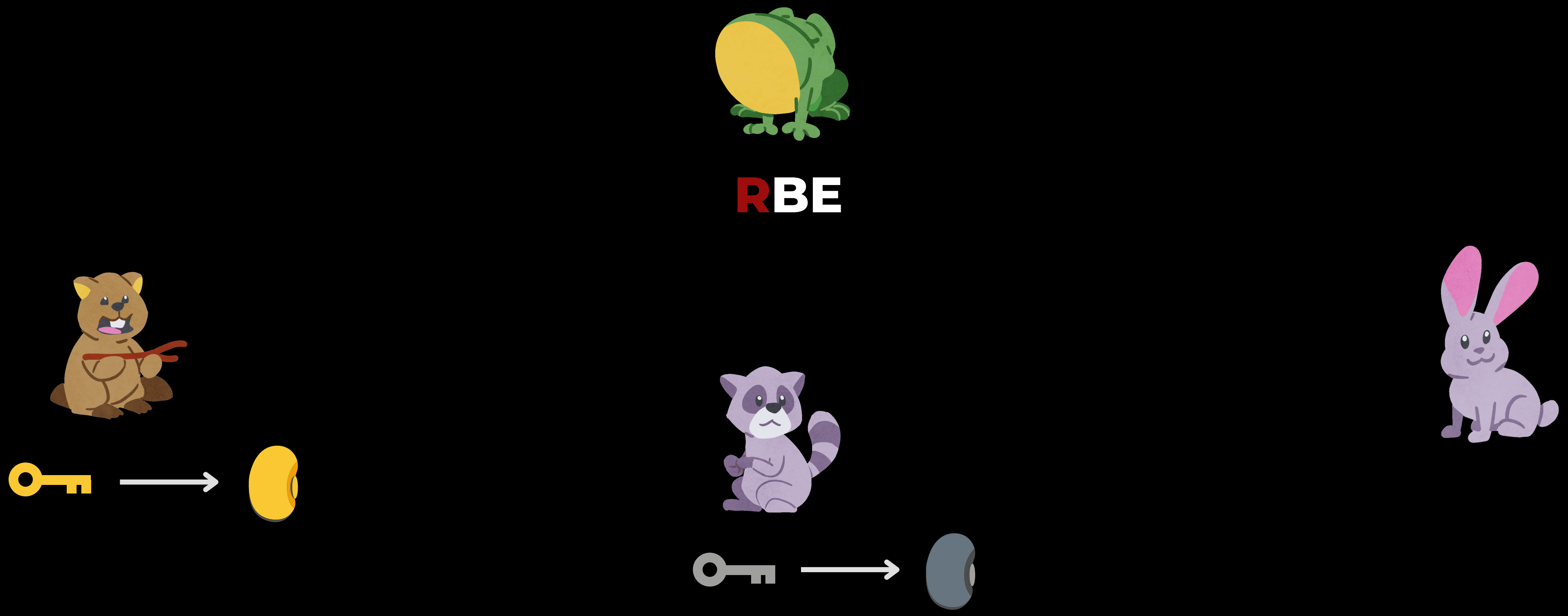

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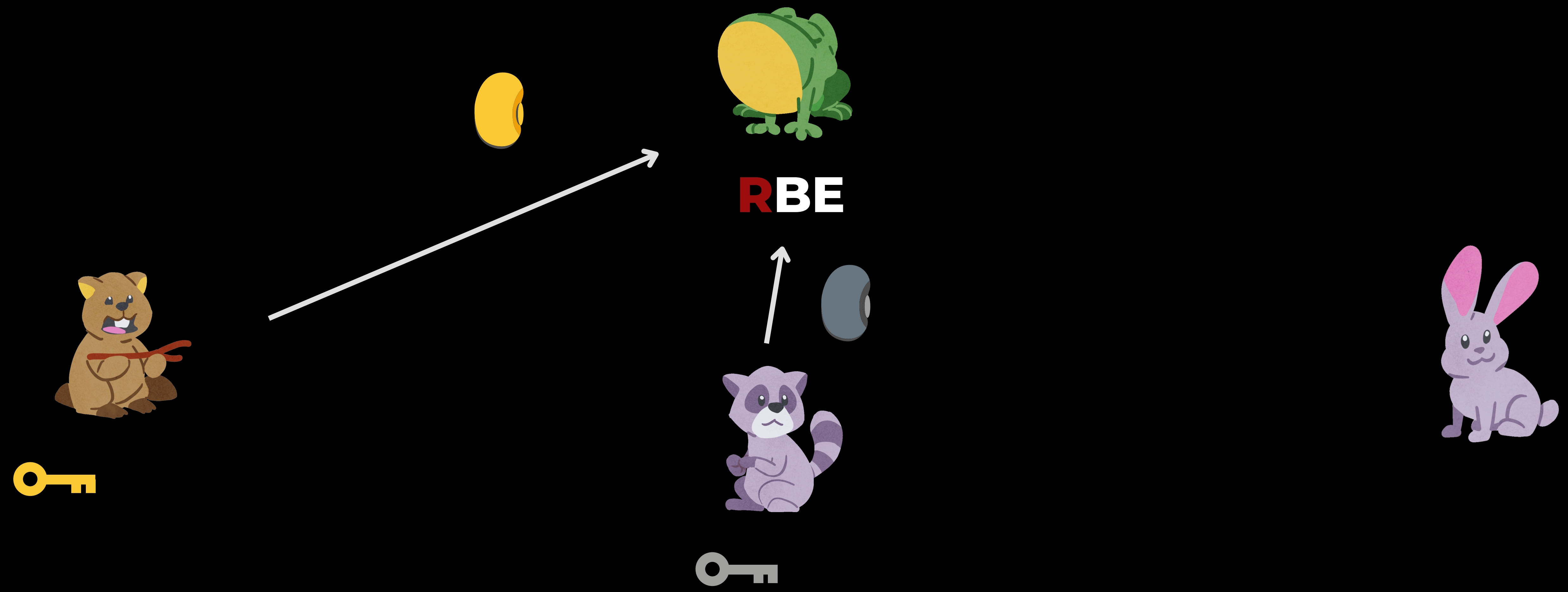

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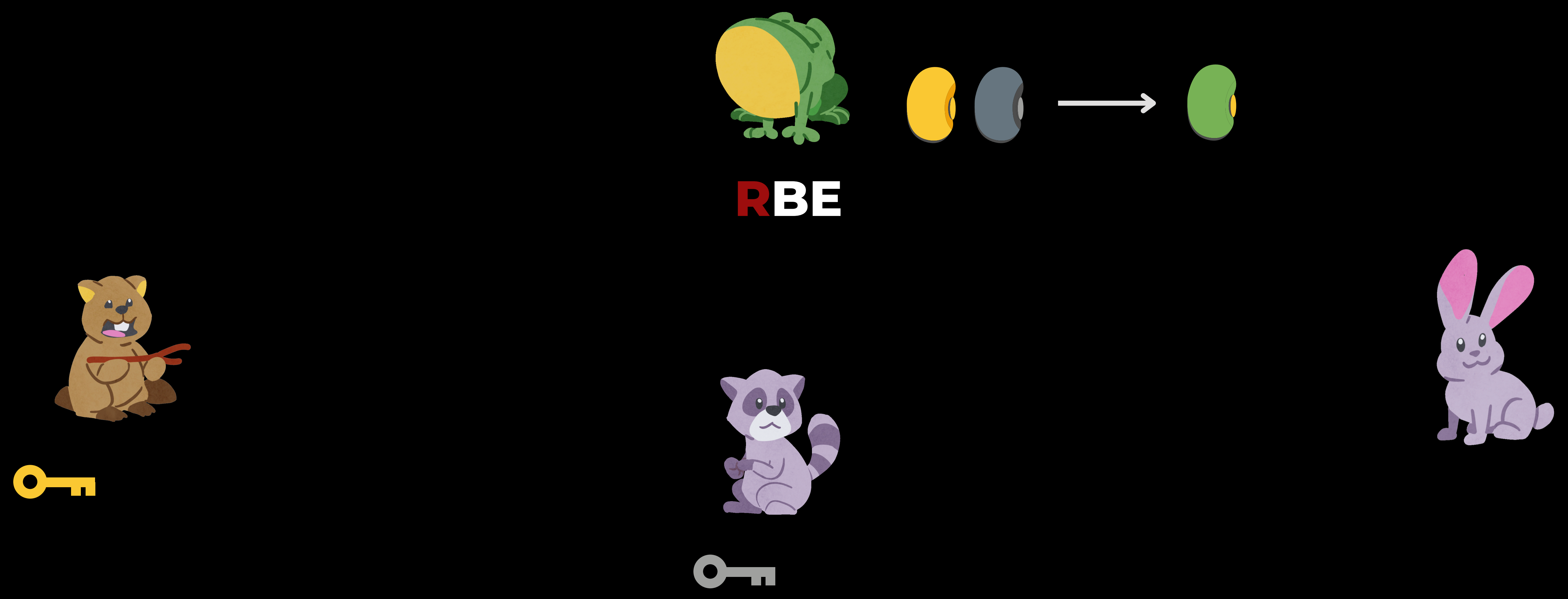

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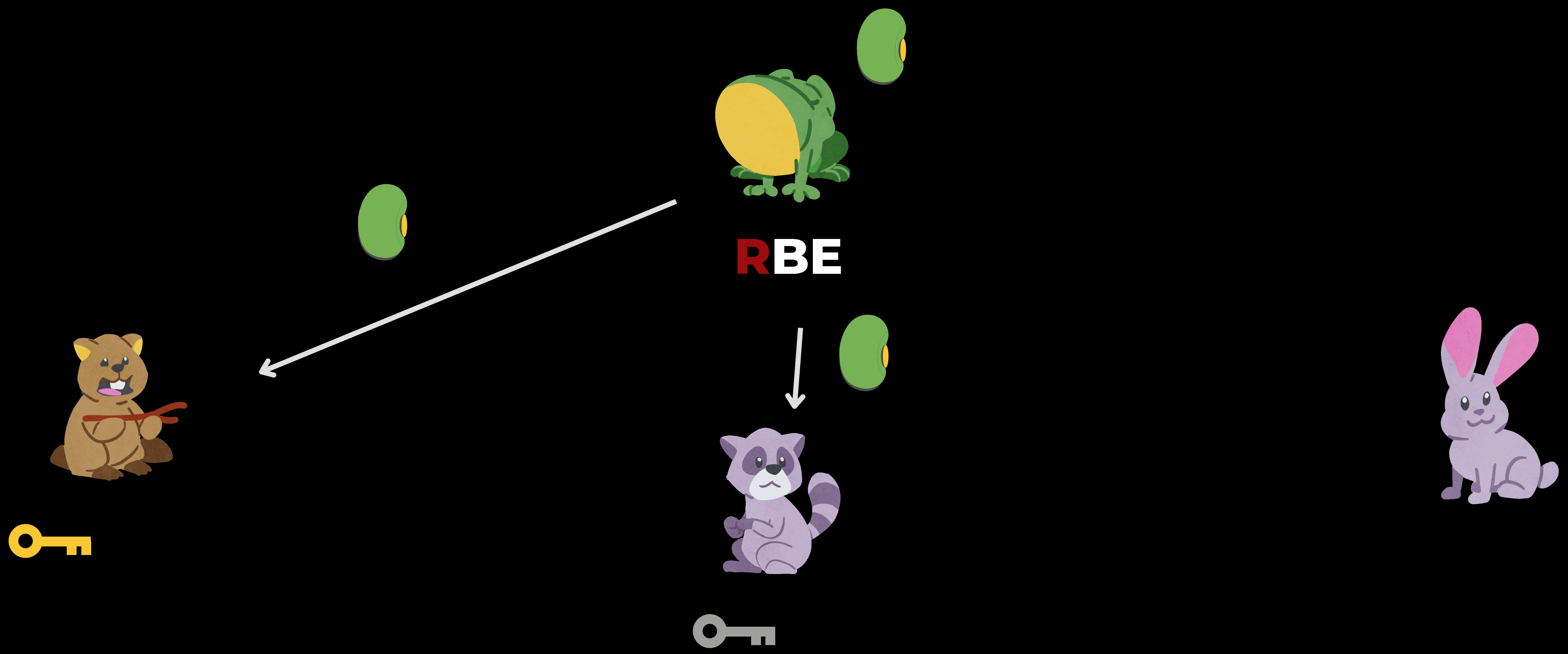

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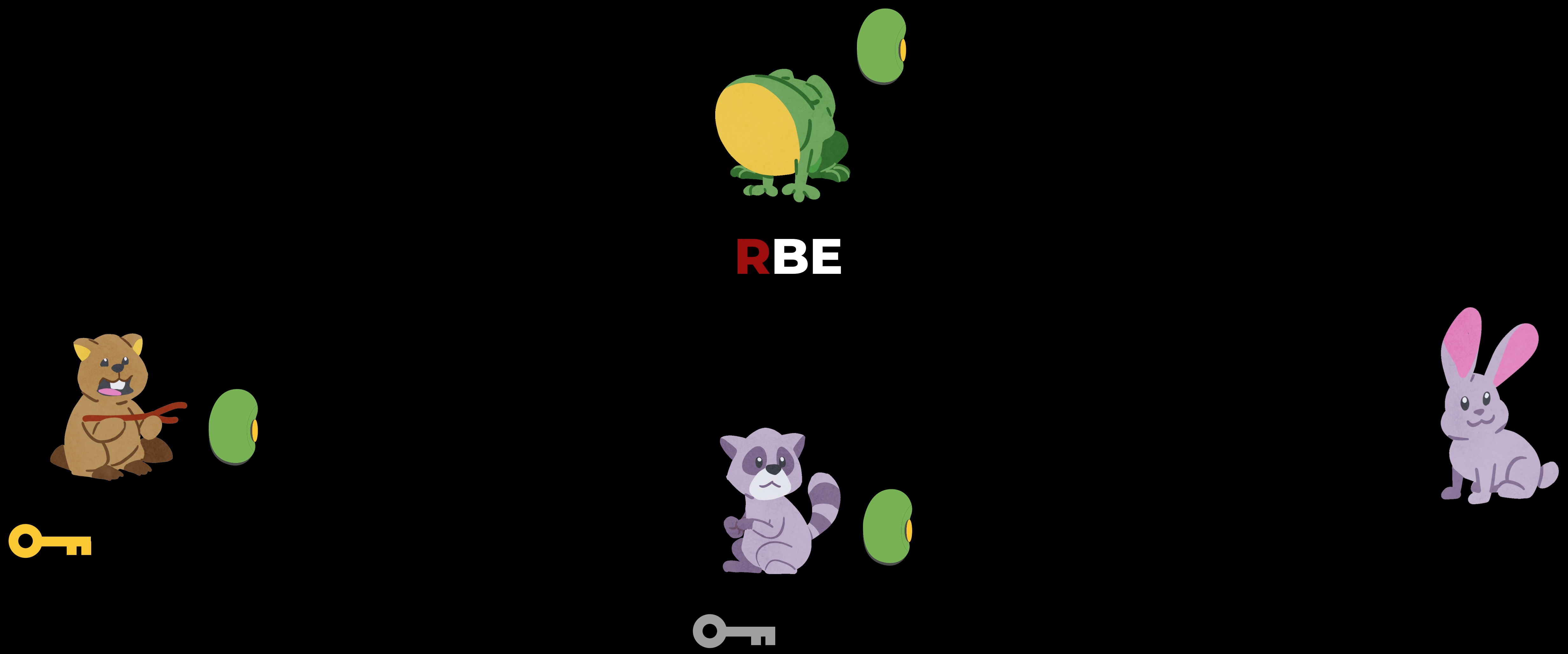

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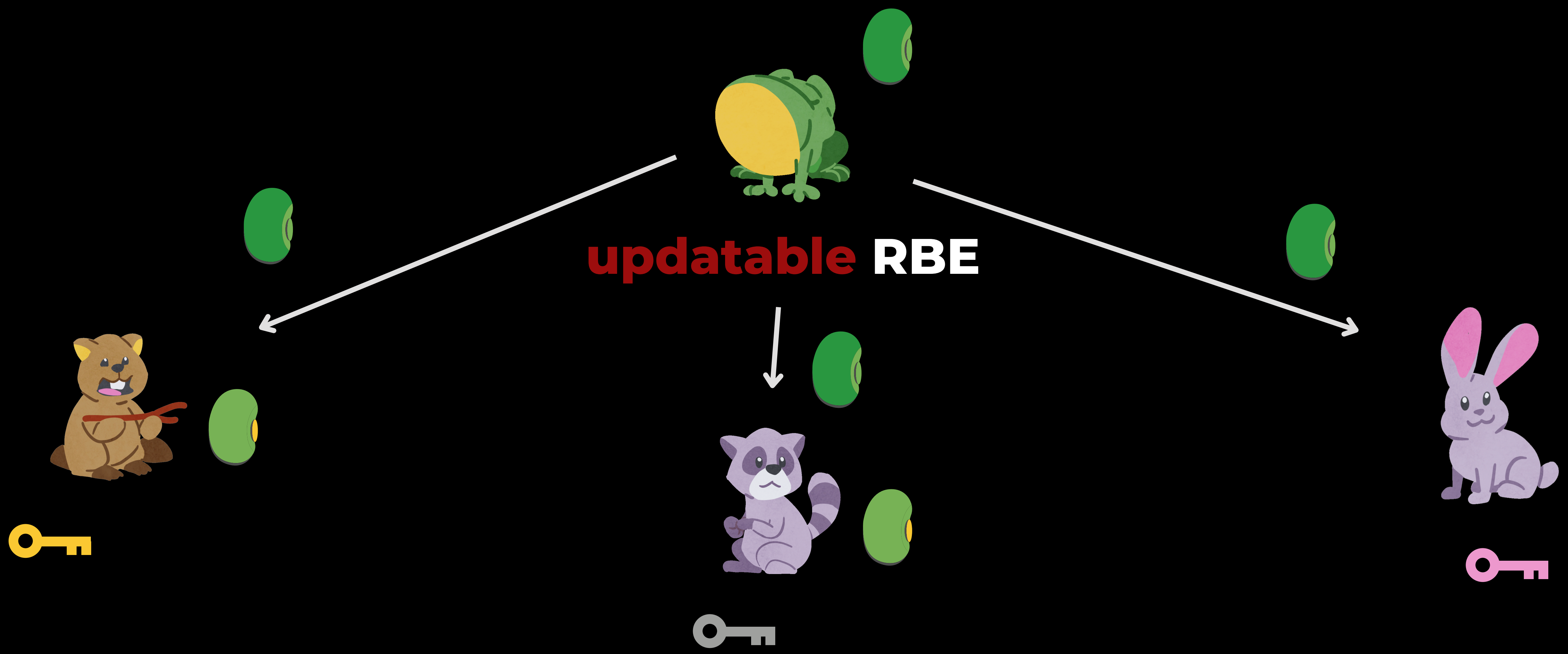

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**State-of-the-art:**
**- first constructions were very inefficient;**
**- efficient black-box constructions in [Glaeser-Kolonelos-Malavolta-Rahimi-22] but identity-space of polynomial size**
**- and [EC:Döttling-Kolonelos-Lai-Lin-Malavolta-Rahimi-23] with lattices, but ciphertexts in GB**

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| | Setting | $\mathcal{ID}$ | Compactness | $\lvert\mathsf{ct}\rvert$ | #updates | $\lvert\mathsf{pp}\rvert + \lvert\mathsf{crs}\rvert$ |
|---|---|---|---|---|---|---|
| [HLWW23] | Pairings (C) | $\{0,1\}^*$ | Adaptive | $O(\lambda \log n)$ | $\log n$ | $O(\lambda n^{2/3} \log n)$ |
| [GKMR22] | Pairings (P) | $[1, n]$ | Adaptive | $4 \log n$ | $\log n$ | $O(\sqrt{n} \log n)$ |
| Ours P1 | Pairings (P) | $\{0,1\}^*$ | Adaptive | $6\lambda \log n$ | $\log n$ | $O(\sqrt{\lambda n} \log n)$ |
| Ours P2 | Pairings (P) | $\{0,1\}^*$ | Selective | $12 \log n$ | $\log n$ | $O(\sqrt{n} \log n)$ |
| [DKL+23] | Lattices | $\{0,1\}^*$ | Adaptive | $(2\lambda + 1) \log n$ | $\log n$ | $O(\log n)$ |
| Ours L | Lattices | $\{0,1\}^*$ | Selective | $4 \log^2 n$ | $\log n$ | $O(\log n)$ |

Table 1: Comparison of the schemes resulting from different instantiations of our compiler. $n$ is the maximum number of users to be registered. Parings (P) indicates prime order groups and Pairings (C) composite order groups respectively. $\lvert\mathsf{ct}\rvert$ in the pairing construction is measured in group elements and in the Lattice constructions LWE ciphertexts.

# A TECHNIQUE BASED ON CUCKOO HASHING

A NEW SETTING FOR CUCKOO HASHING

# CUCKOO HASHING

**A powerful technique**

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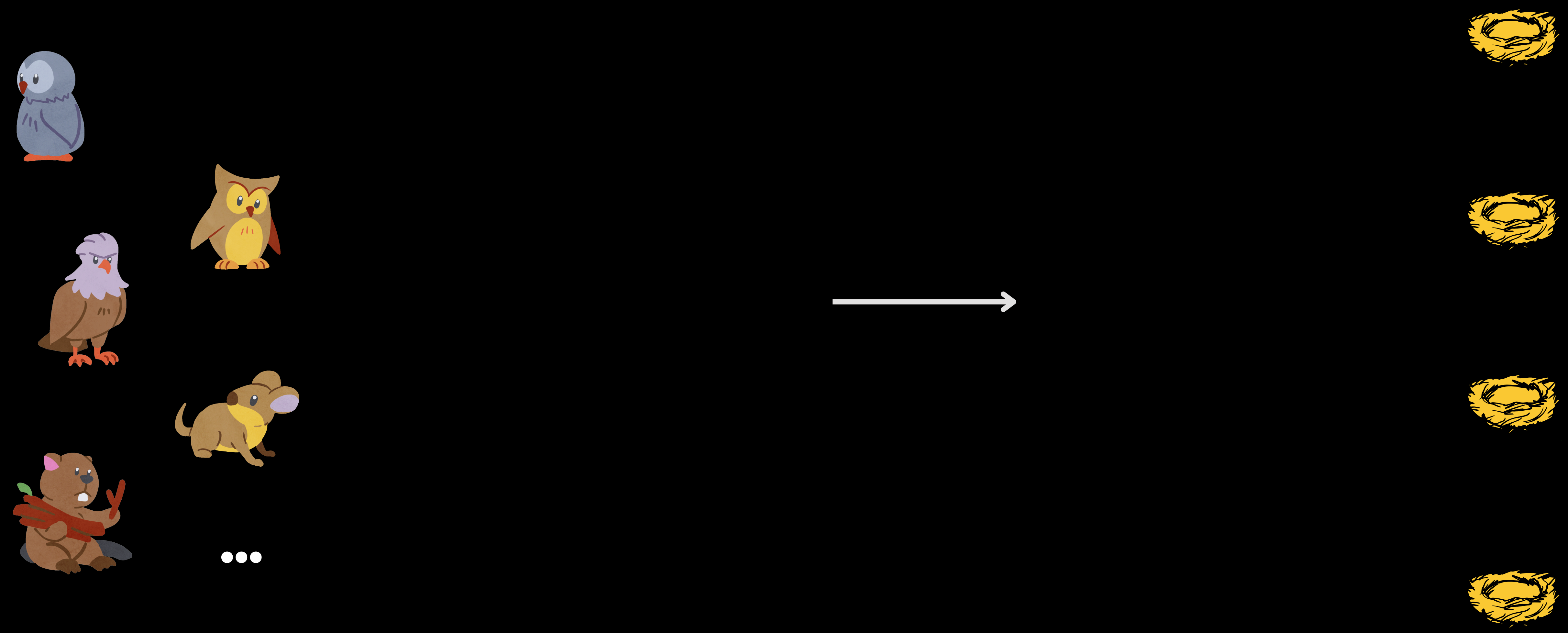

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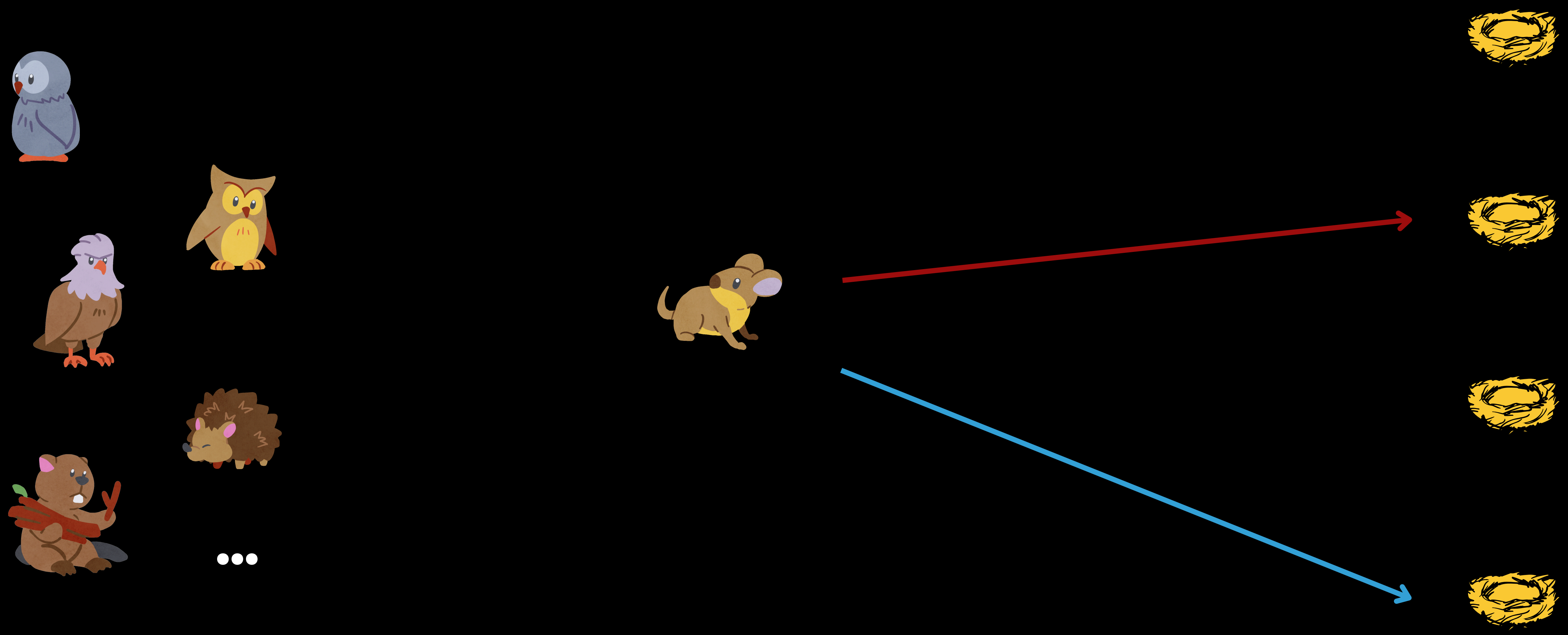
**A powerful technique; an example with two hash functions, and one animal per nest**



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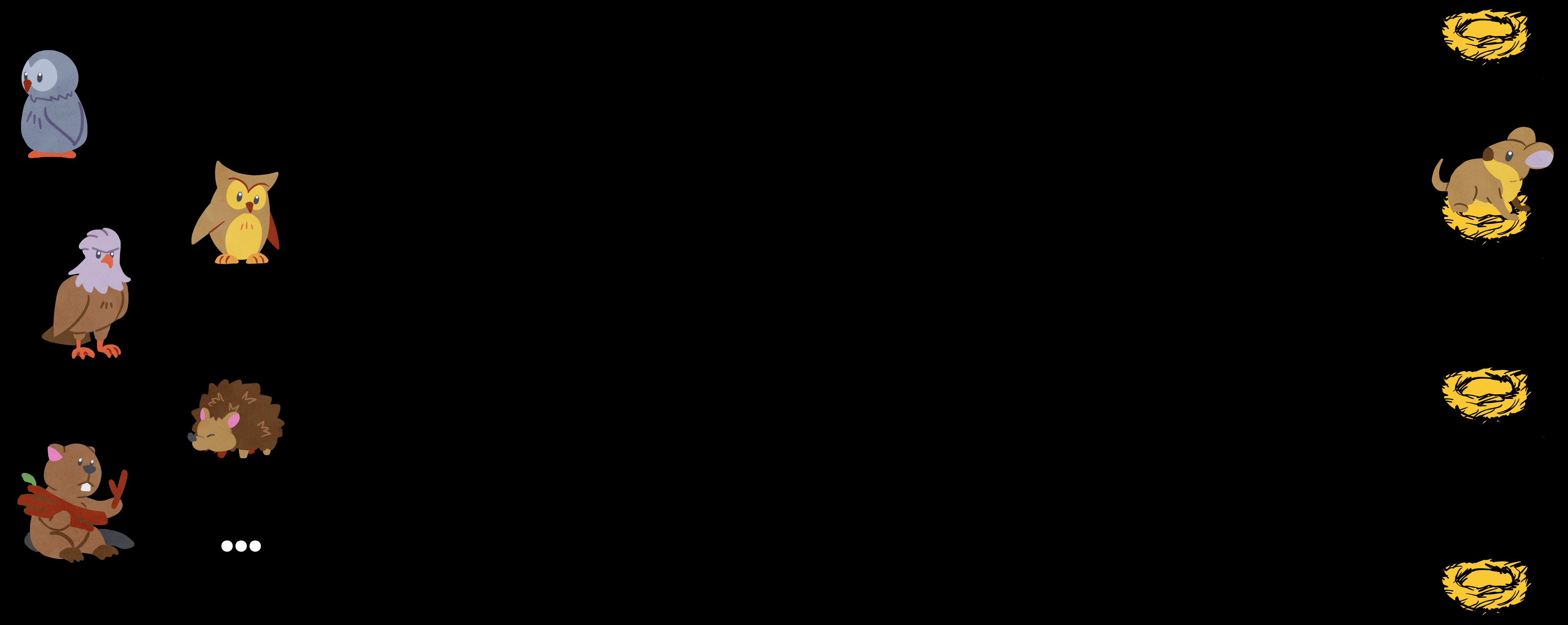

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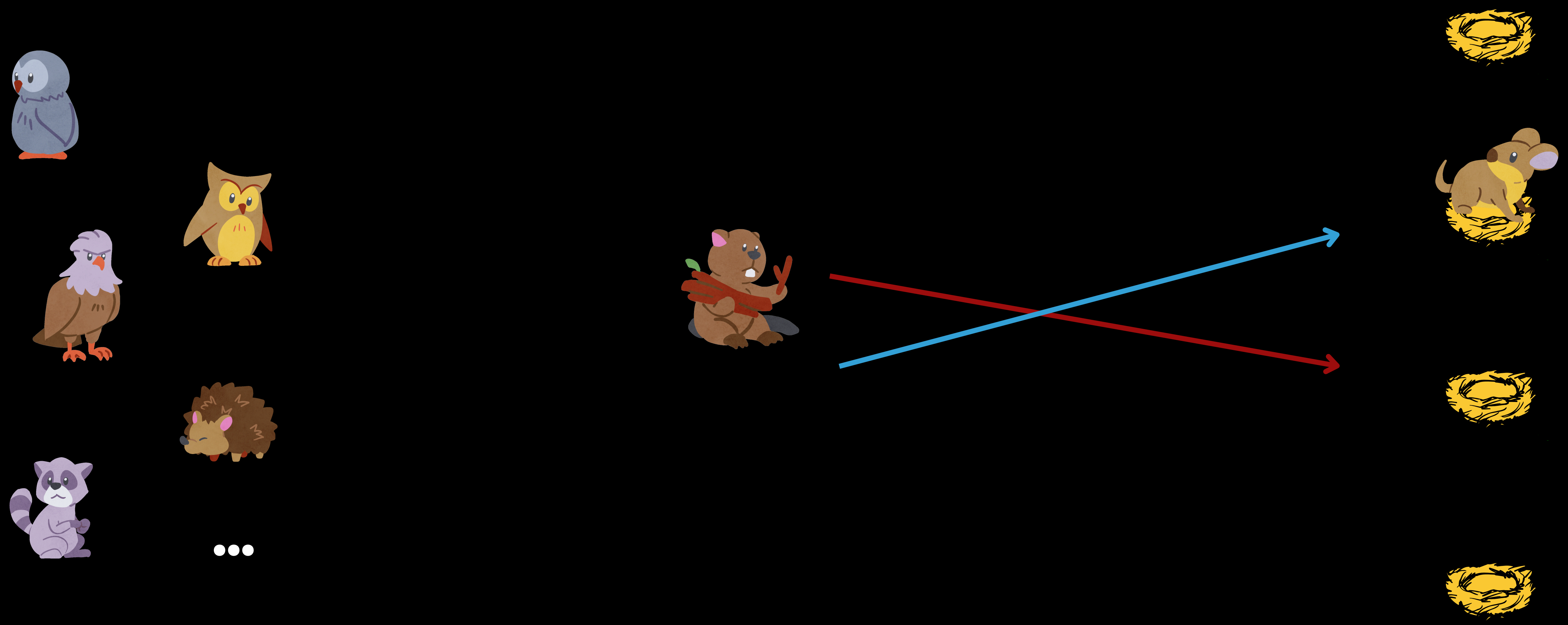

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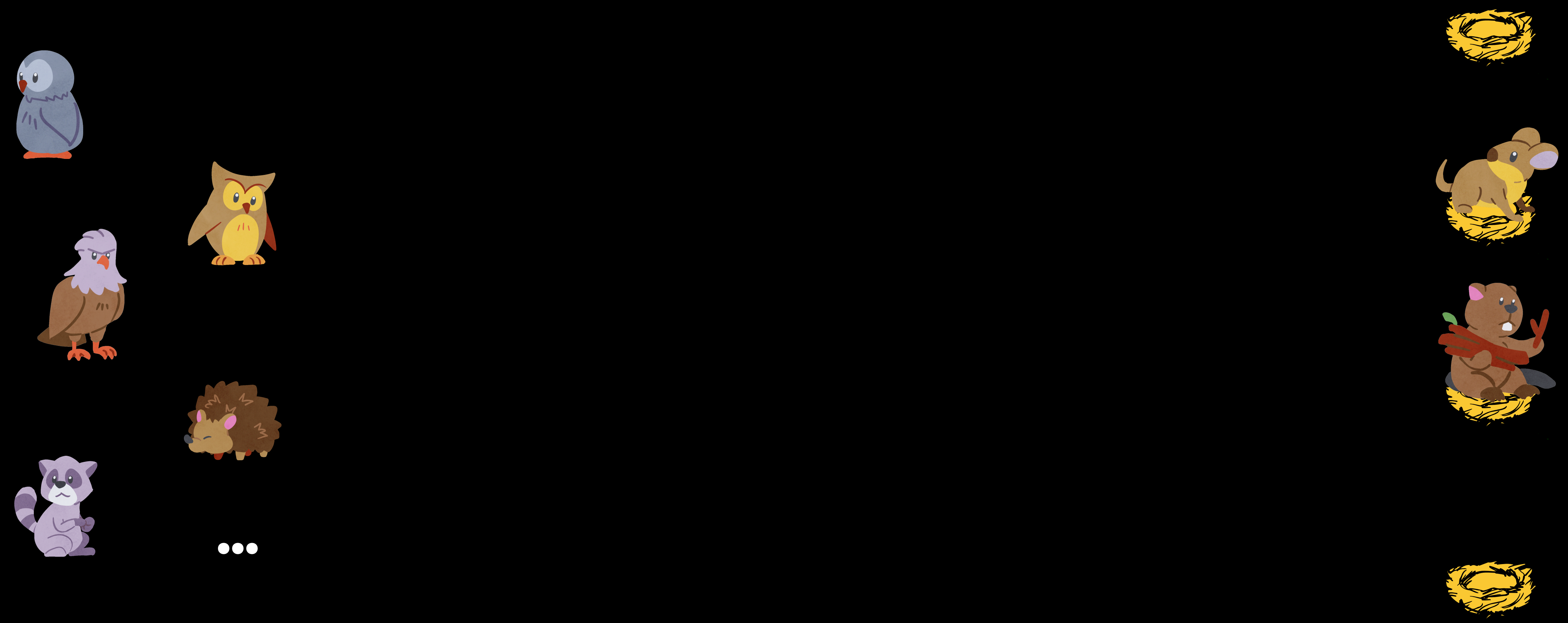

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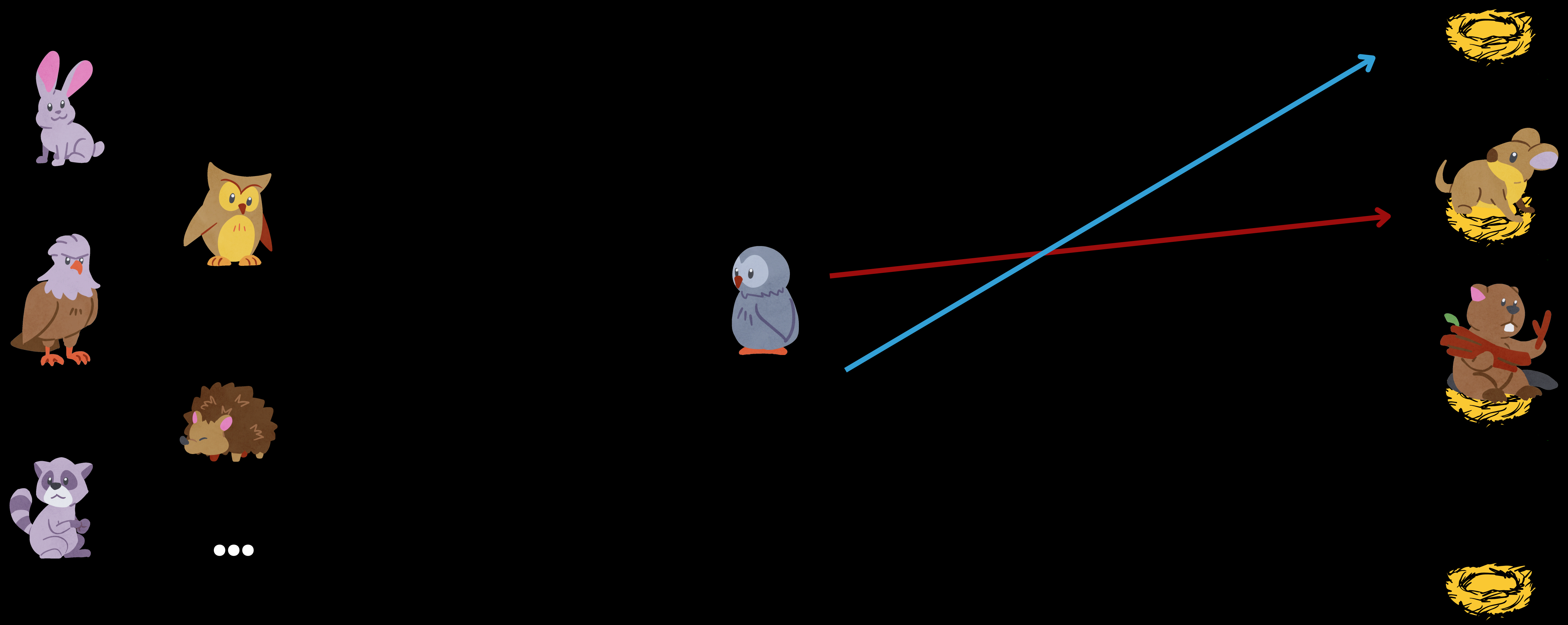

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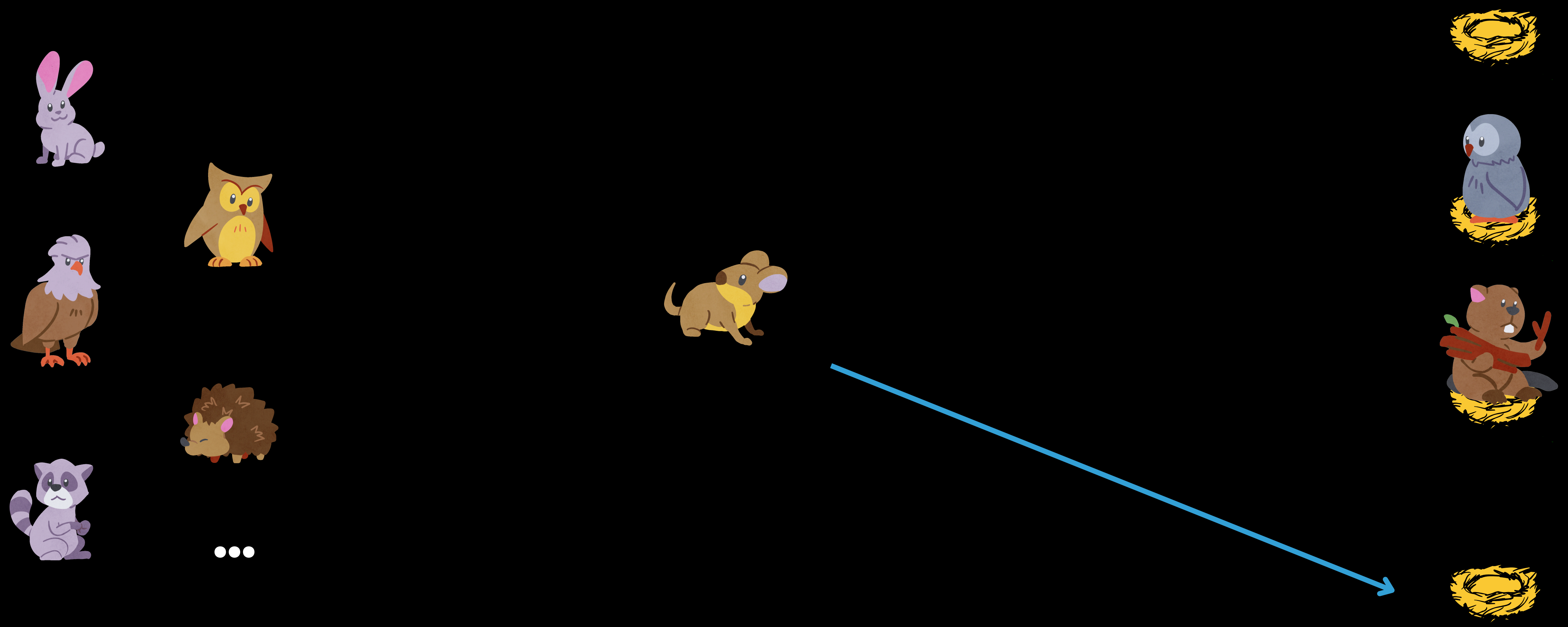

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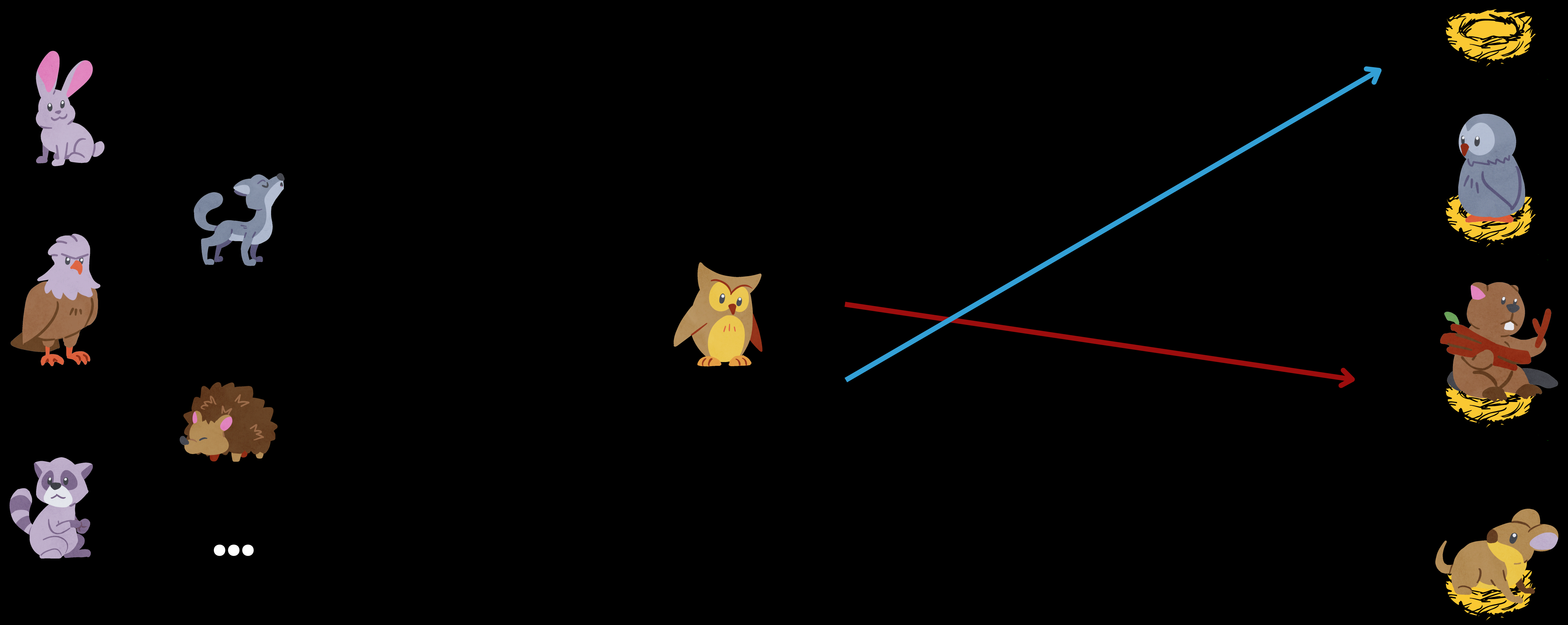

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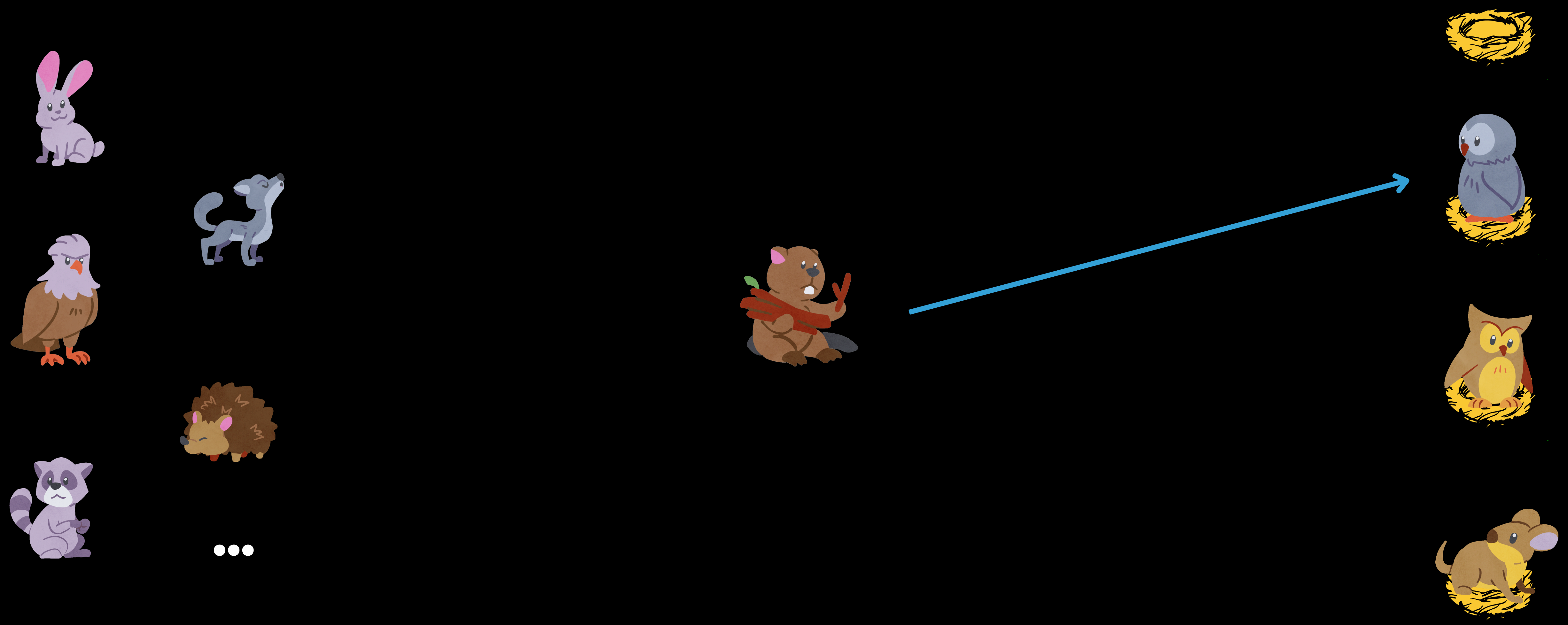

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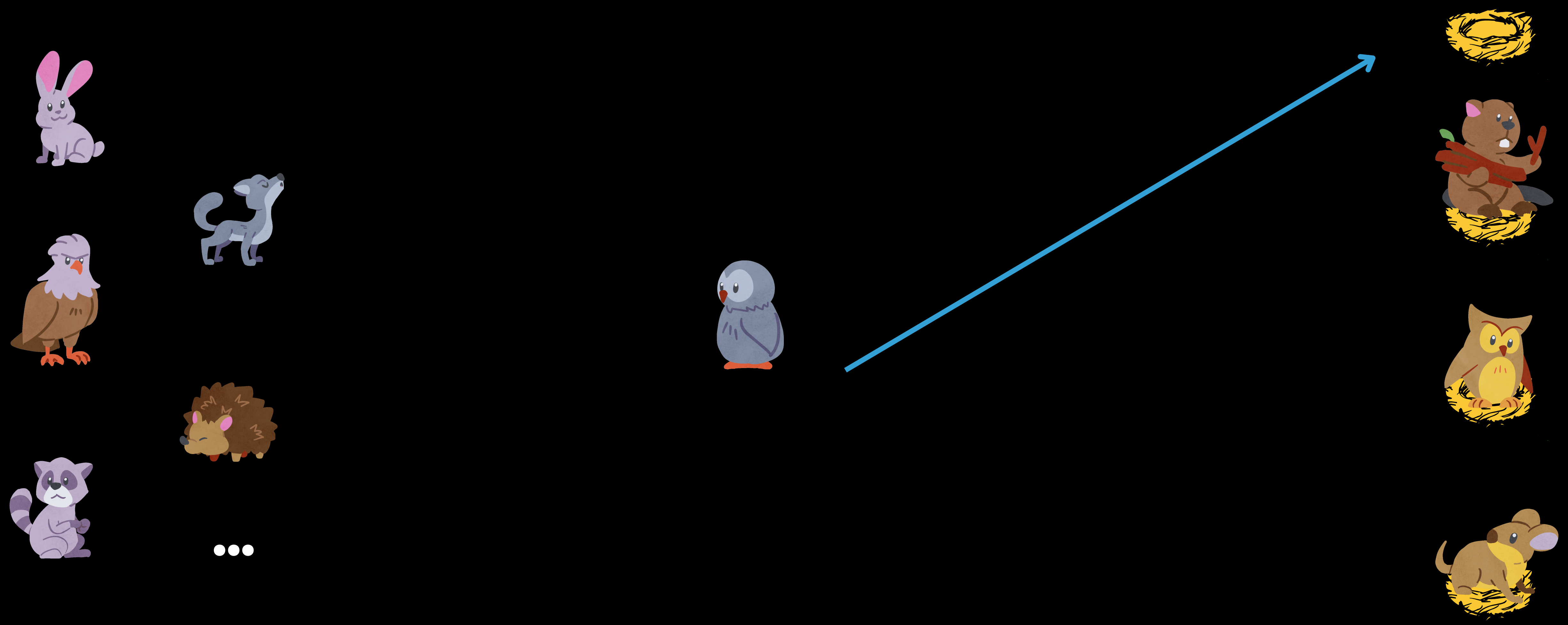

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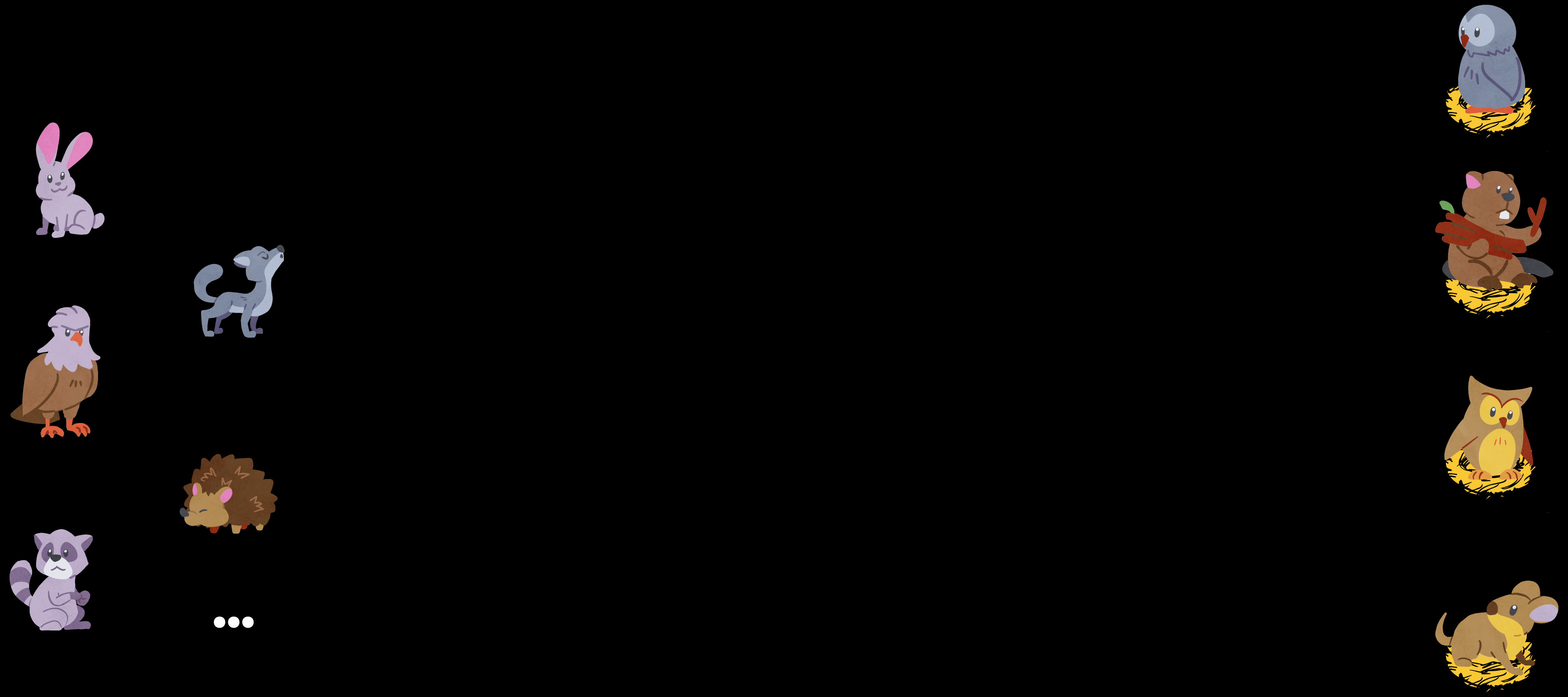

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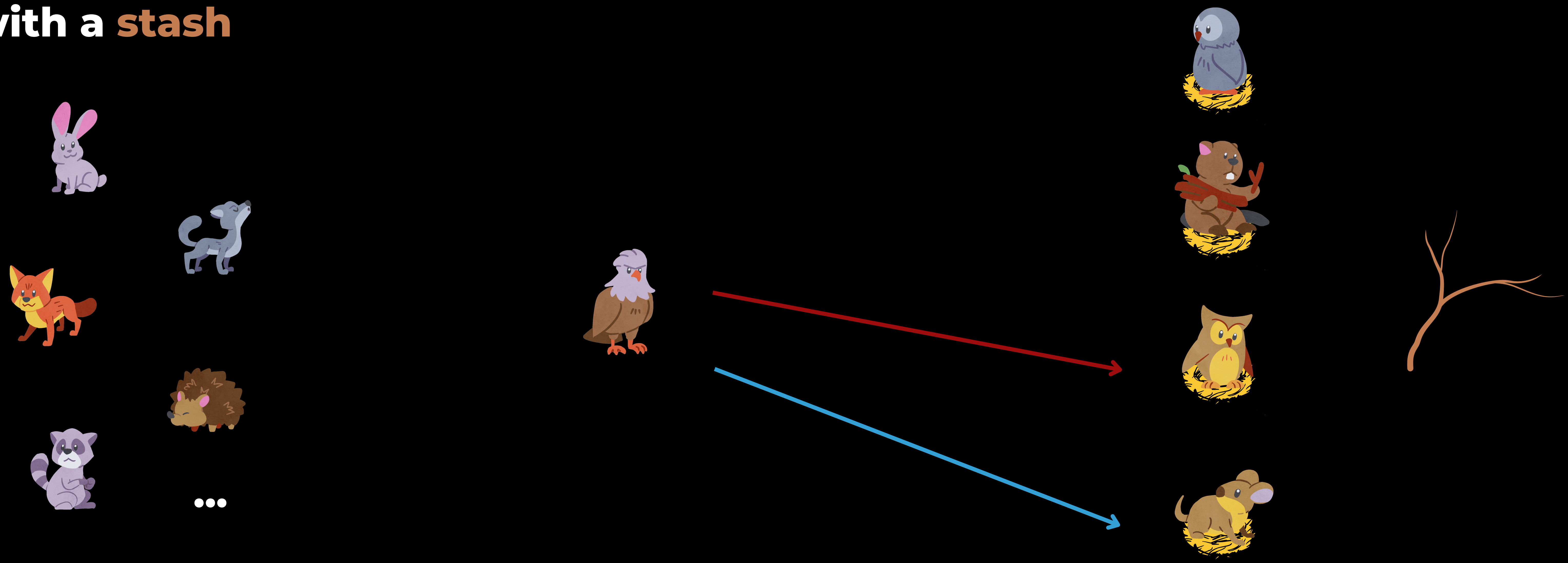

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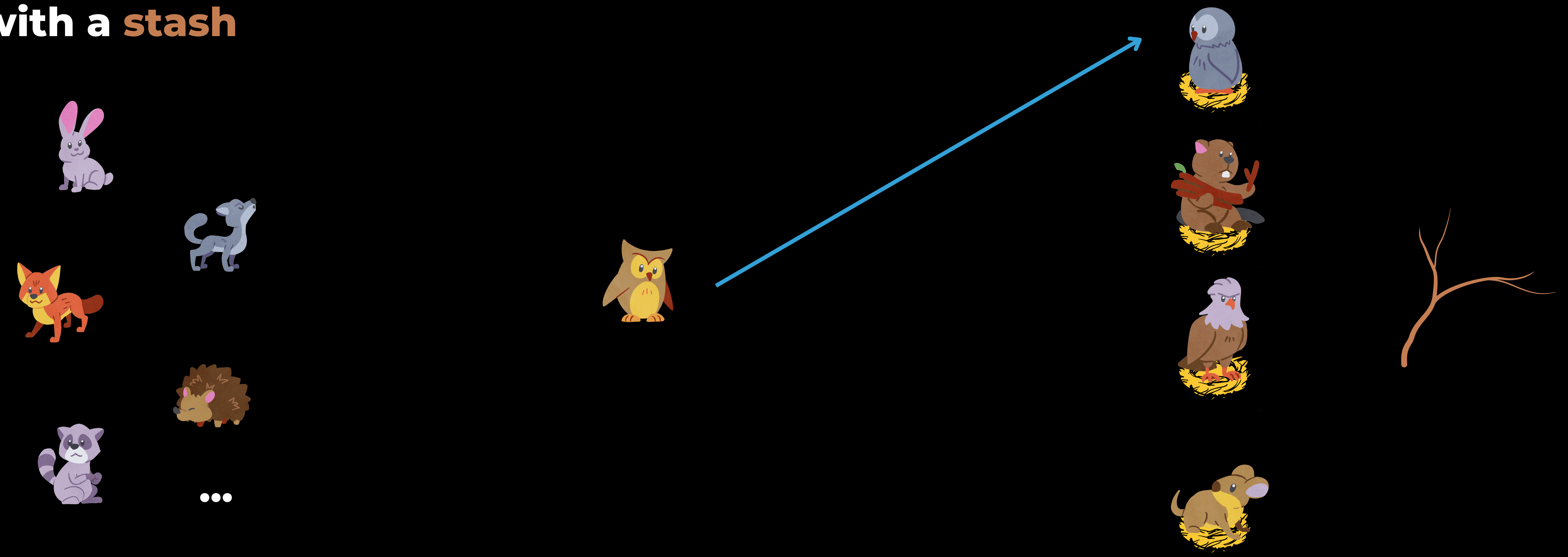

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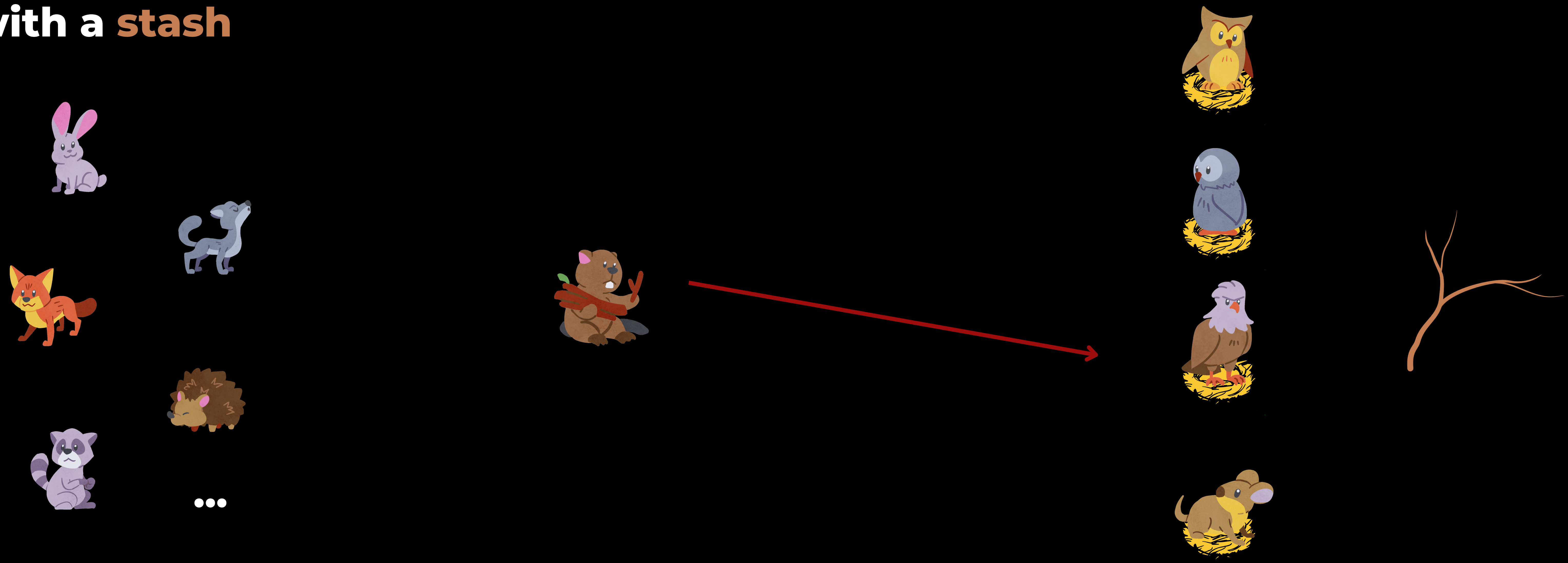

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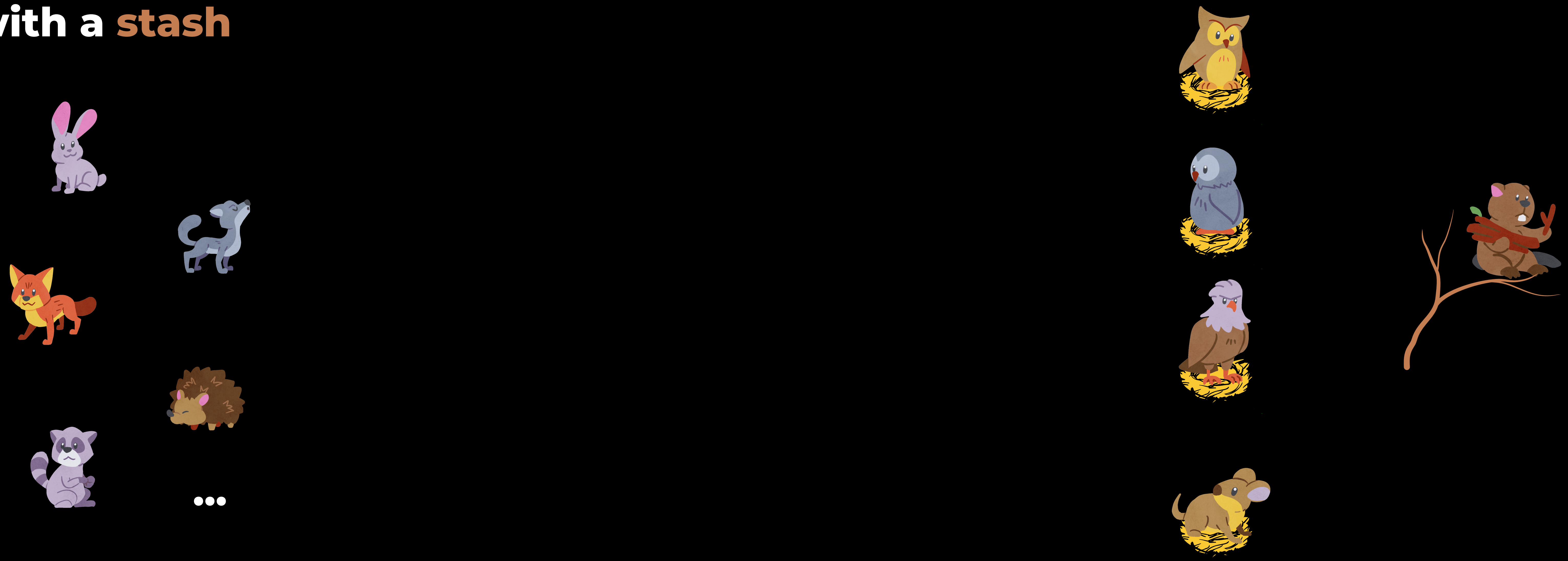

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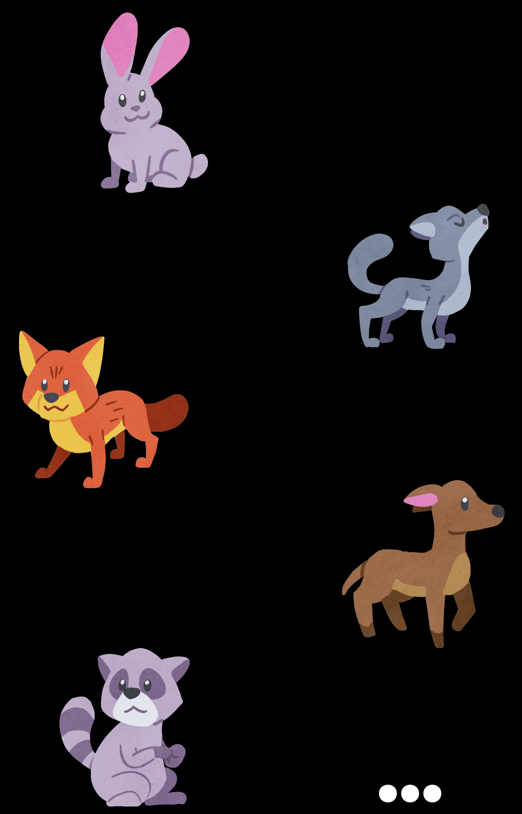

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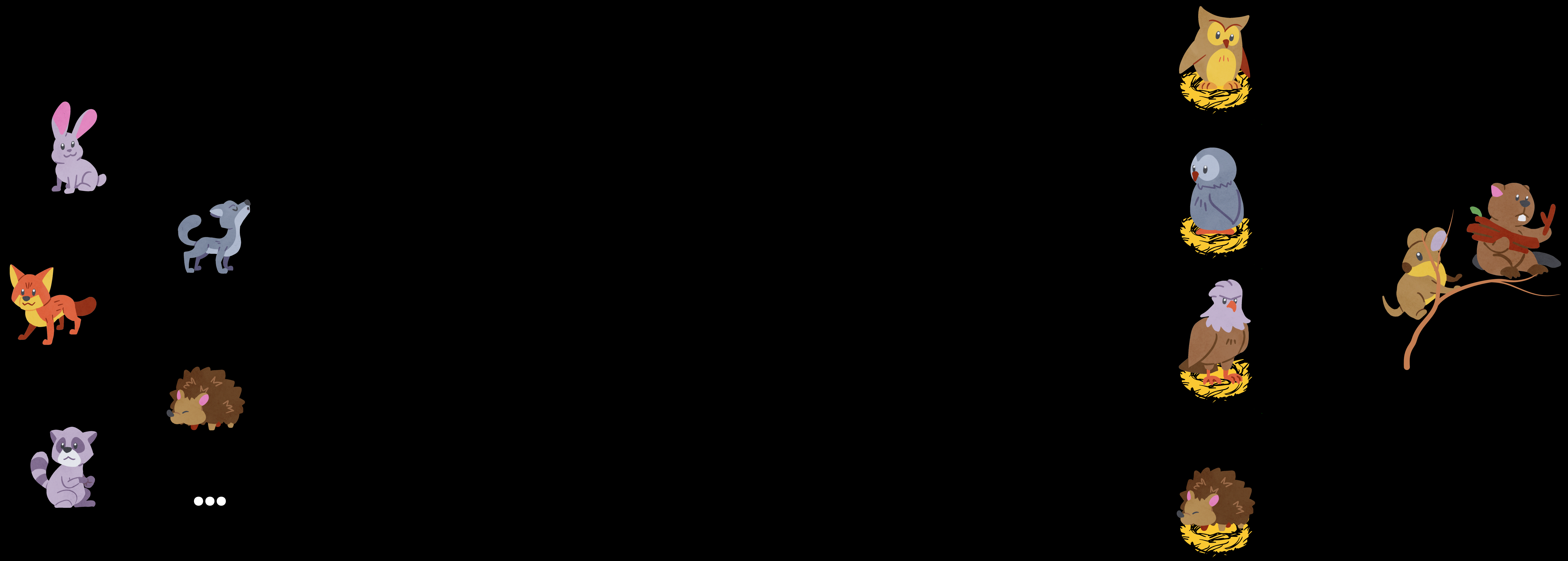
# CUCKOO HASHING

## Performance



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**Performance, for negligible failure (in λ):**
**- h = 2 hash functions, N = 2hn nests with capacity one, to store n animals:**
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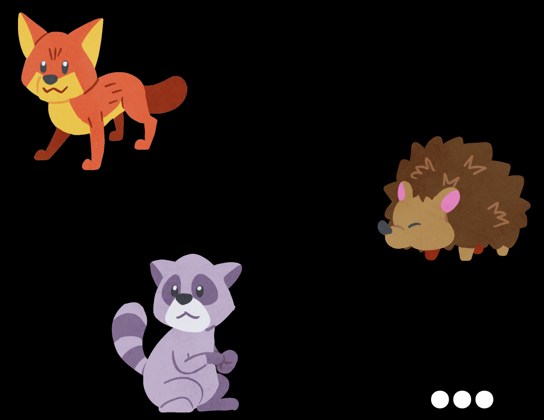
**- h = 2, N = 2kn nests: average constant insertion, worst-case n stash**



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**- $h = 2$, $N = 2kn$ nests: average constant insertion, worst-case $n$ stash**

**- $h = \lambda$, $N = 2\lambda n$ nests: average $\lambda$ time insertion, worst-case empty stash**

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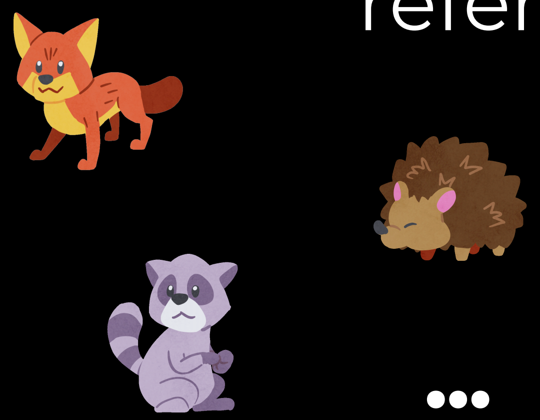
reference for parameters in cryptography: [C:Yeo23]



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# OUR CONSTRUCTION

**USING CUCKOO HASHING WITH VECTOR COMMITMENTS (VC), AND WITNESS ENCRYPTION FOR VC (VCWE)**

# THE GLAESER-KOLONELOS-MALAVOLTA-RAHIMI (GKMR) RBE, USING LIBERT-YUNG VECTOR COMMITMENTS [TCC:LY10]

$$\mathsf{crs} = g_1, g_2, g_3, g_5, g_6$$

 $= 1$

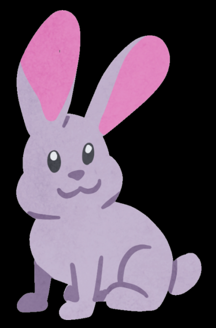
$\longrightarrow \; = g_1$

$g_2, g_3$

 $= 2$

$g_3, g_5$

$\longrightarrow \; = g_2$



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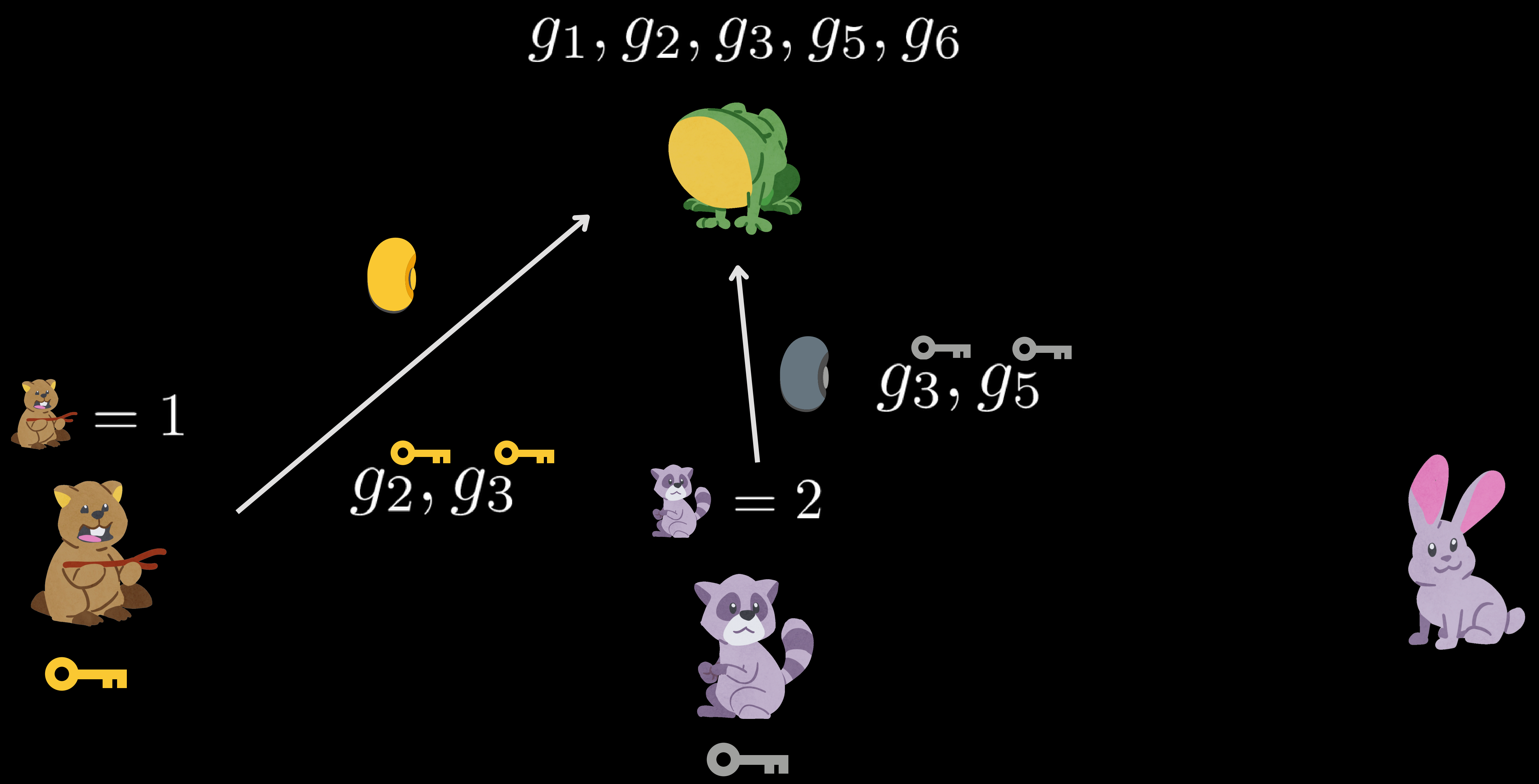

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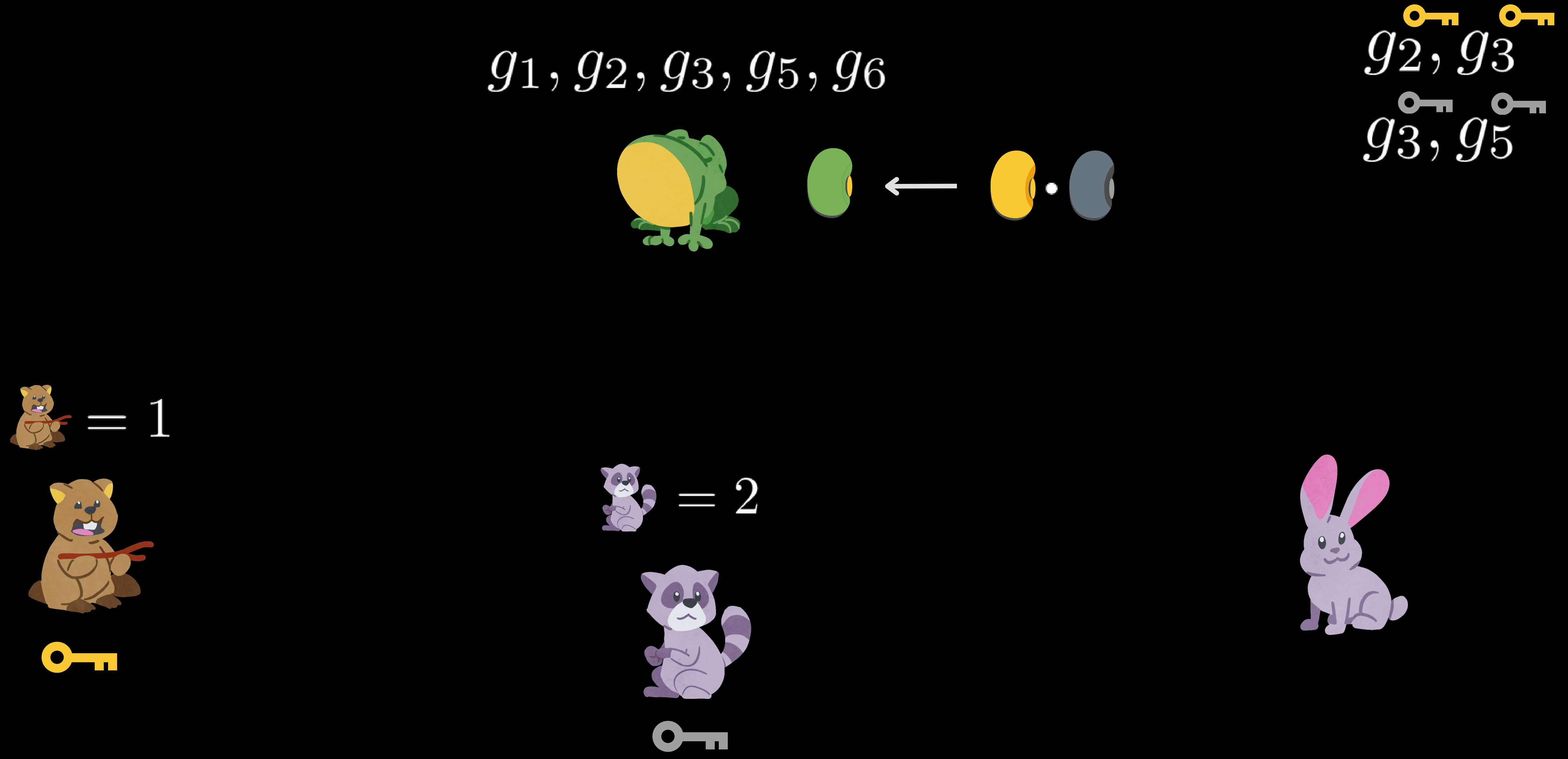

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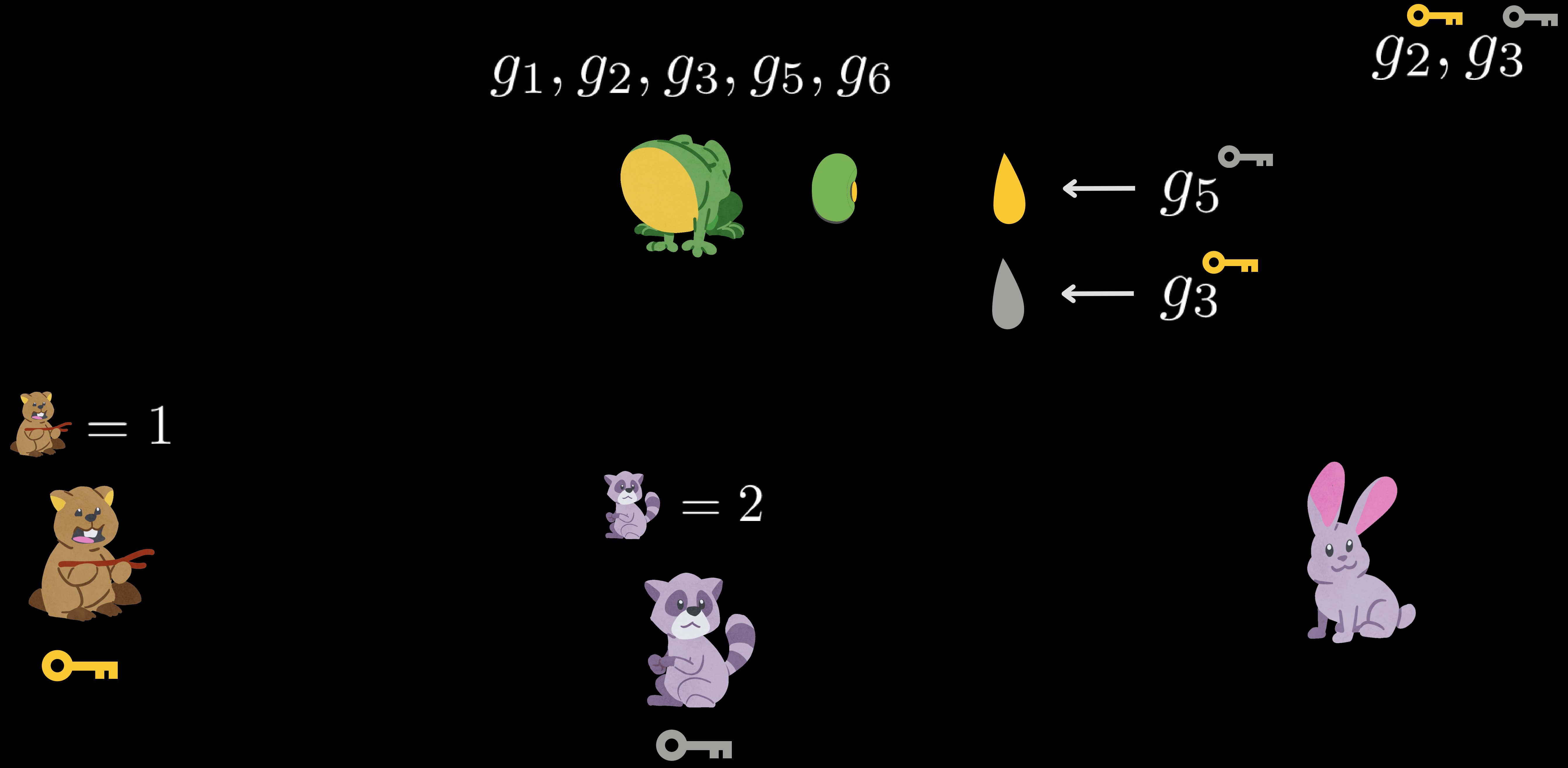

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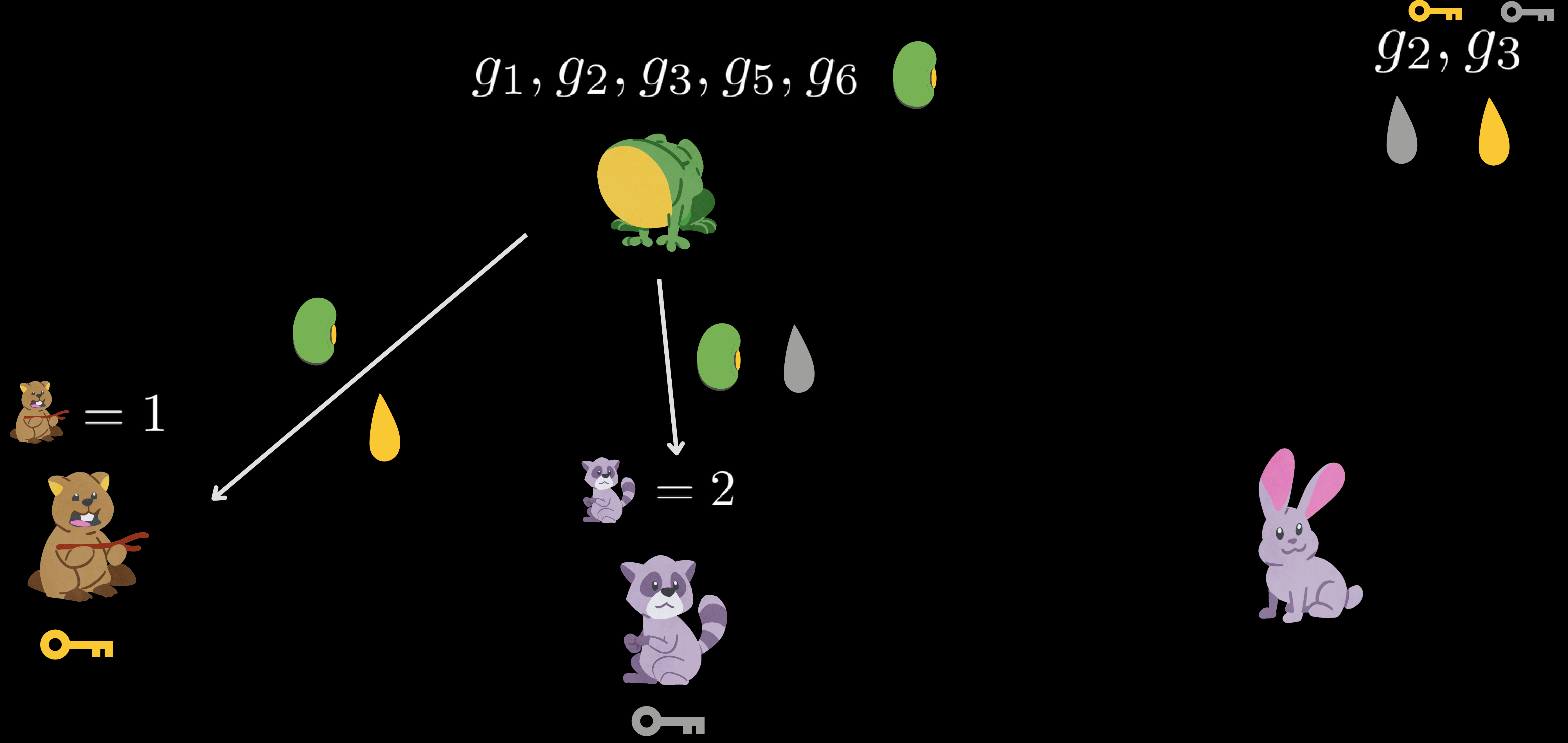

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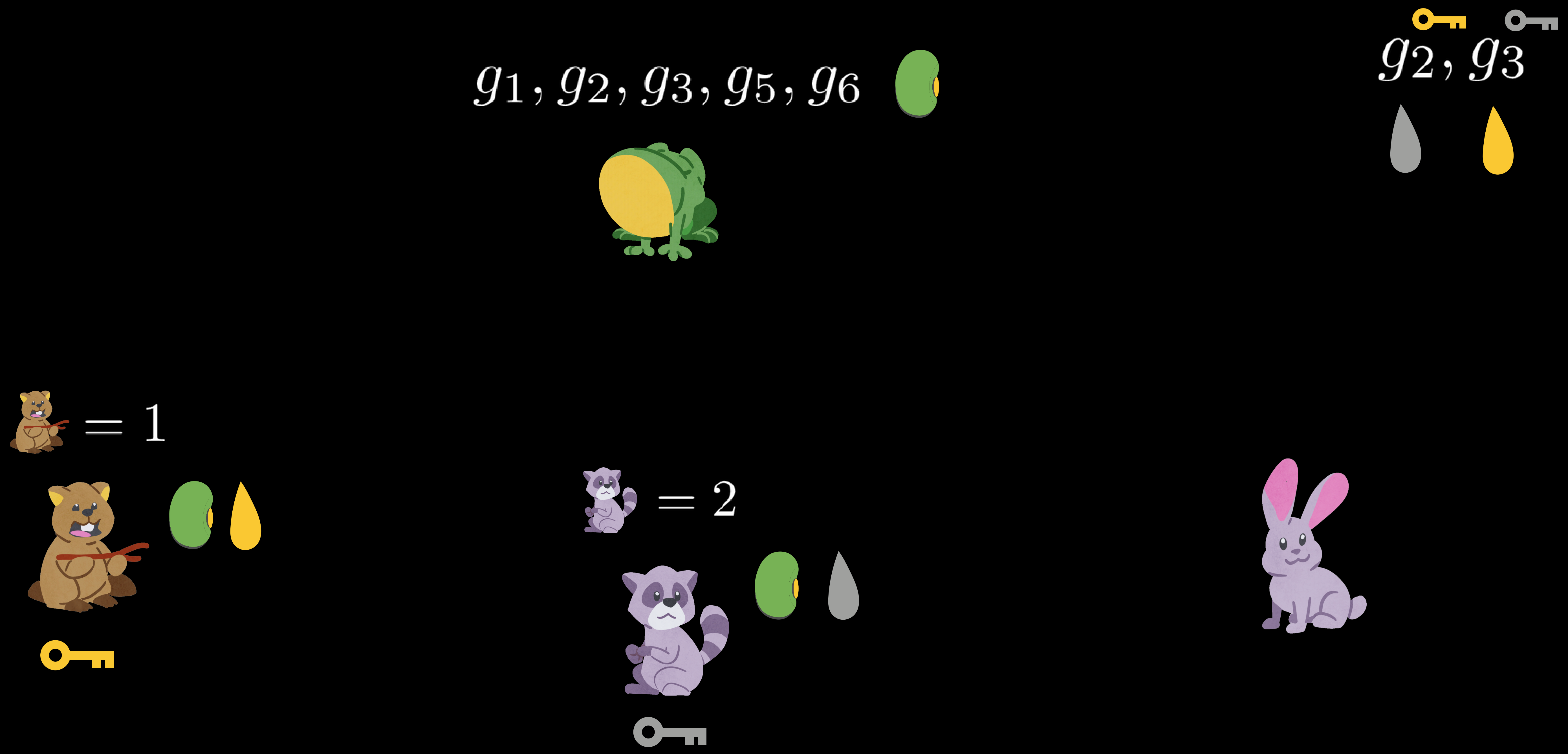

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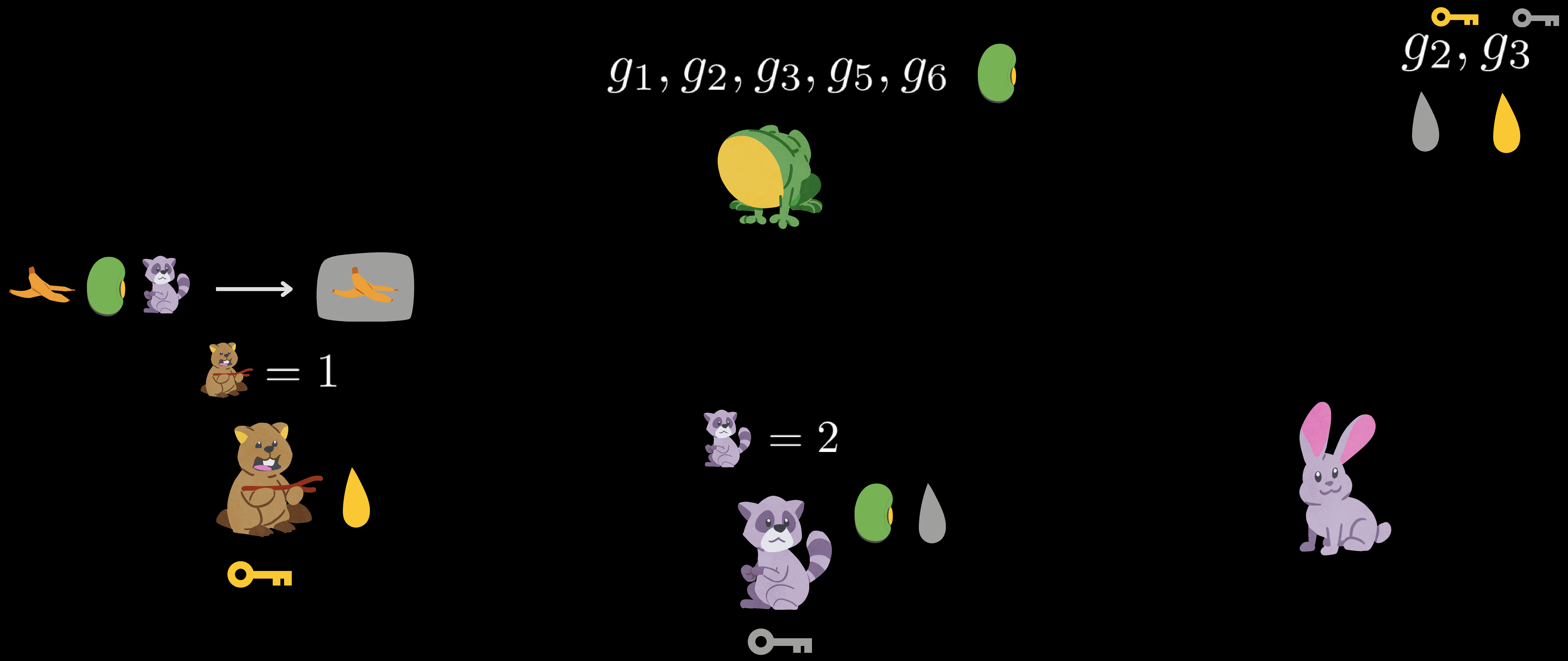

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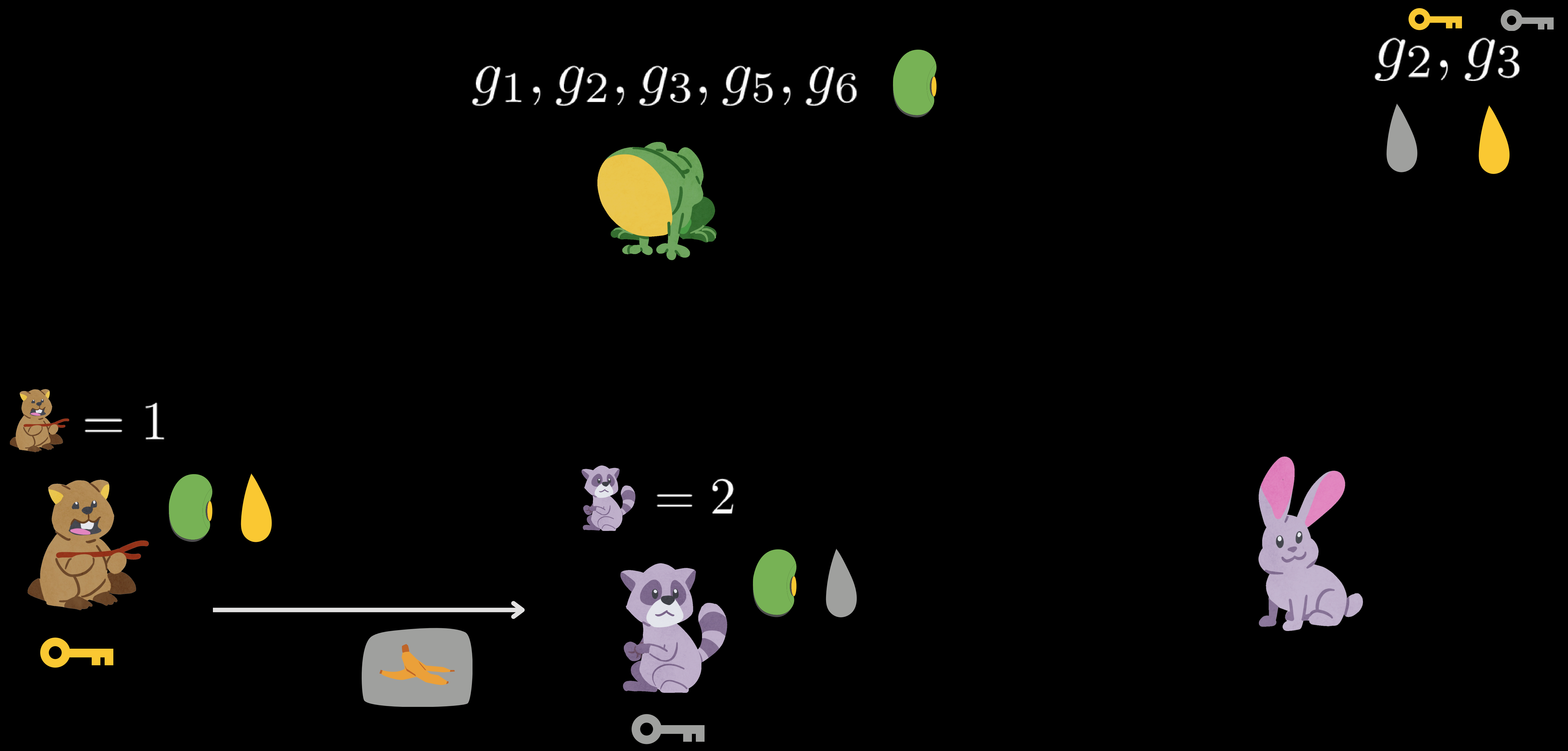

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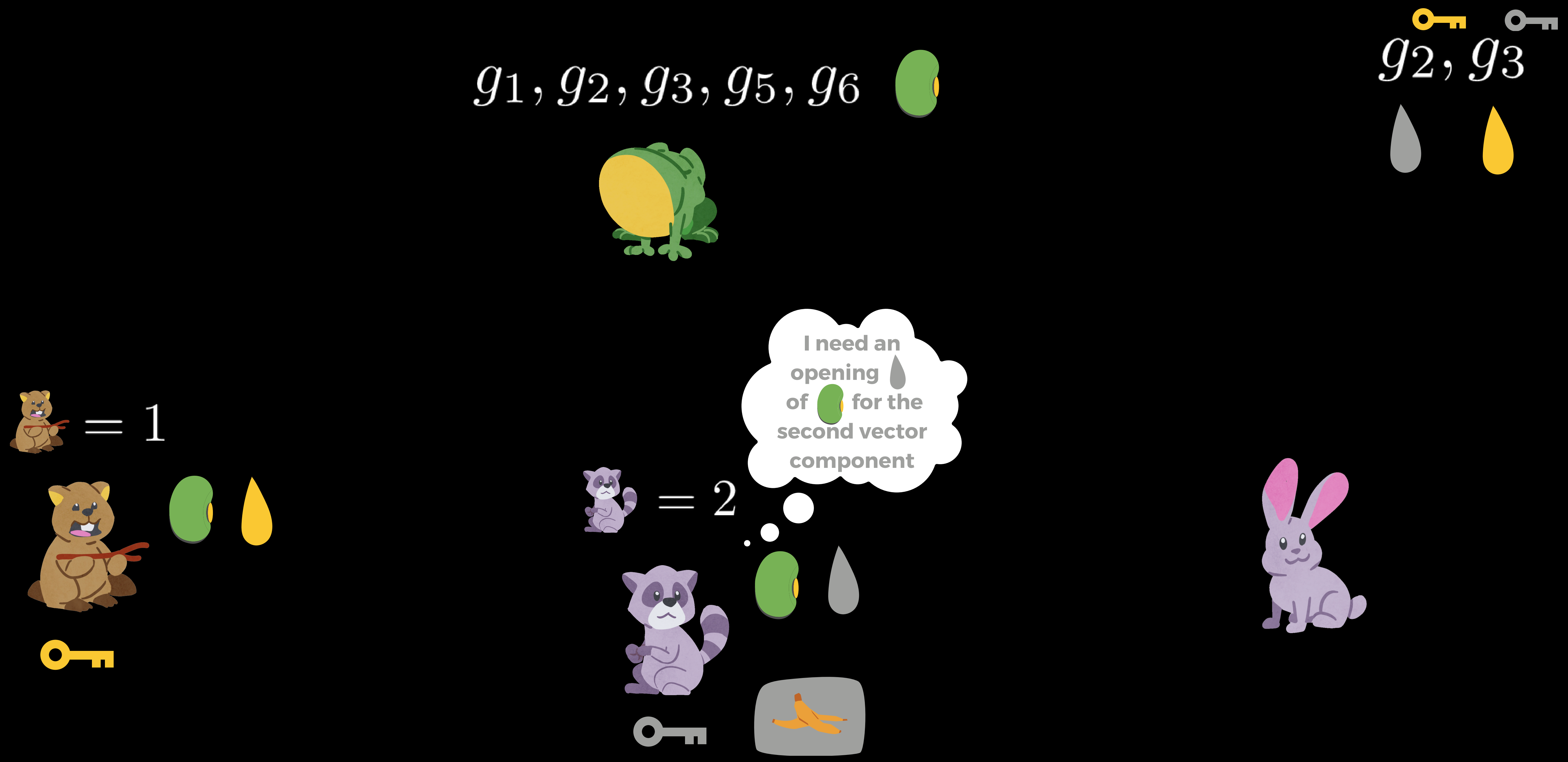

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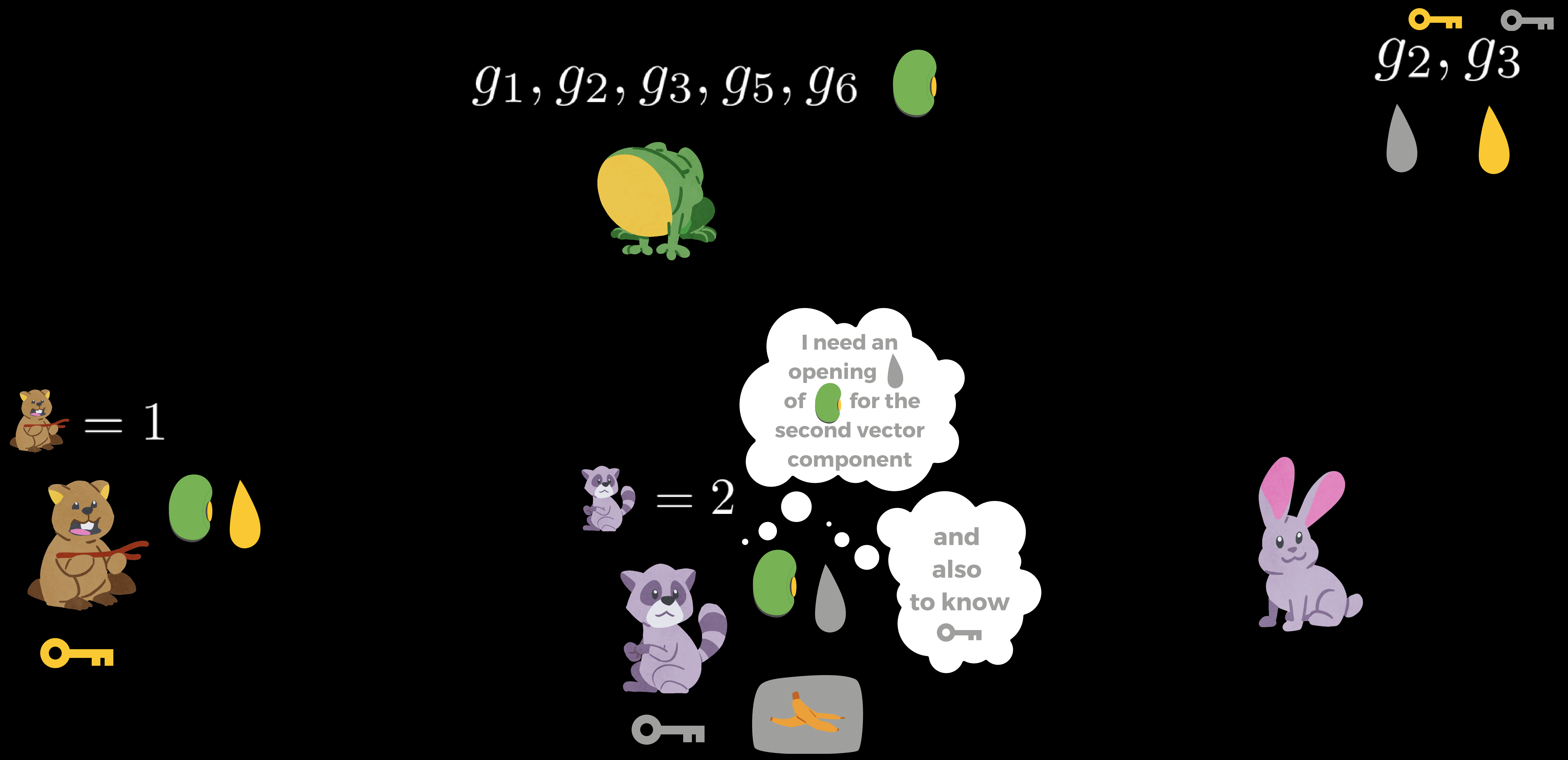

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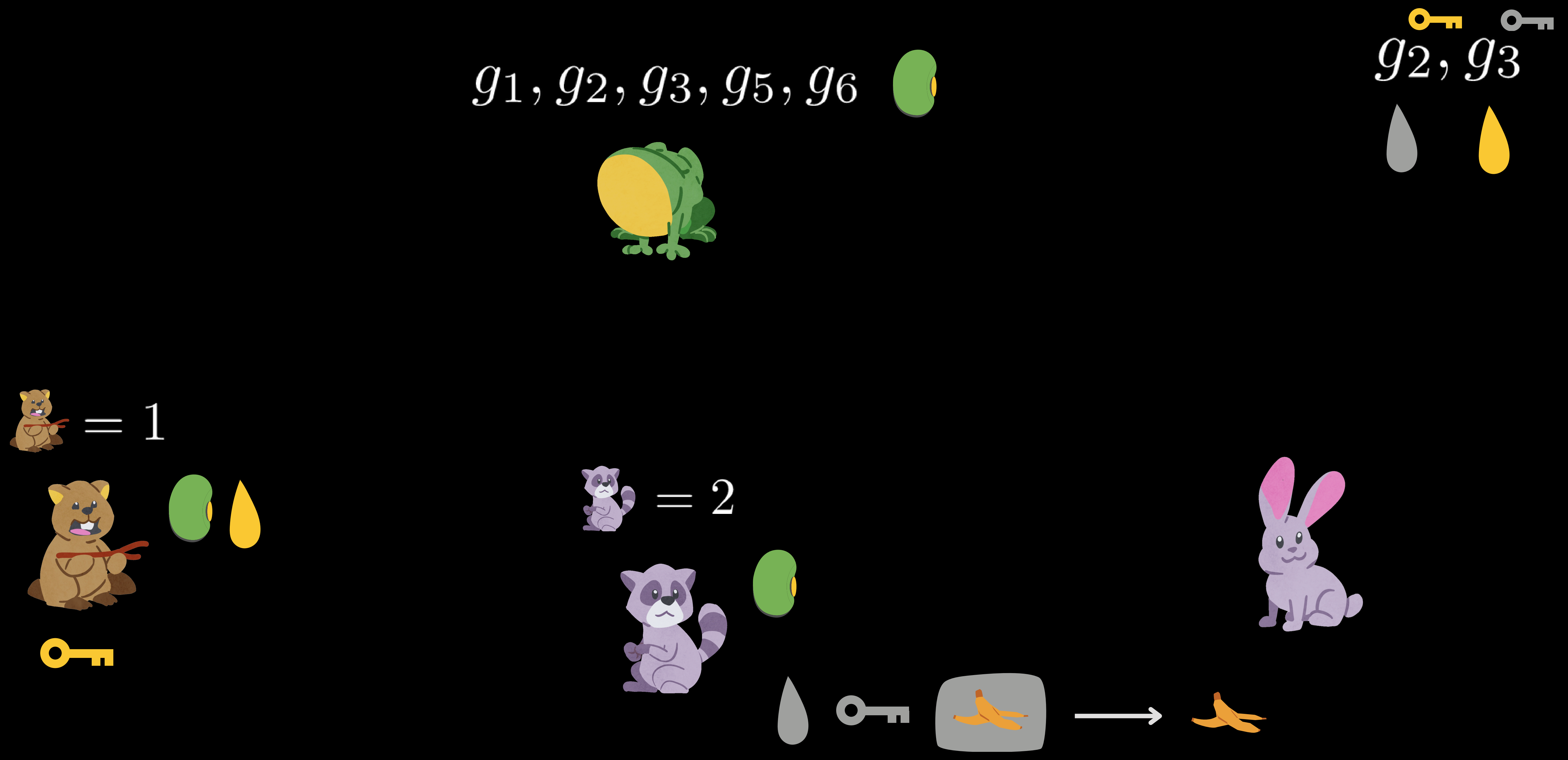

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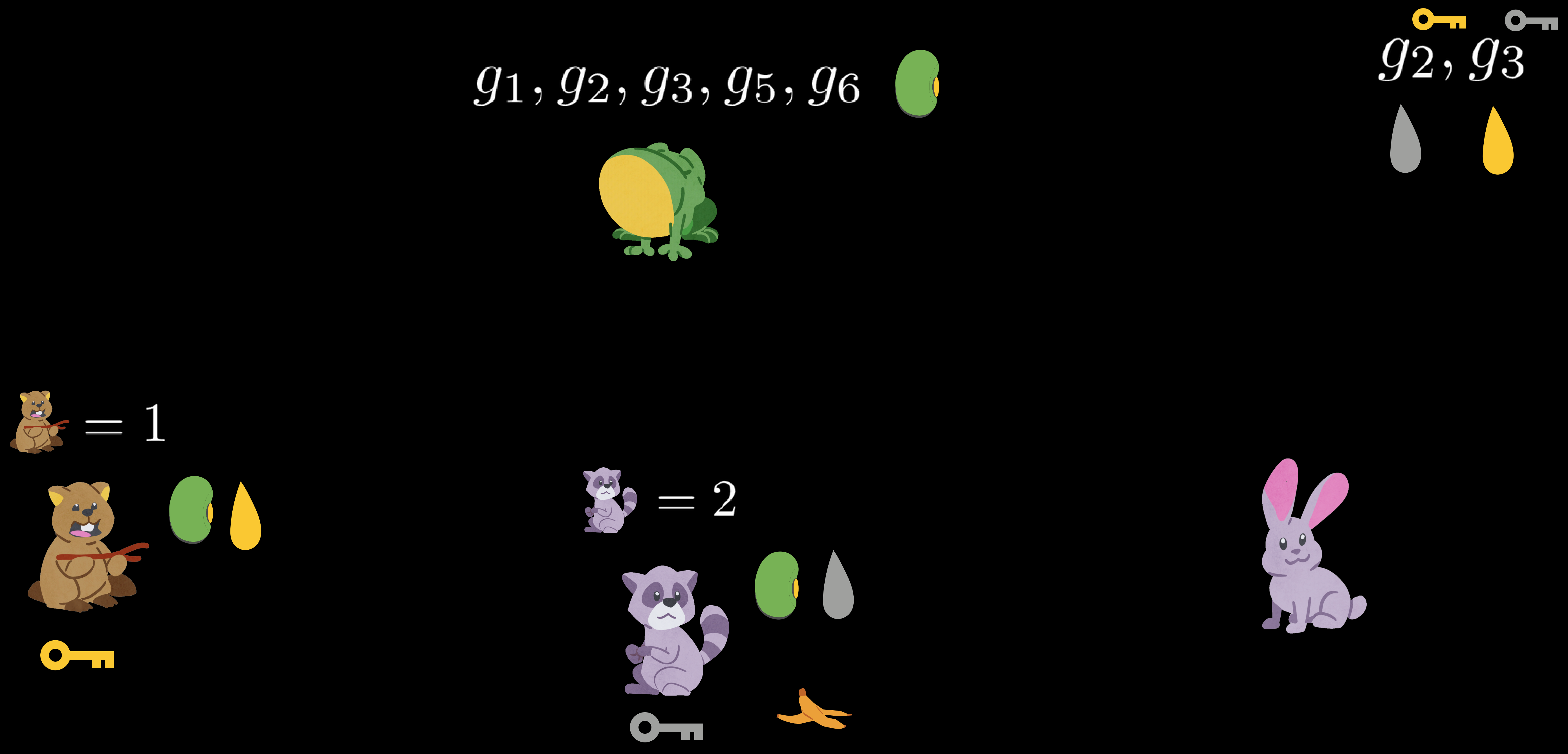

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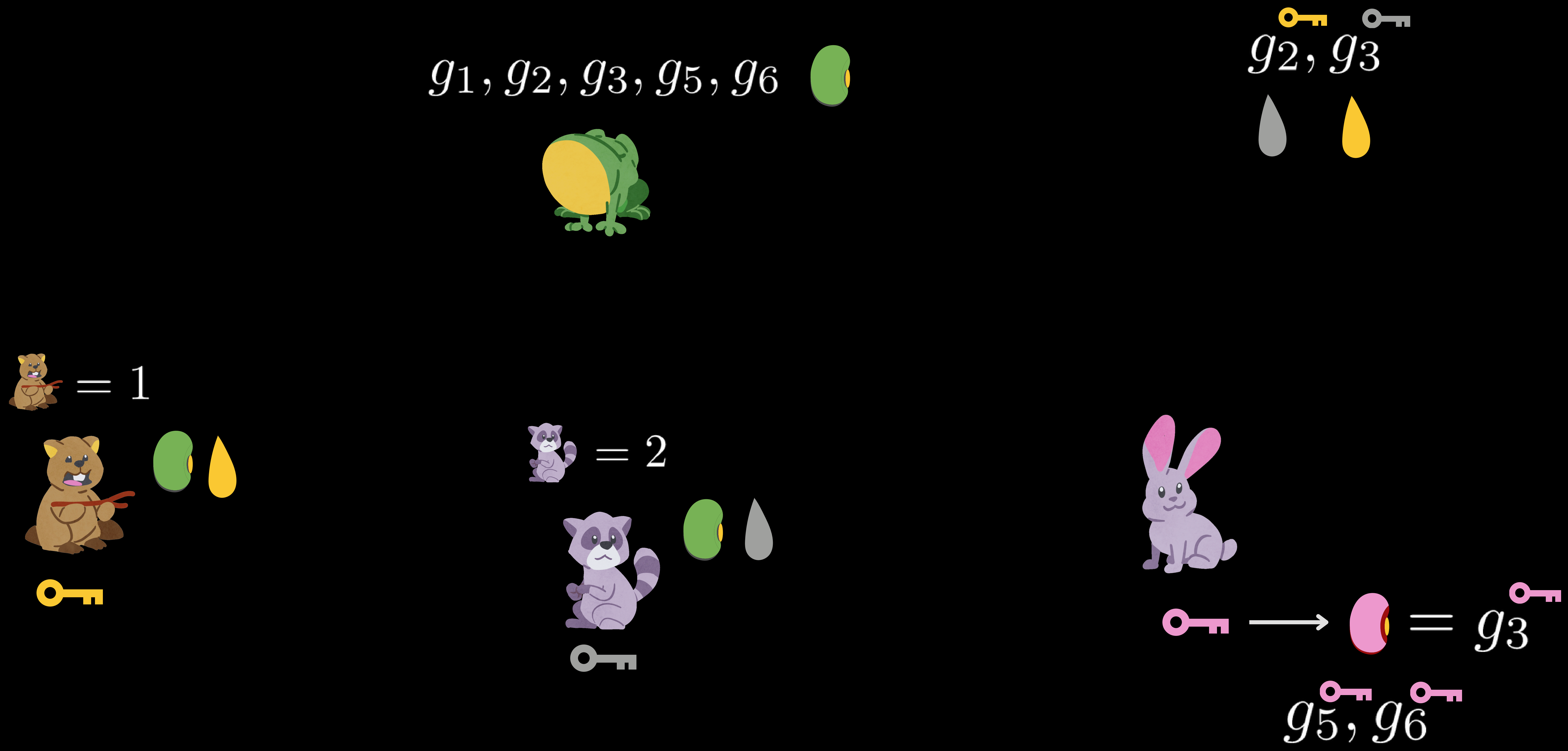
## Updates



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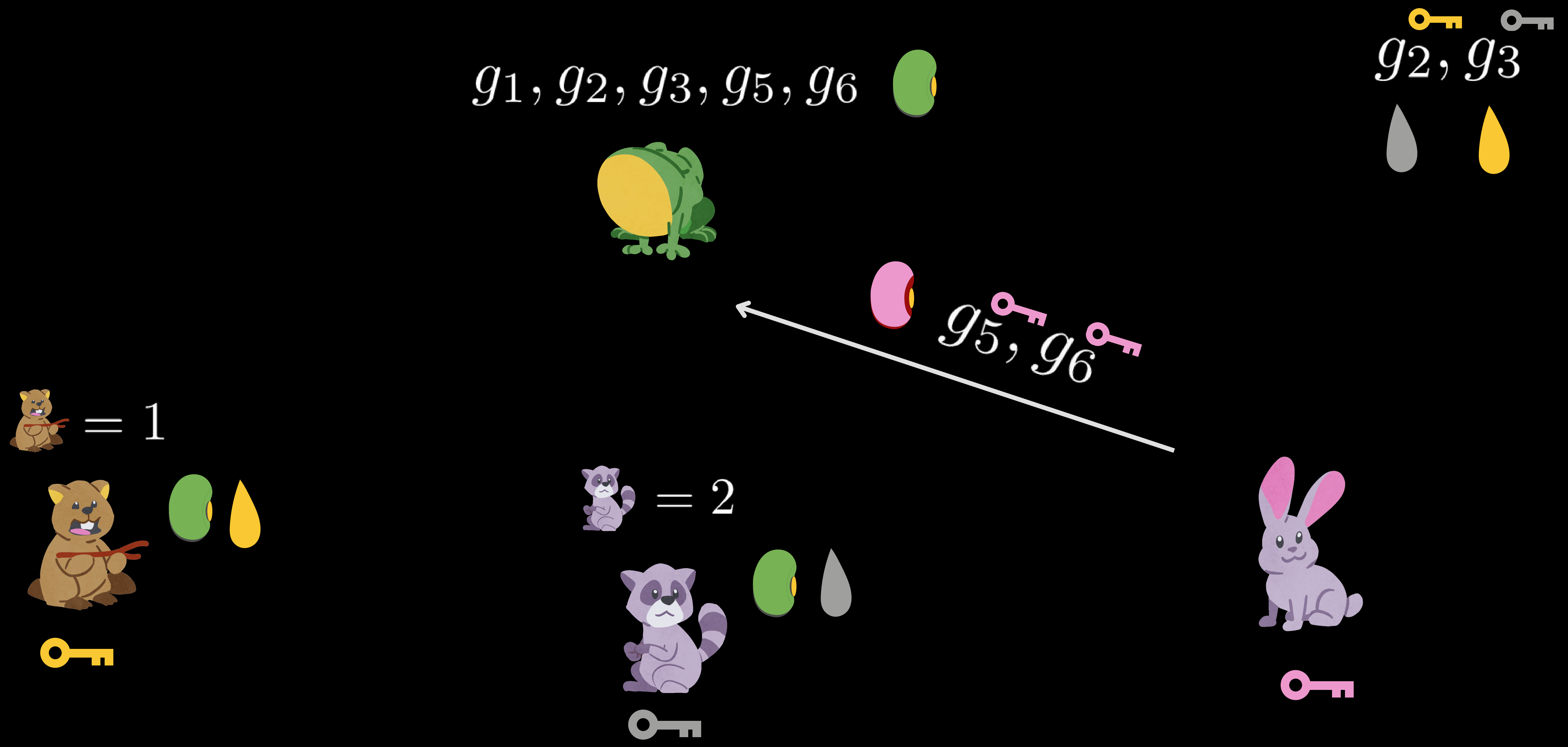
**Updates**



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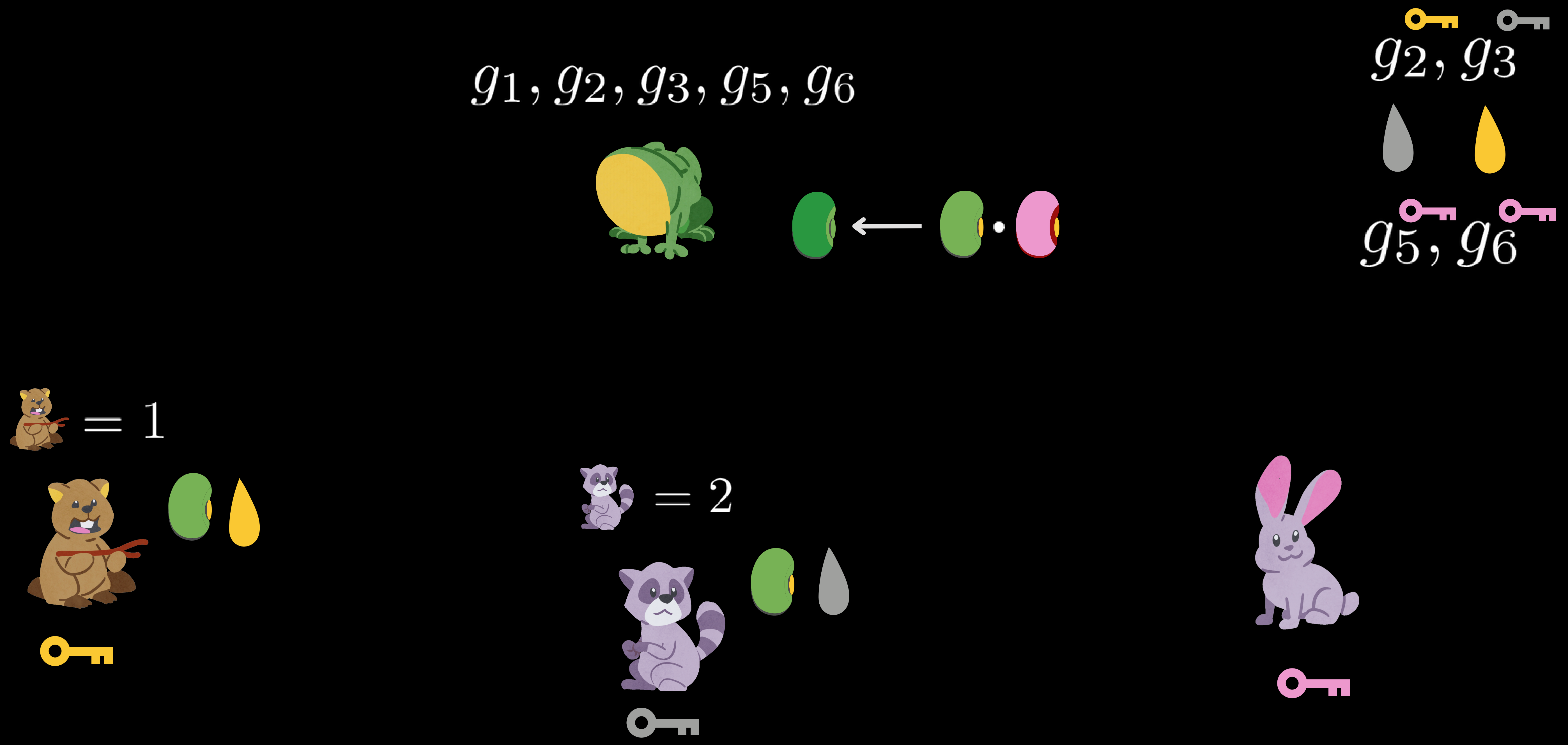

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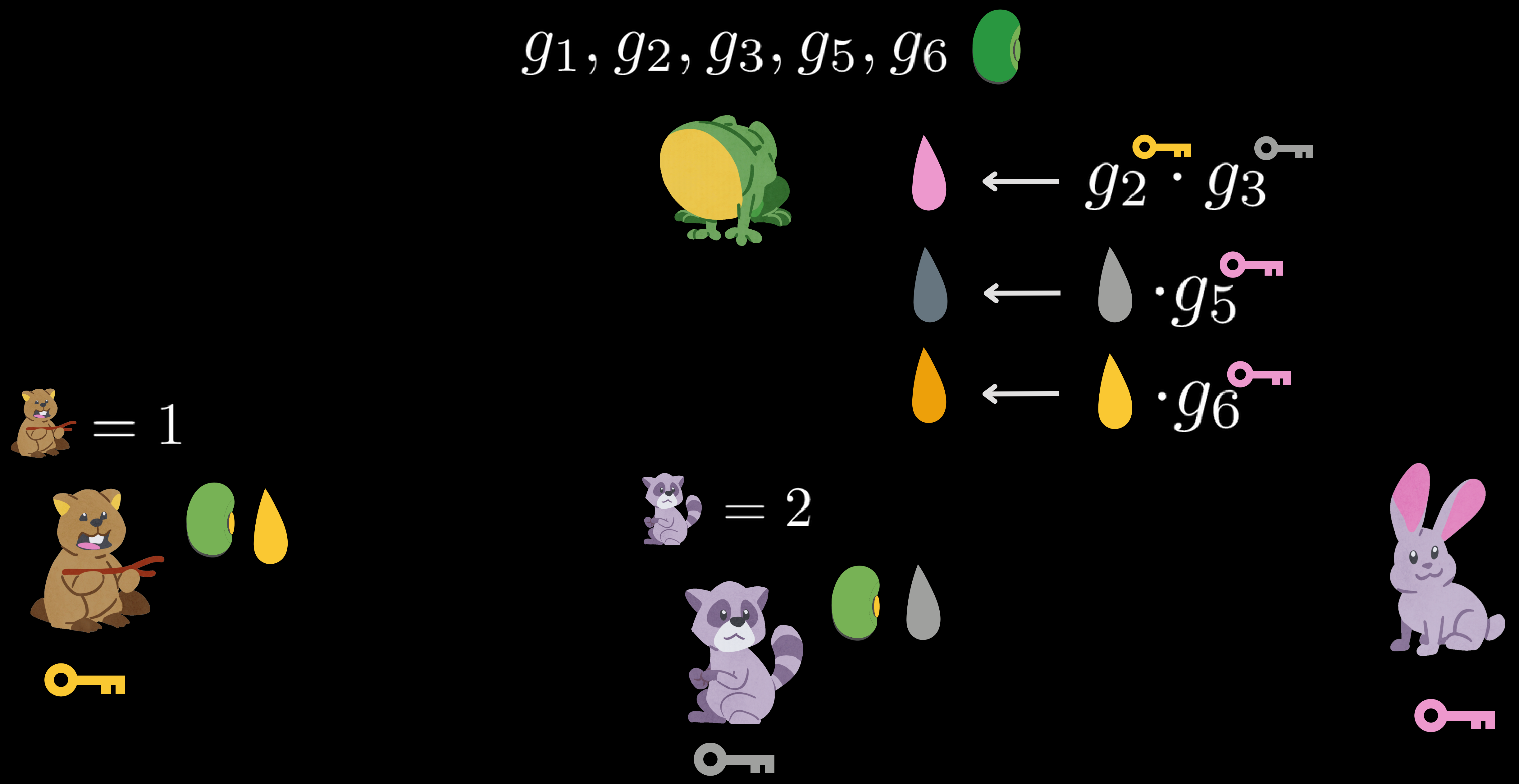
**Updates**



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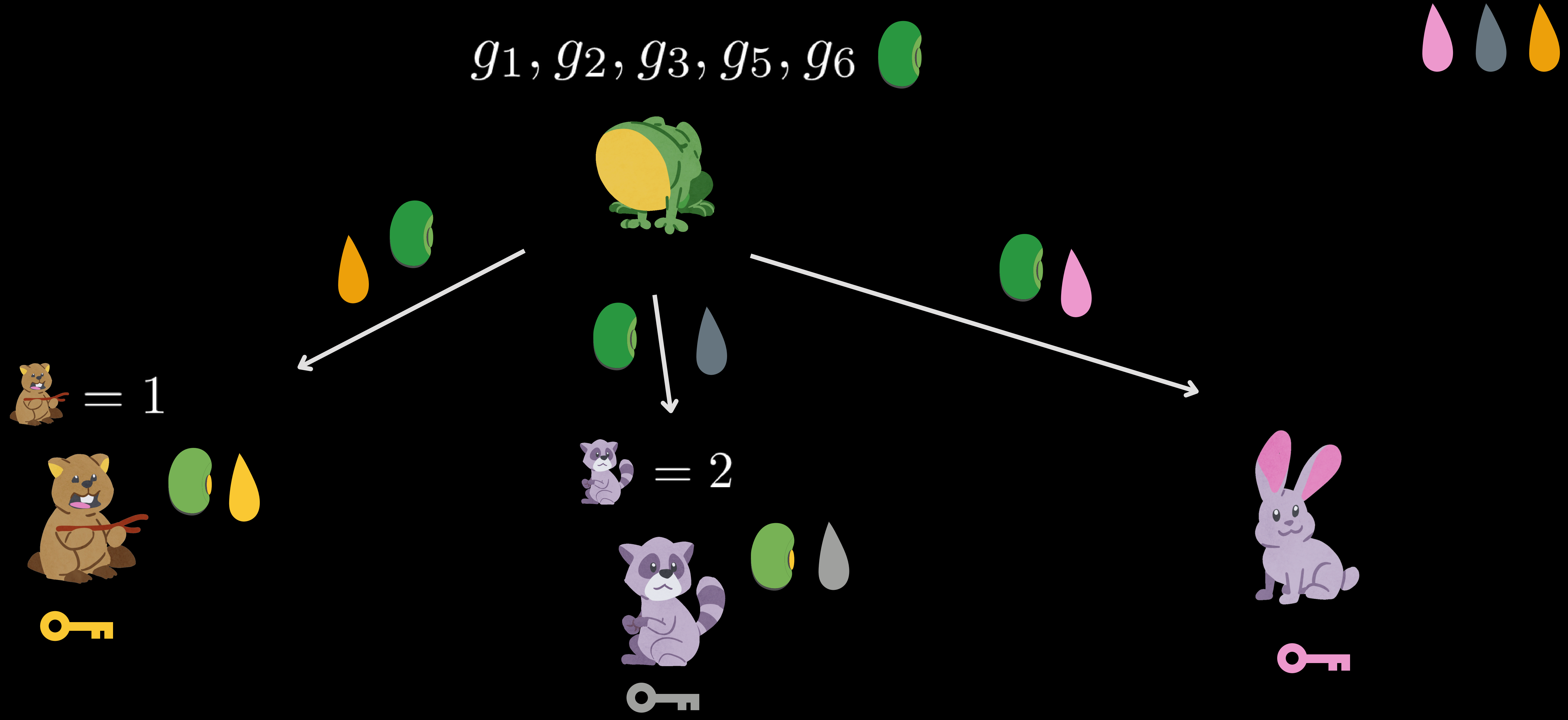

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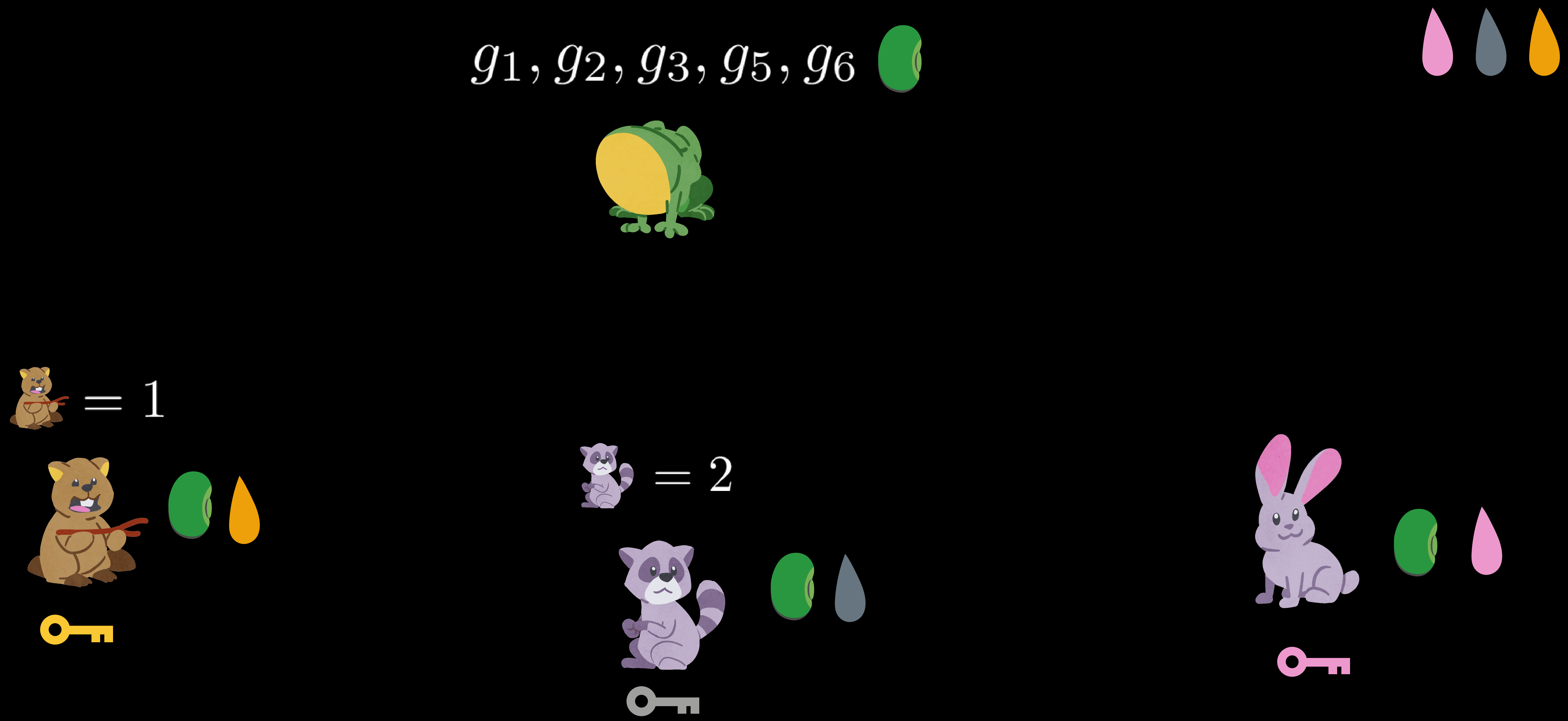
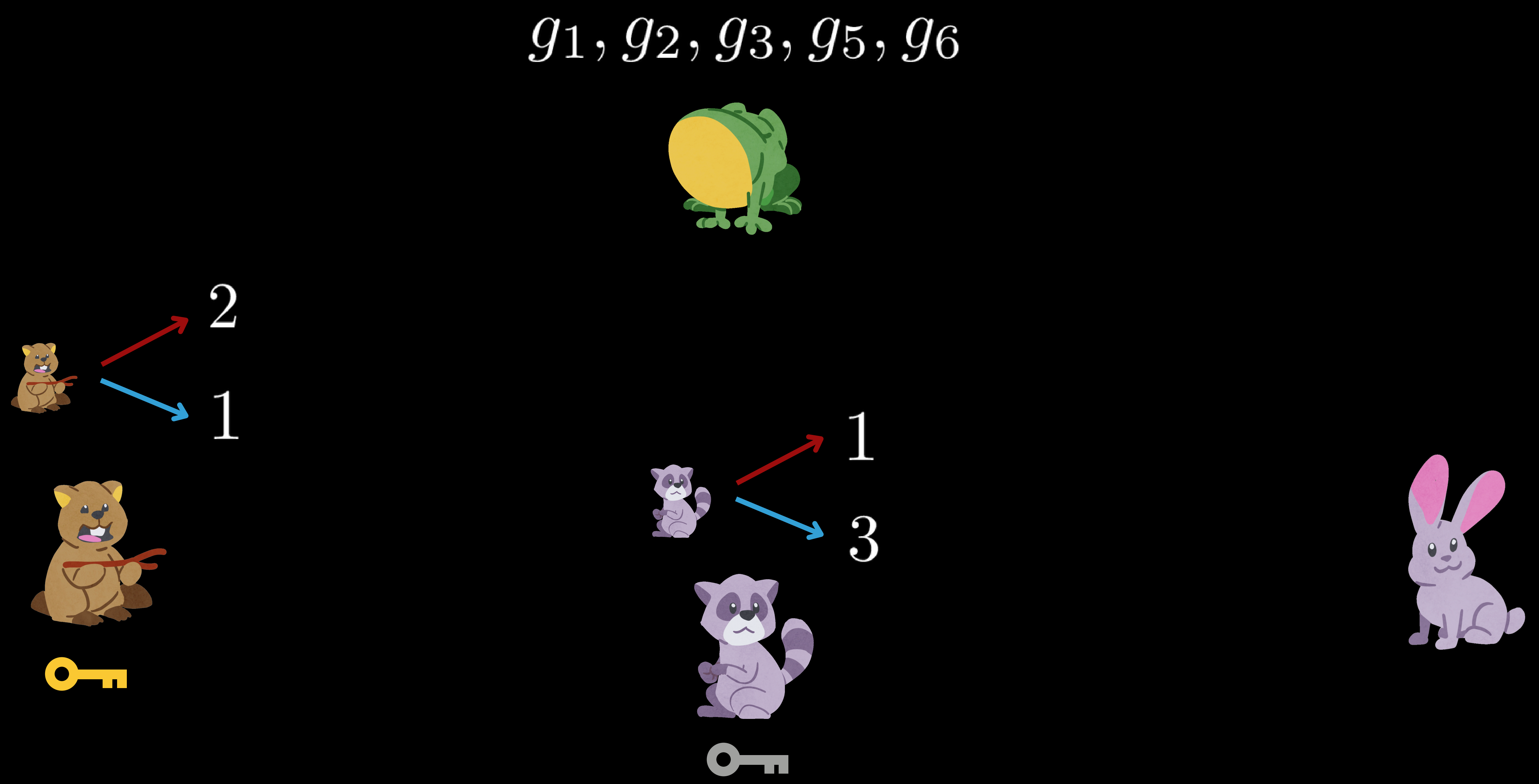
## Updates



# OUR SCHEME,
# COMBINING GKMR WITH CUCKOO HASHING



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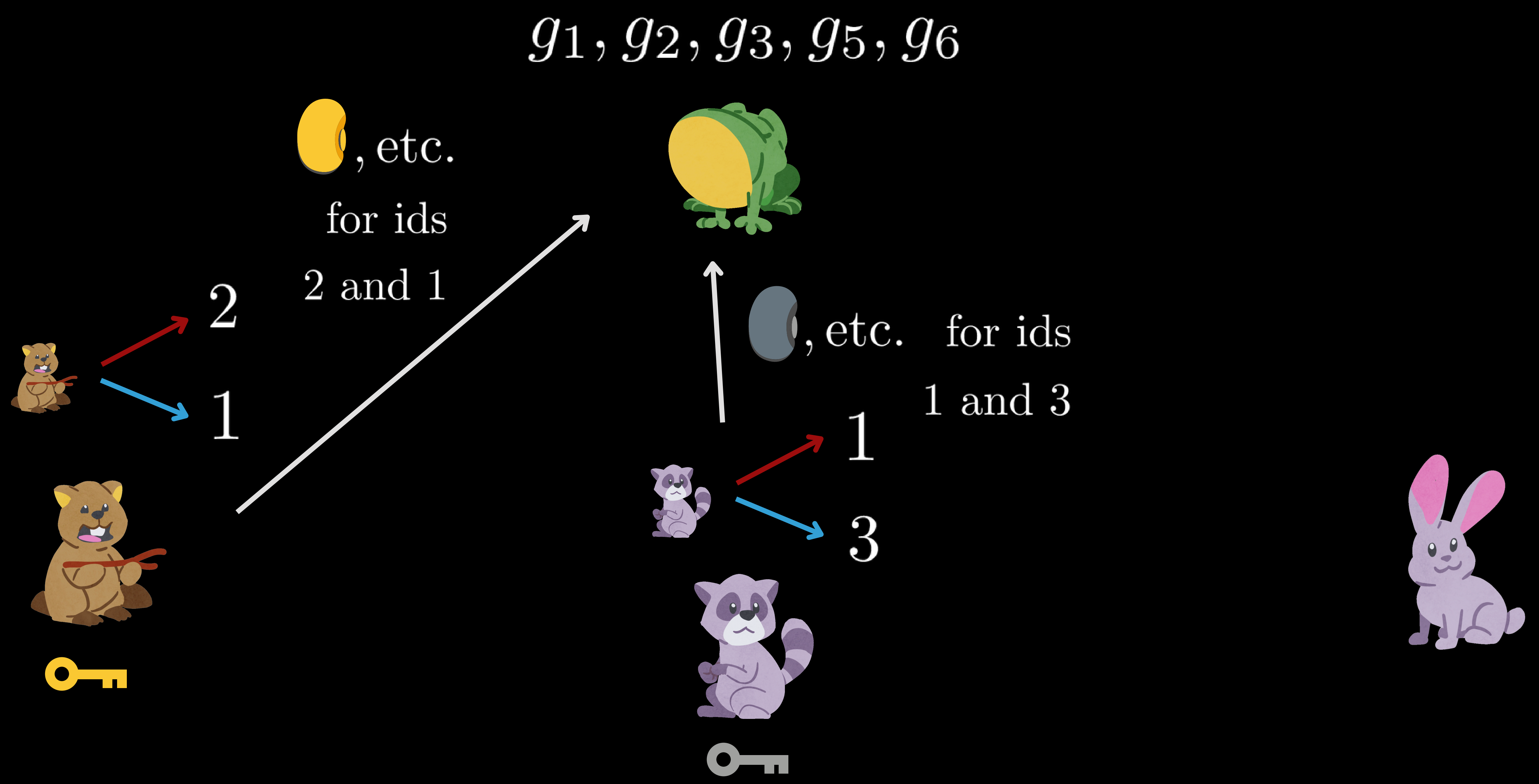

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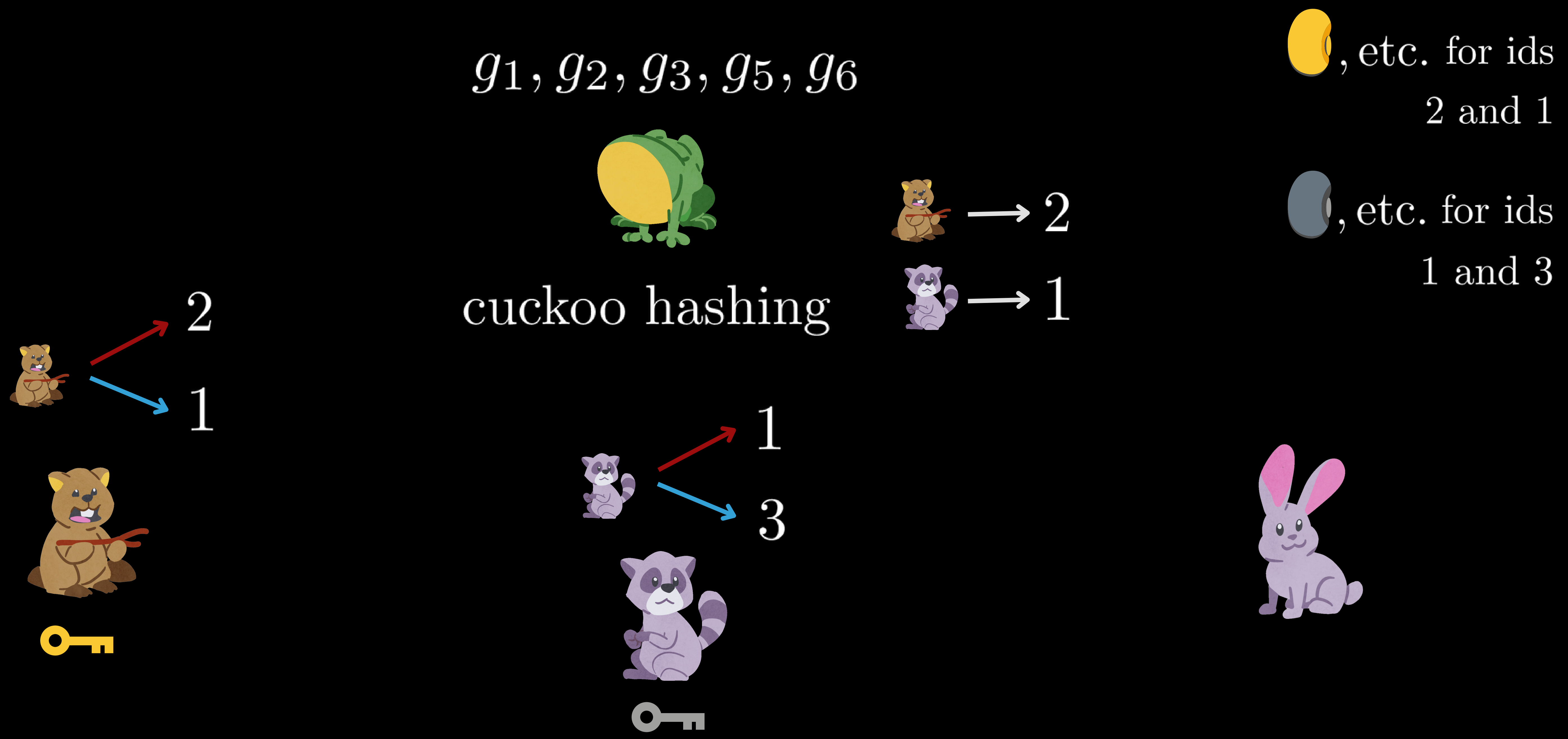

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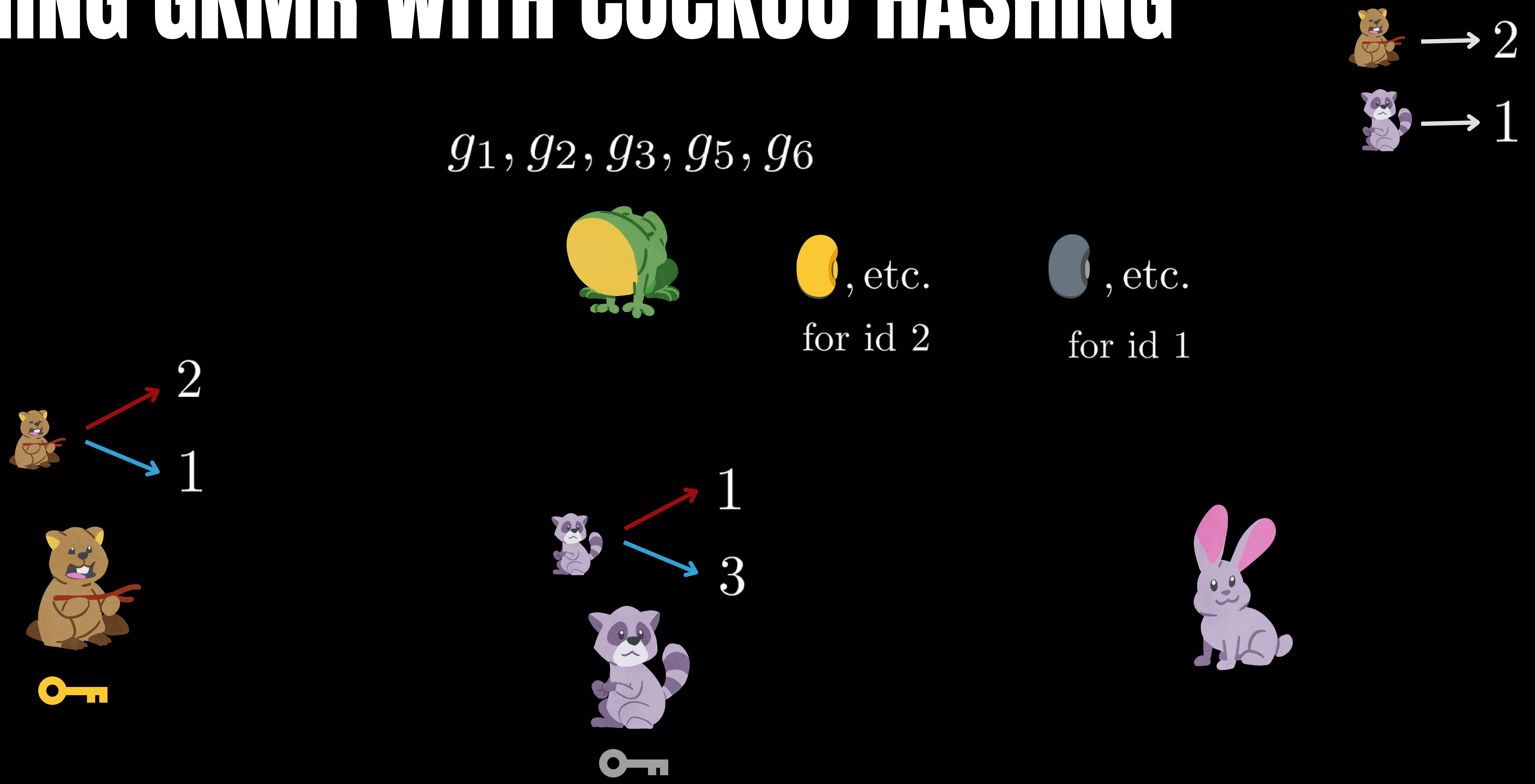

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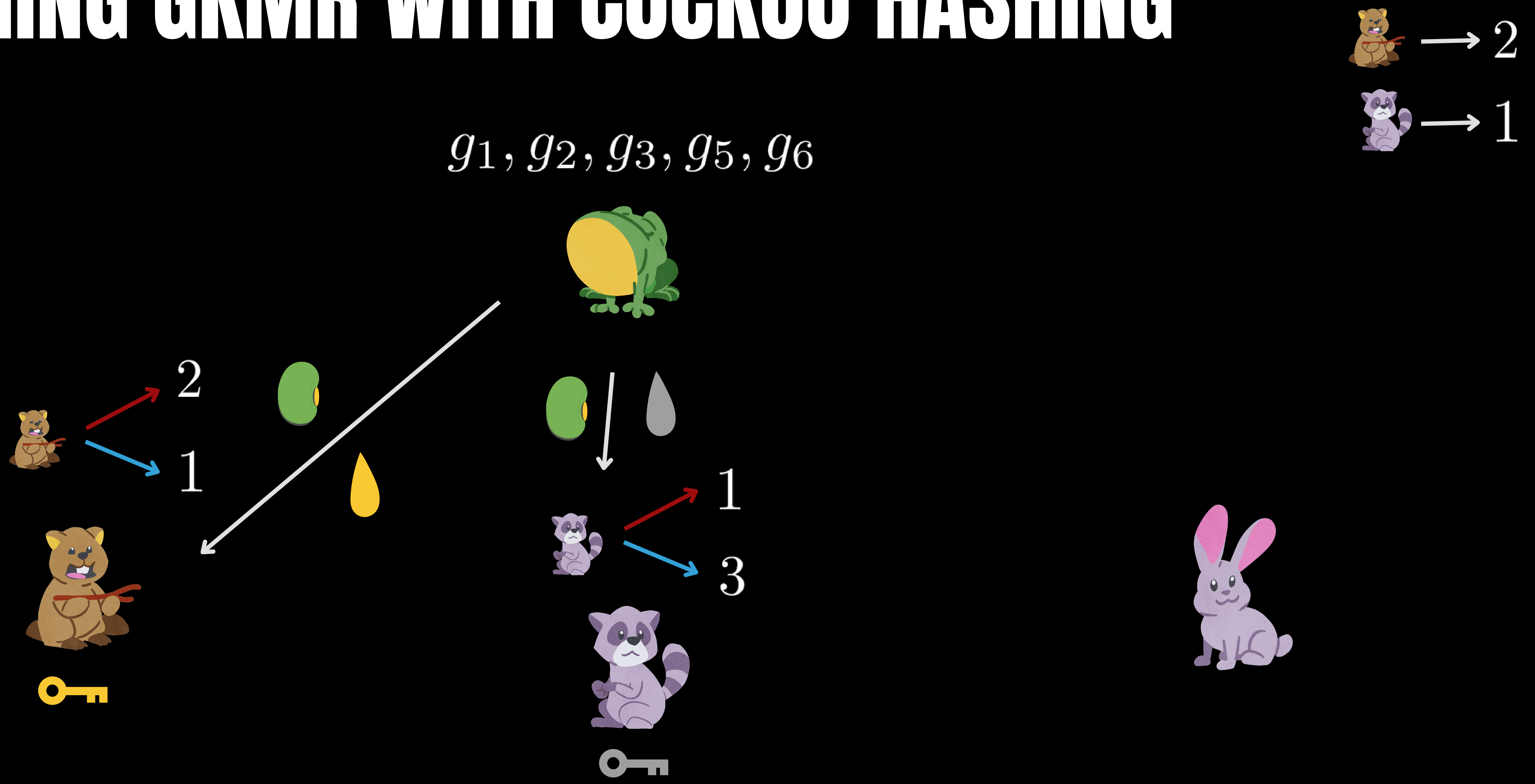

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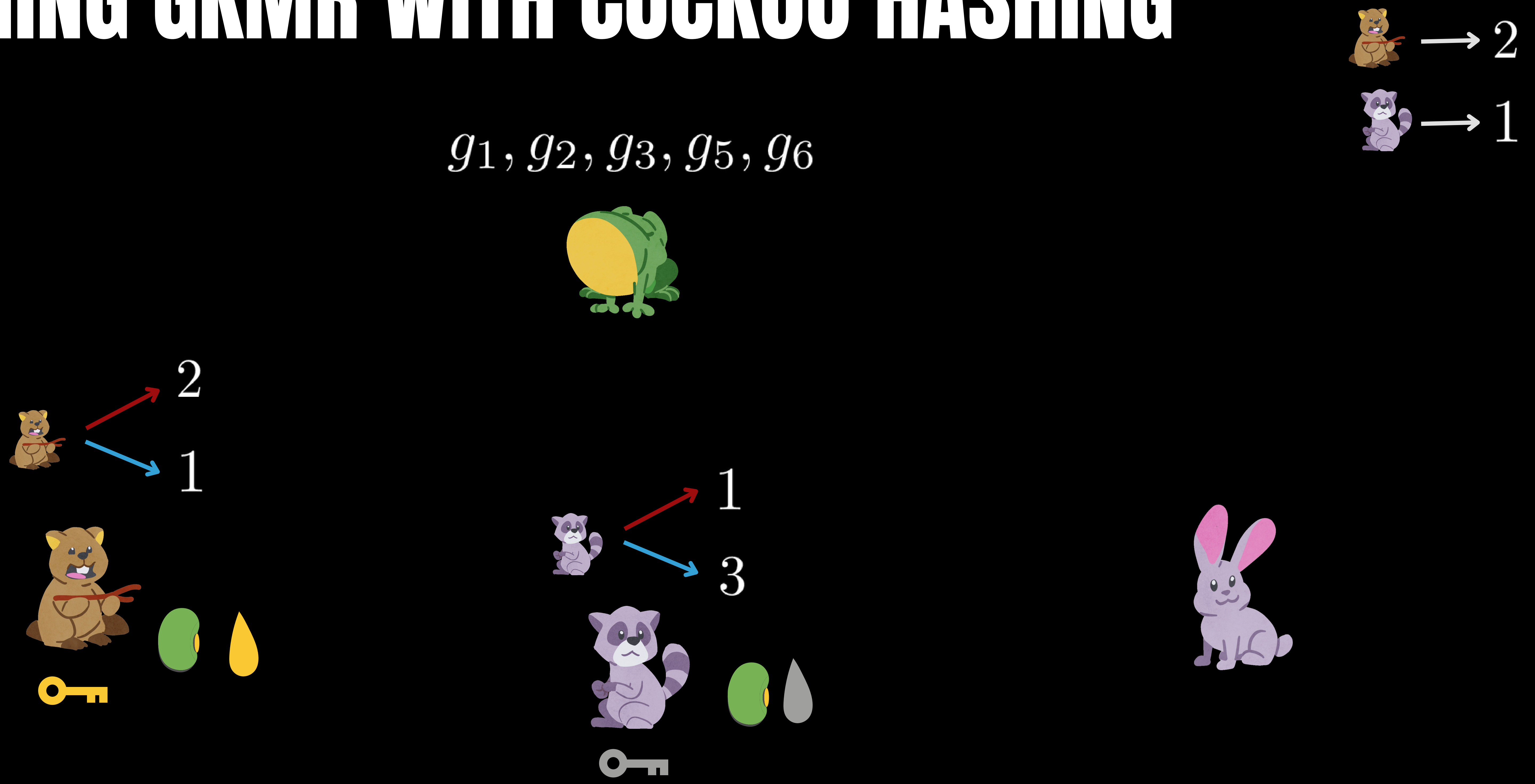
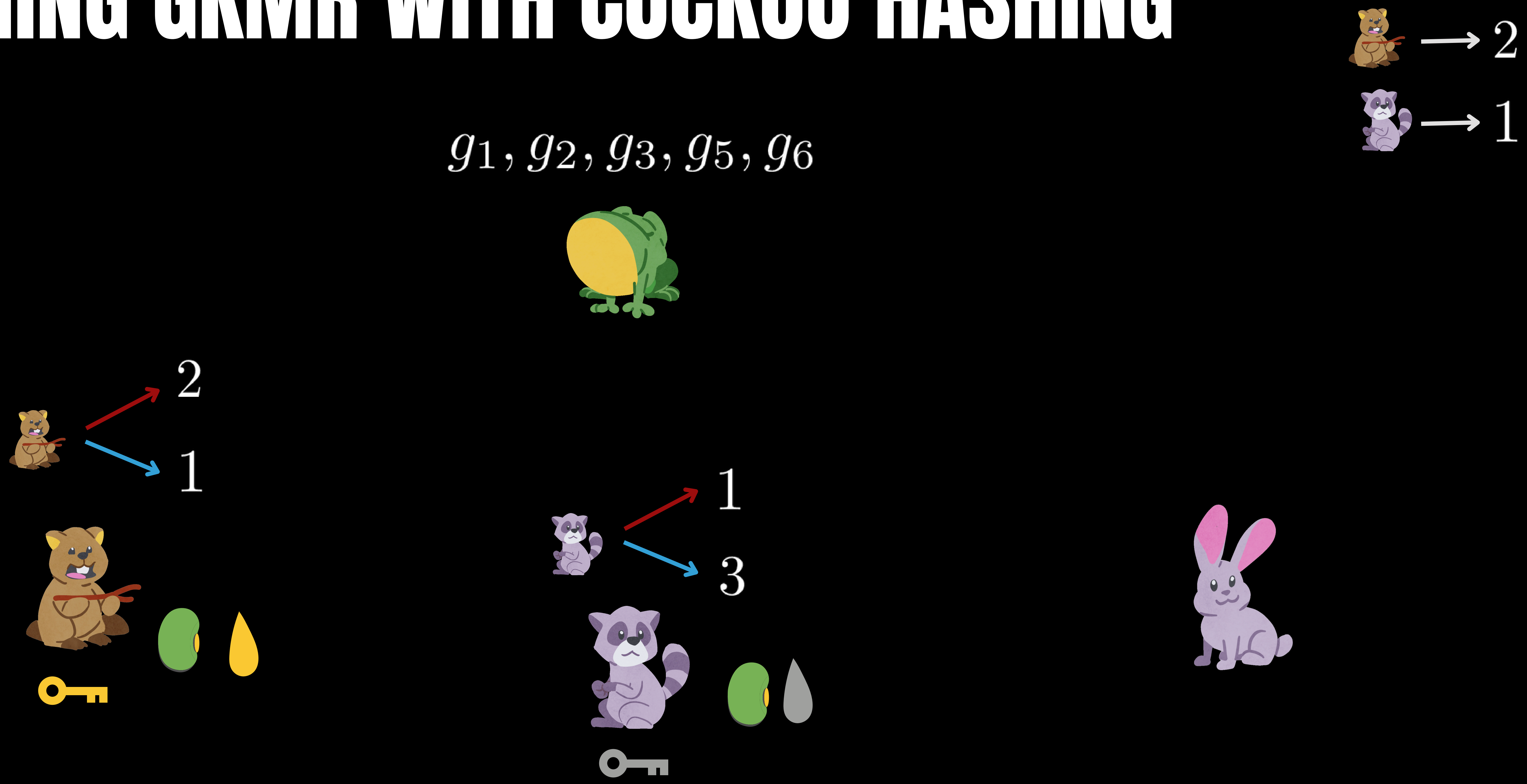


# OUR SCHEME, COMBINING GKMR WITH CUCKOO HASHING

**Problem**



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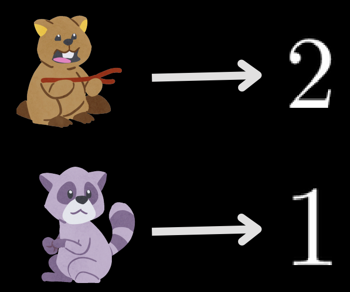
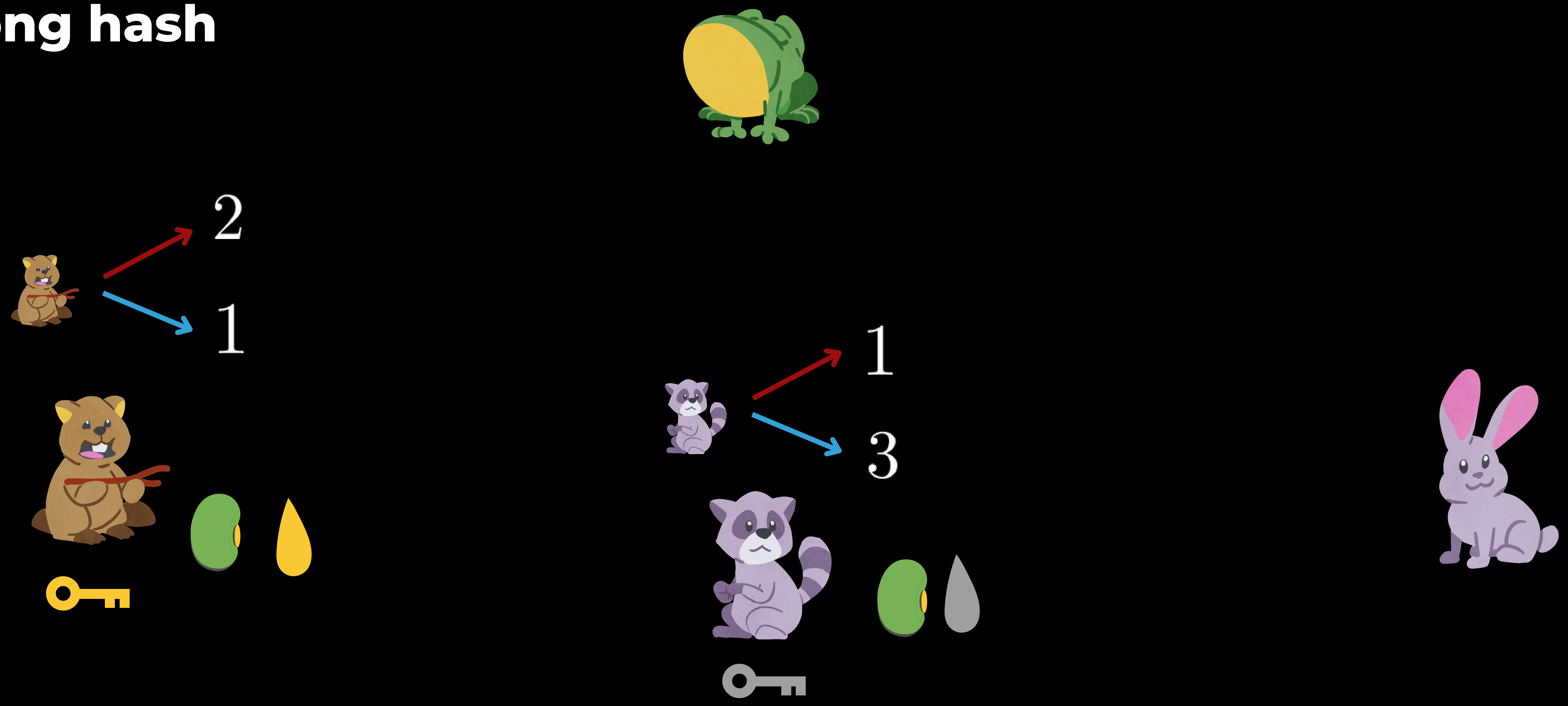



**Problem:**
**what if encryptors use the wrong hash function?**

$g_1, g_2, g_3, g_5, g_6$



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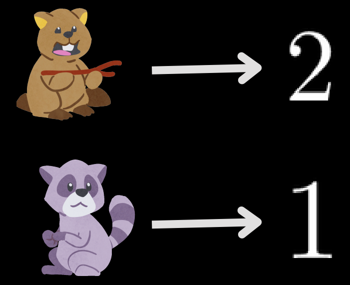
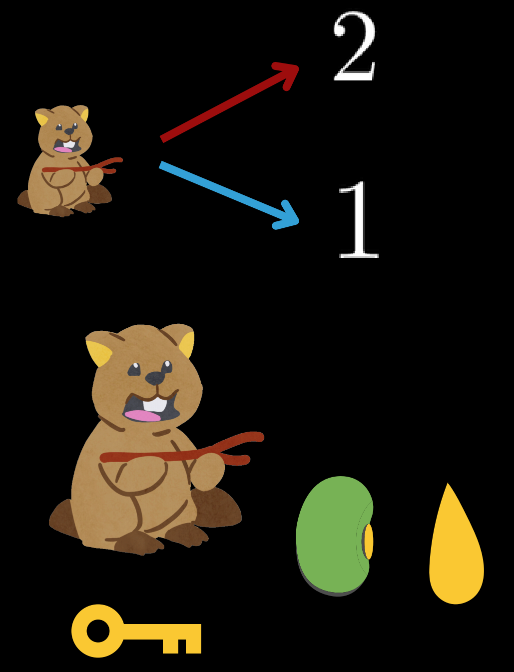
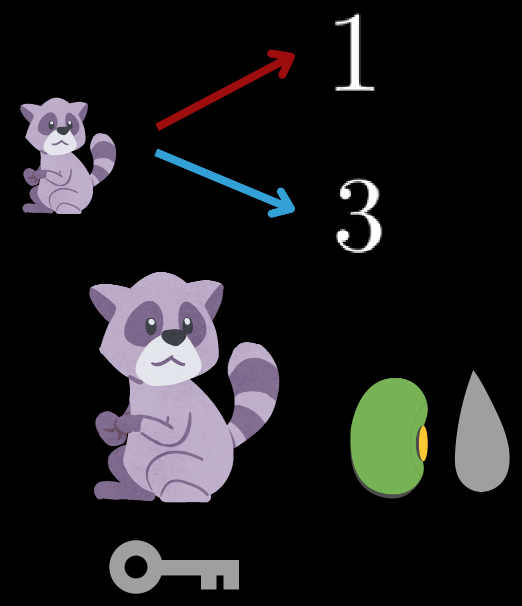
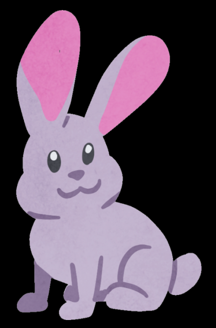



**Encryption needs to be not only with respect to the position, but also the identity.**

$g_1, g_2, g_3, g_5, g_6$



# OUR SCHEME,
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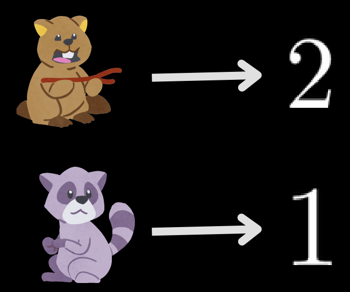
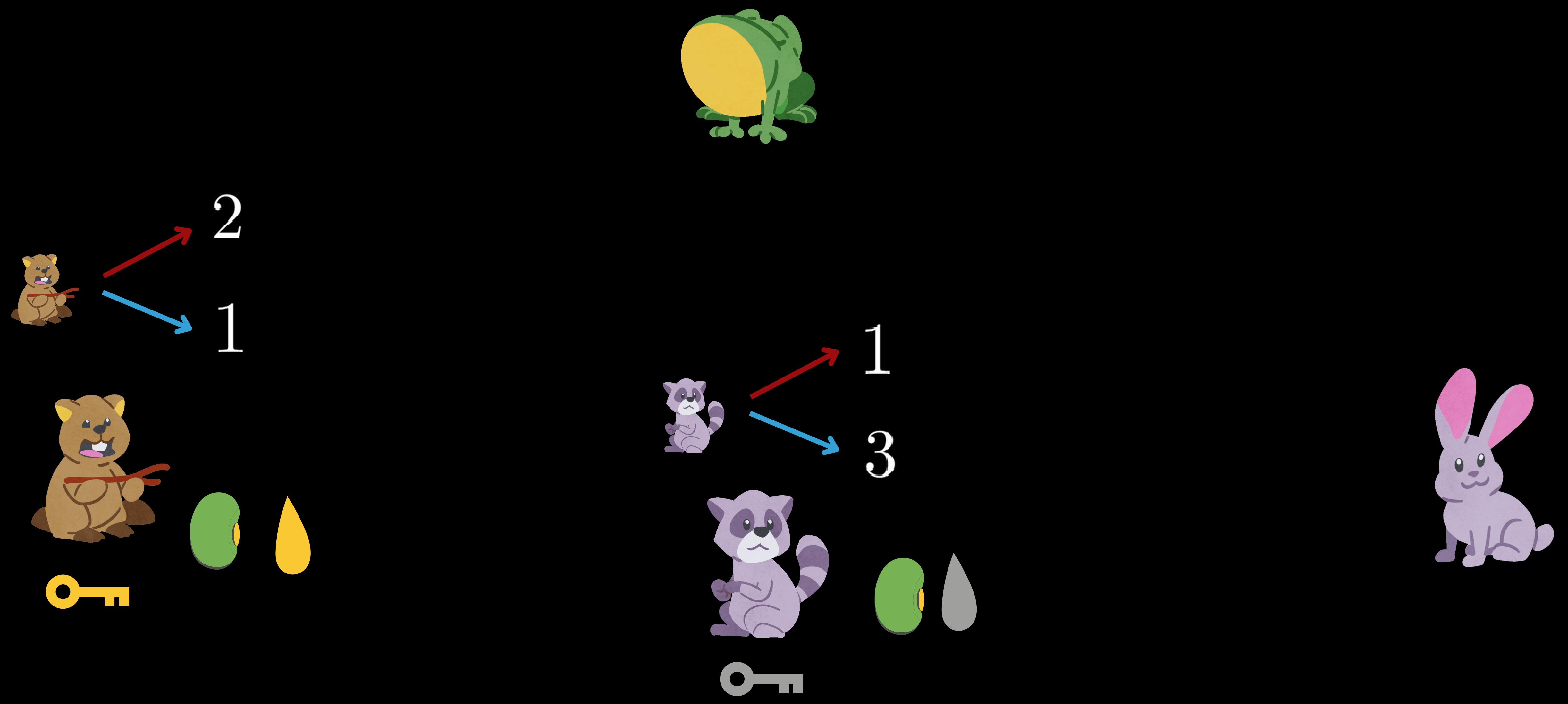
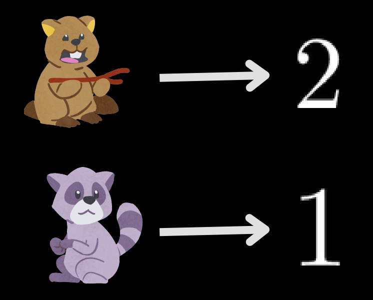


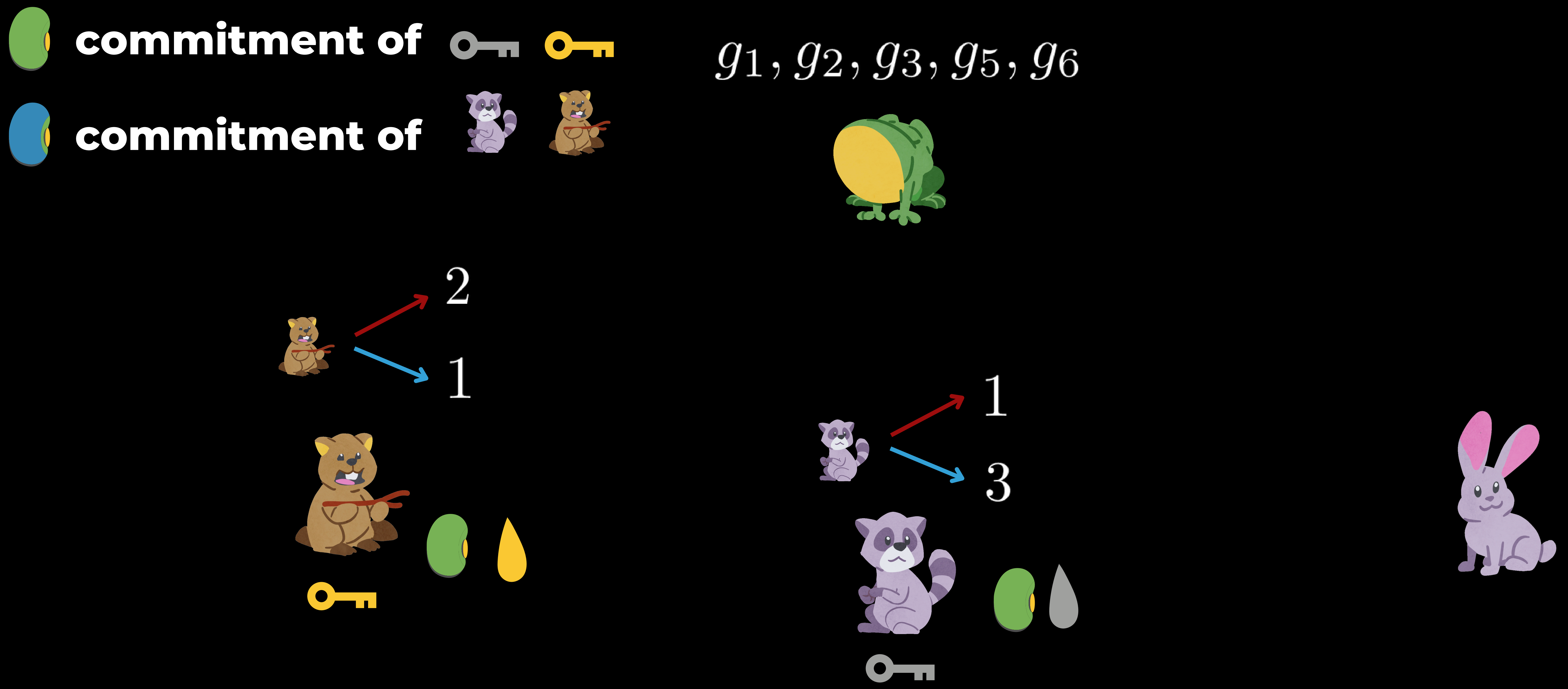

commitment of

$$g_1, g_2, g_3, g_5, g_6$$



# OUR SCHEME, COMBINING GKMR WITH CUCKOO HASHING



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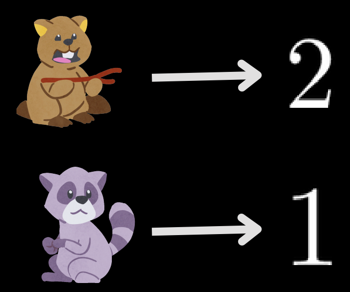


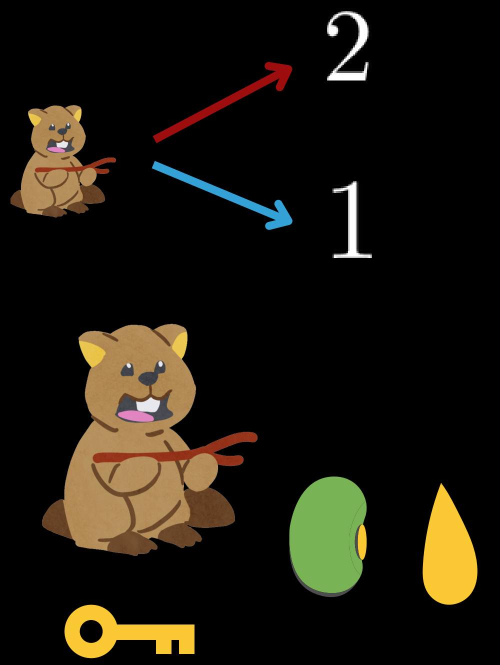

commitment of

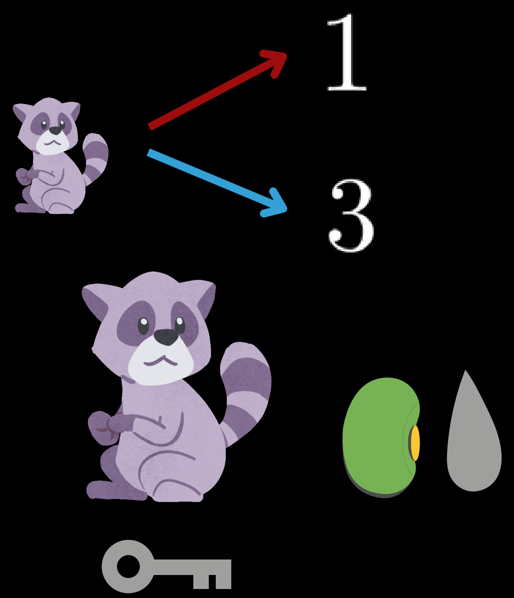
commitment of

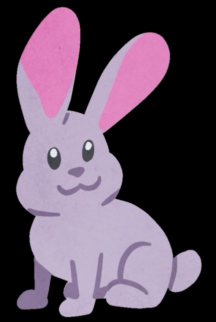
opening of in $g_2$

opening of in $g_2$

(in position 2)



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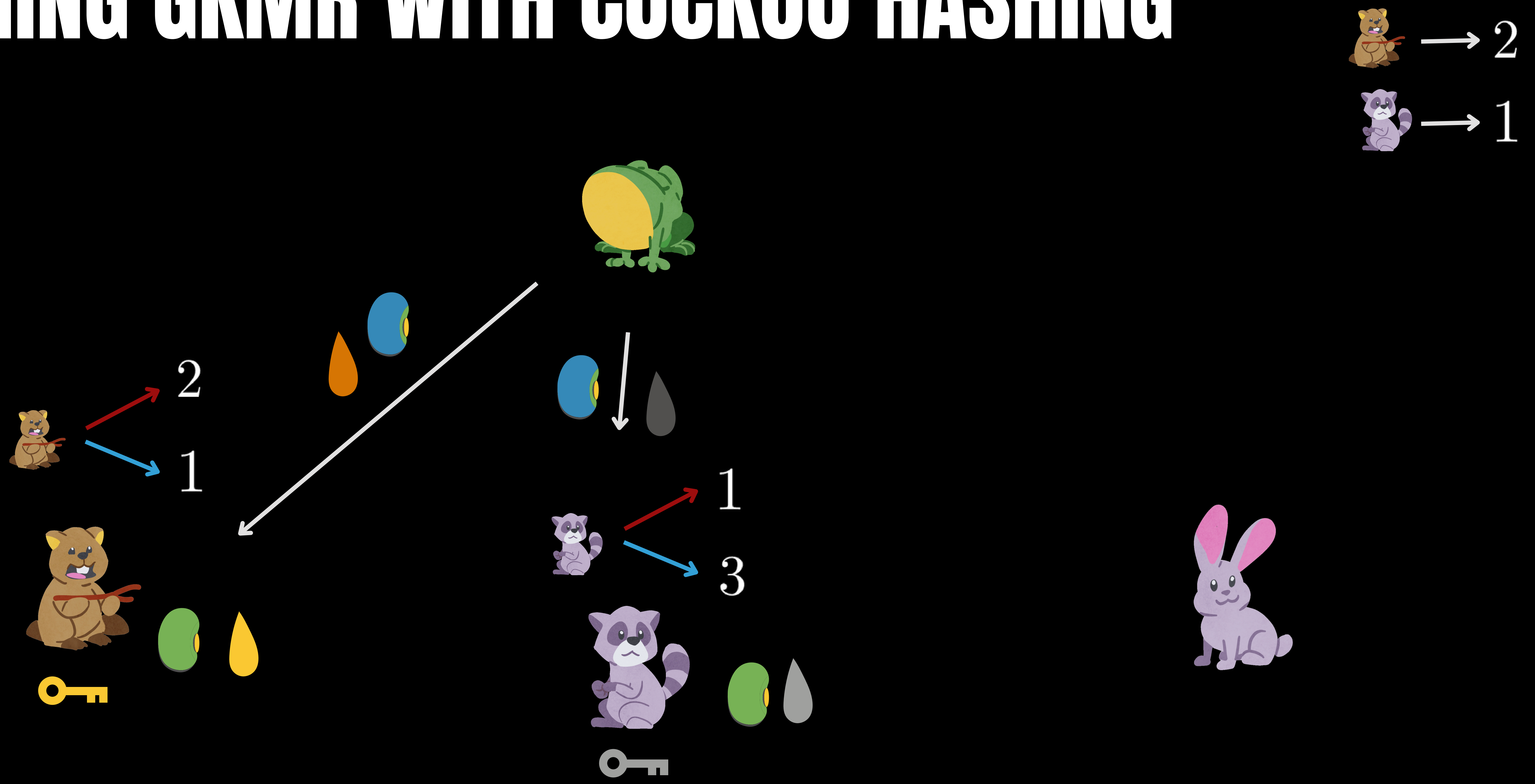

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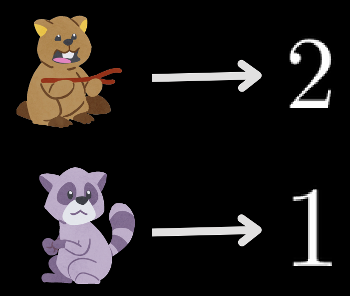


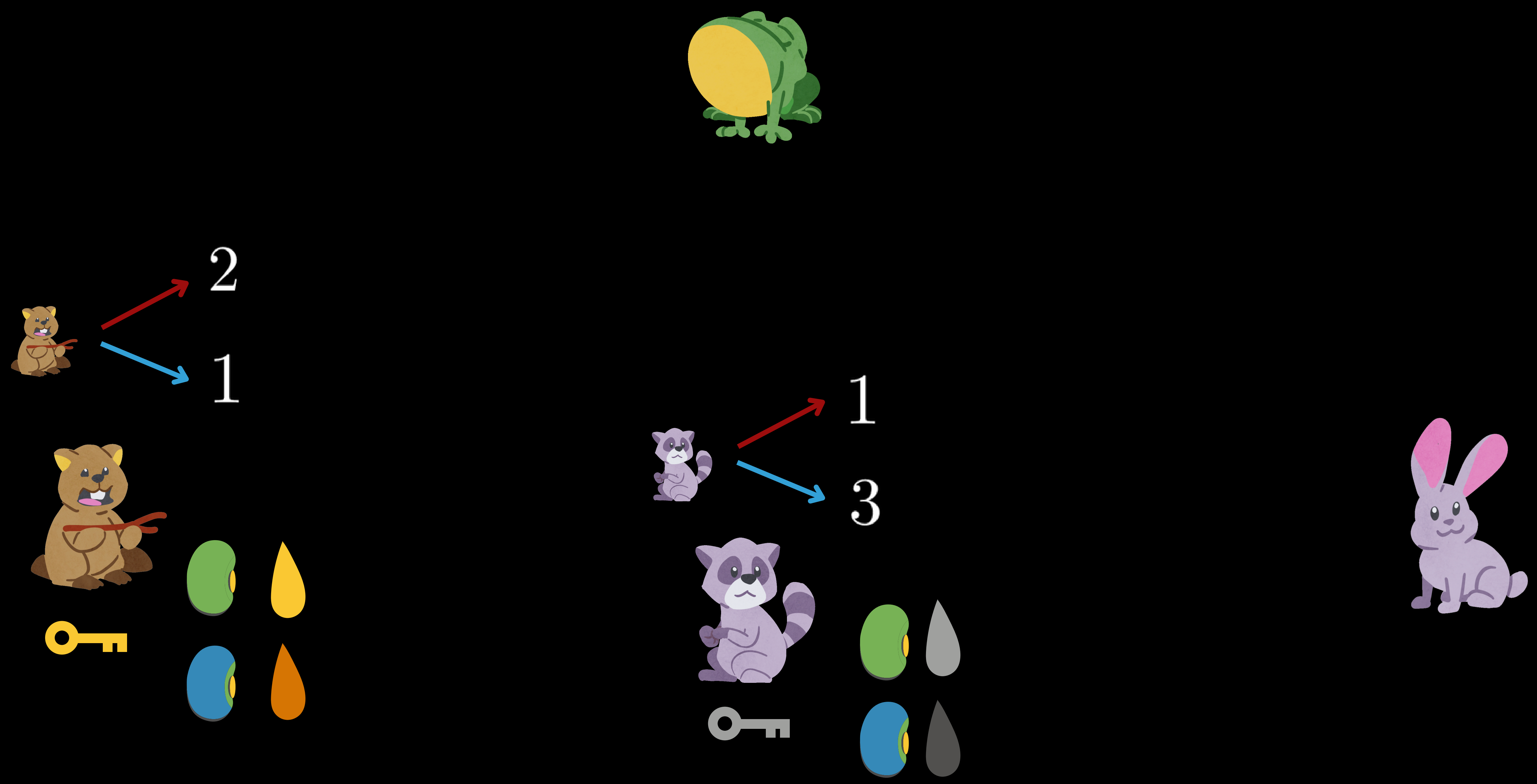

# OUR SCHEME,
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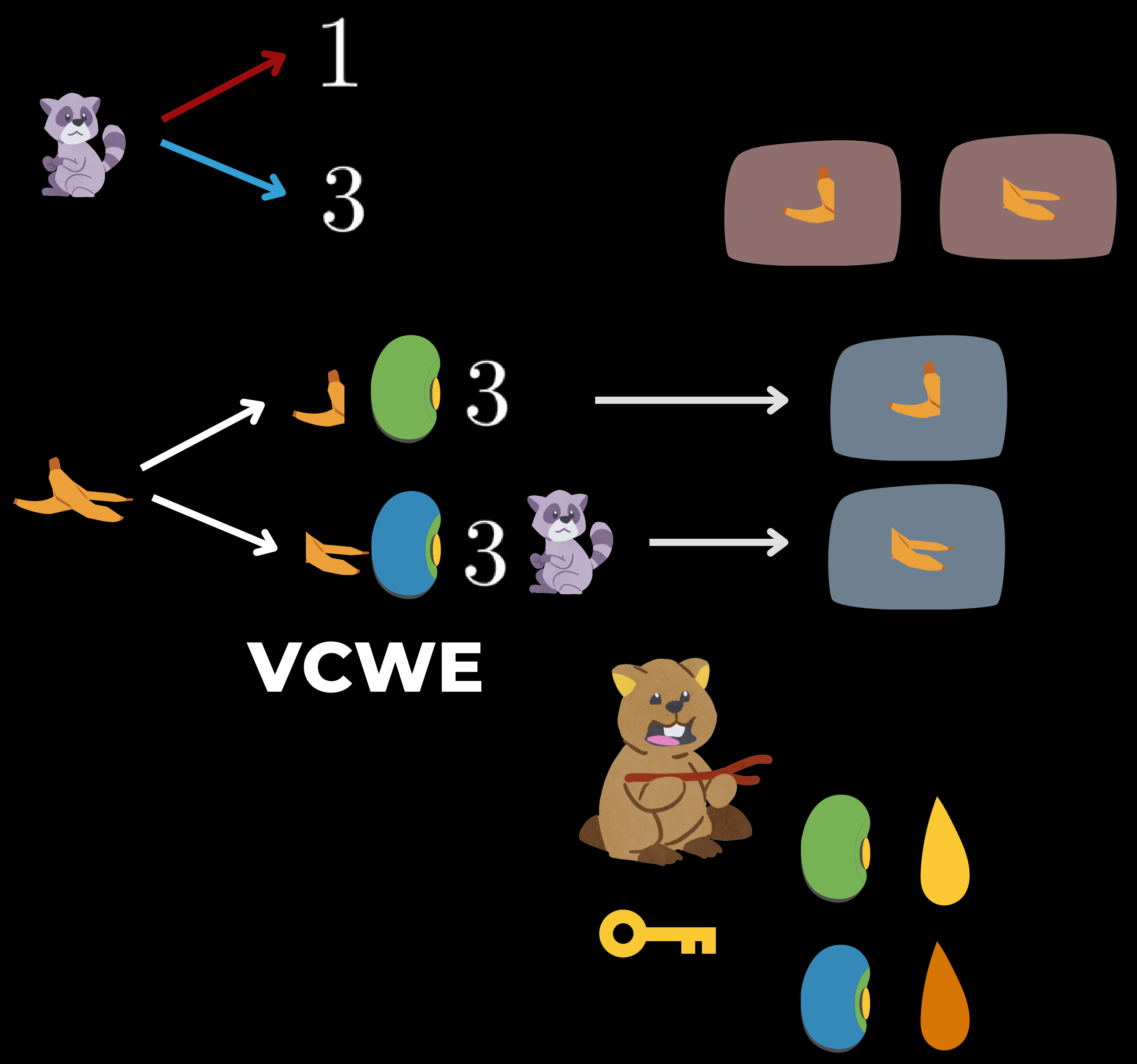


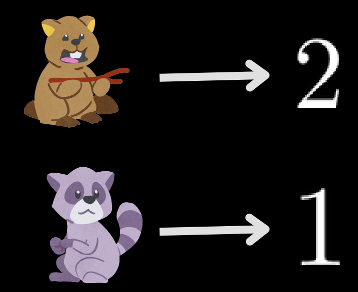


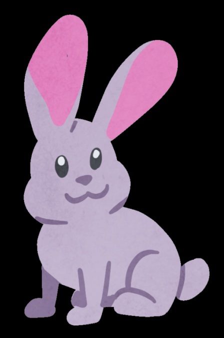

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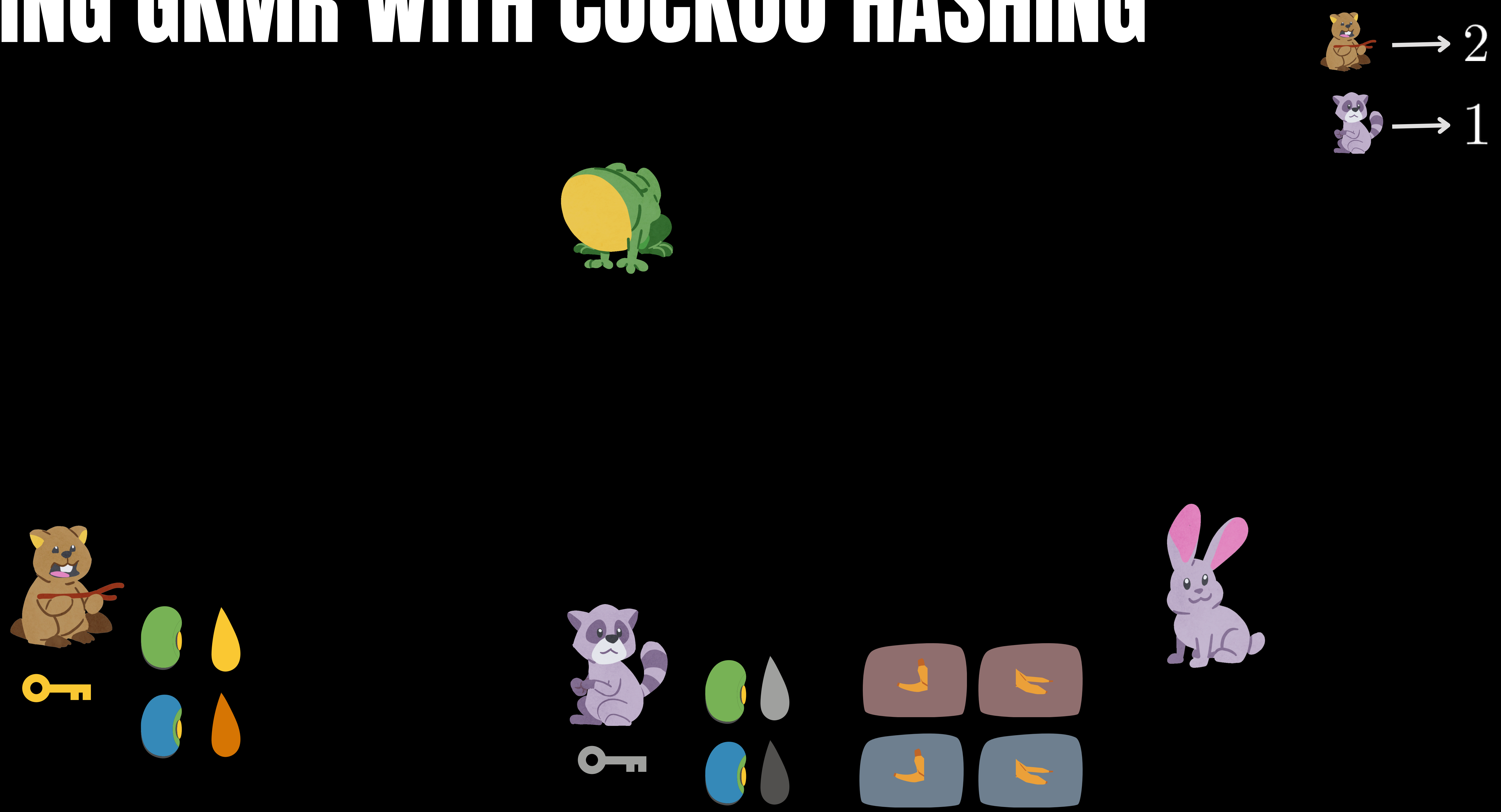

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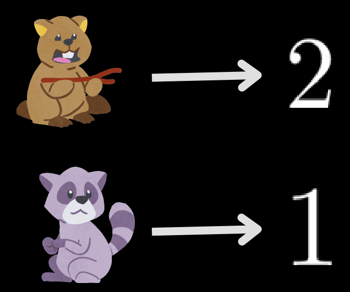


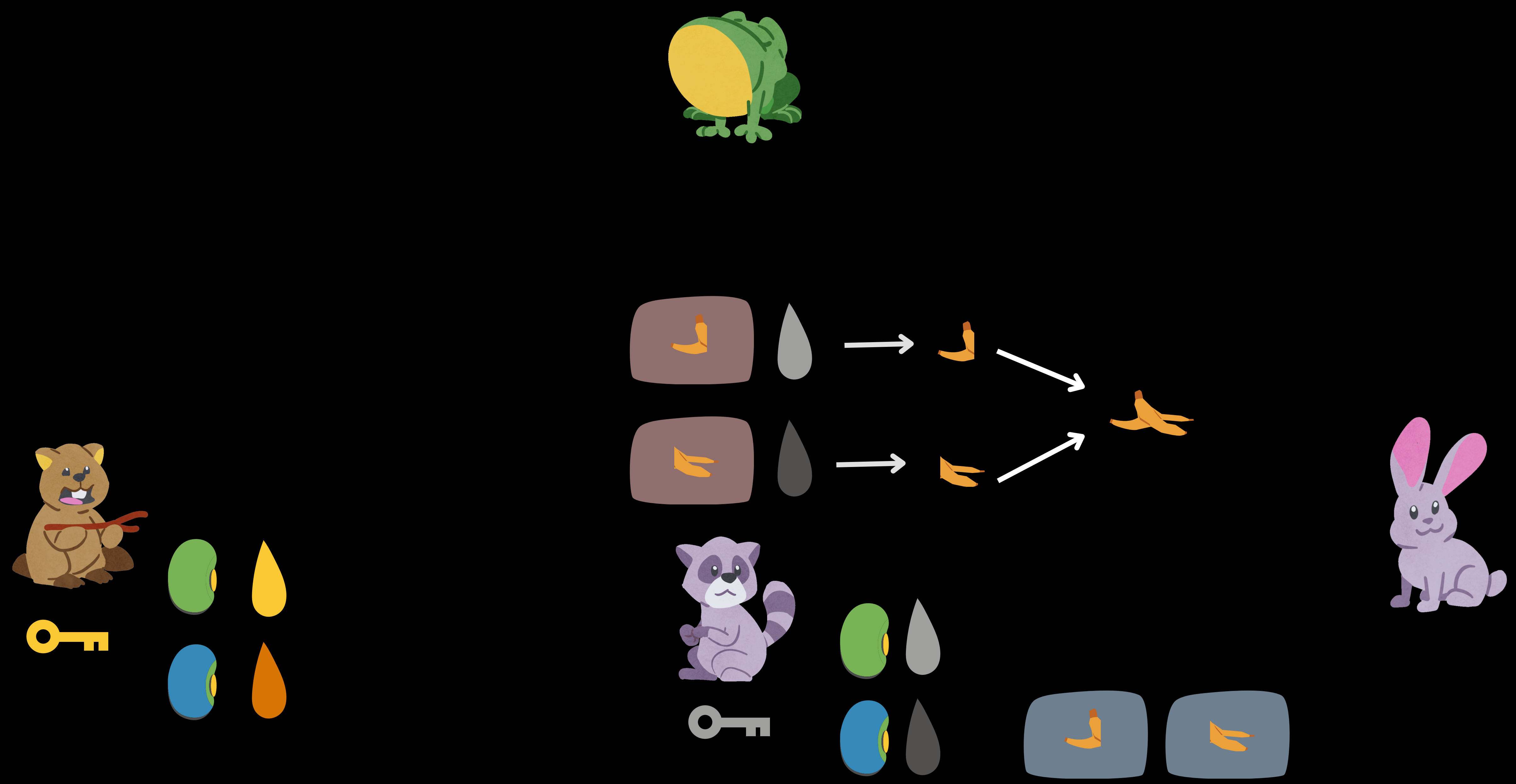

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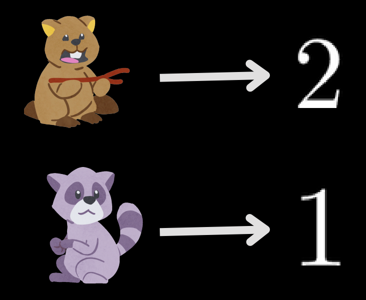
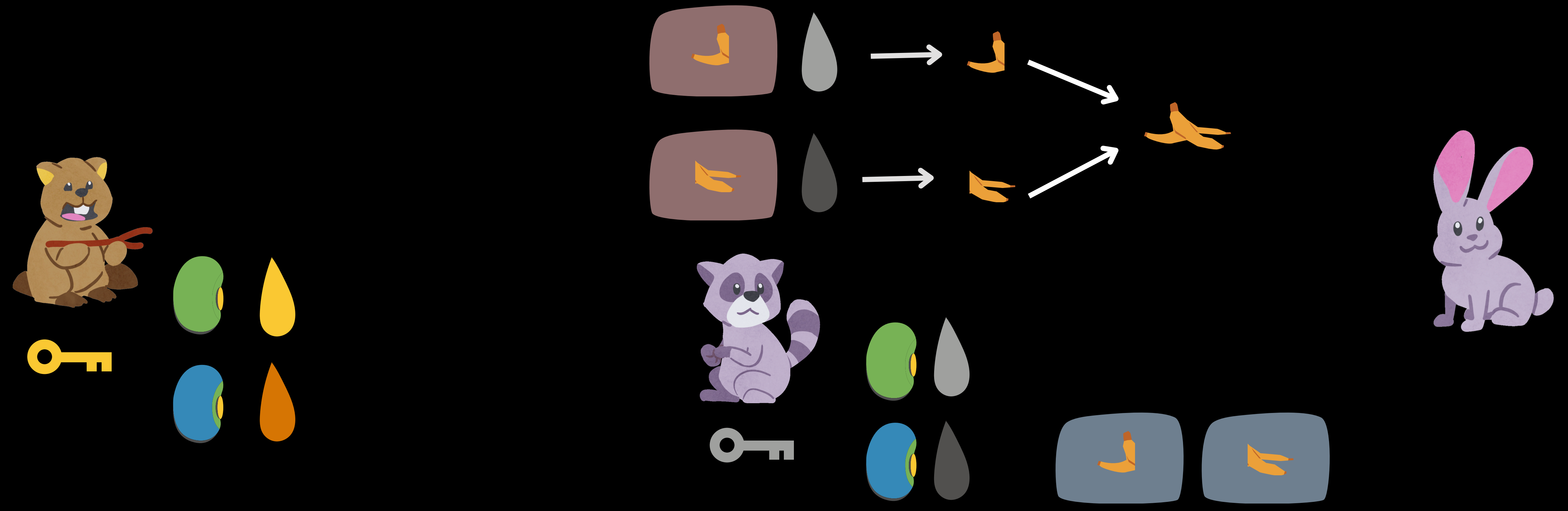



**Without both openings for position 1,**
**without committed to in in position 1,**
**without made for this cuckoo hashing,**
**nothing could be inferred.**



# OUR SCHEME,
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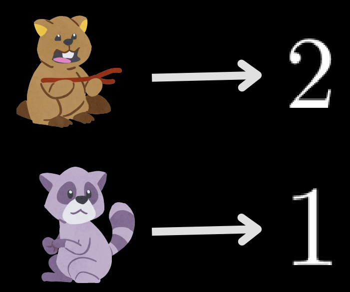
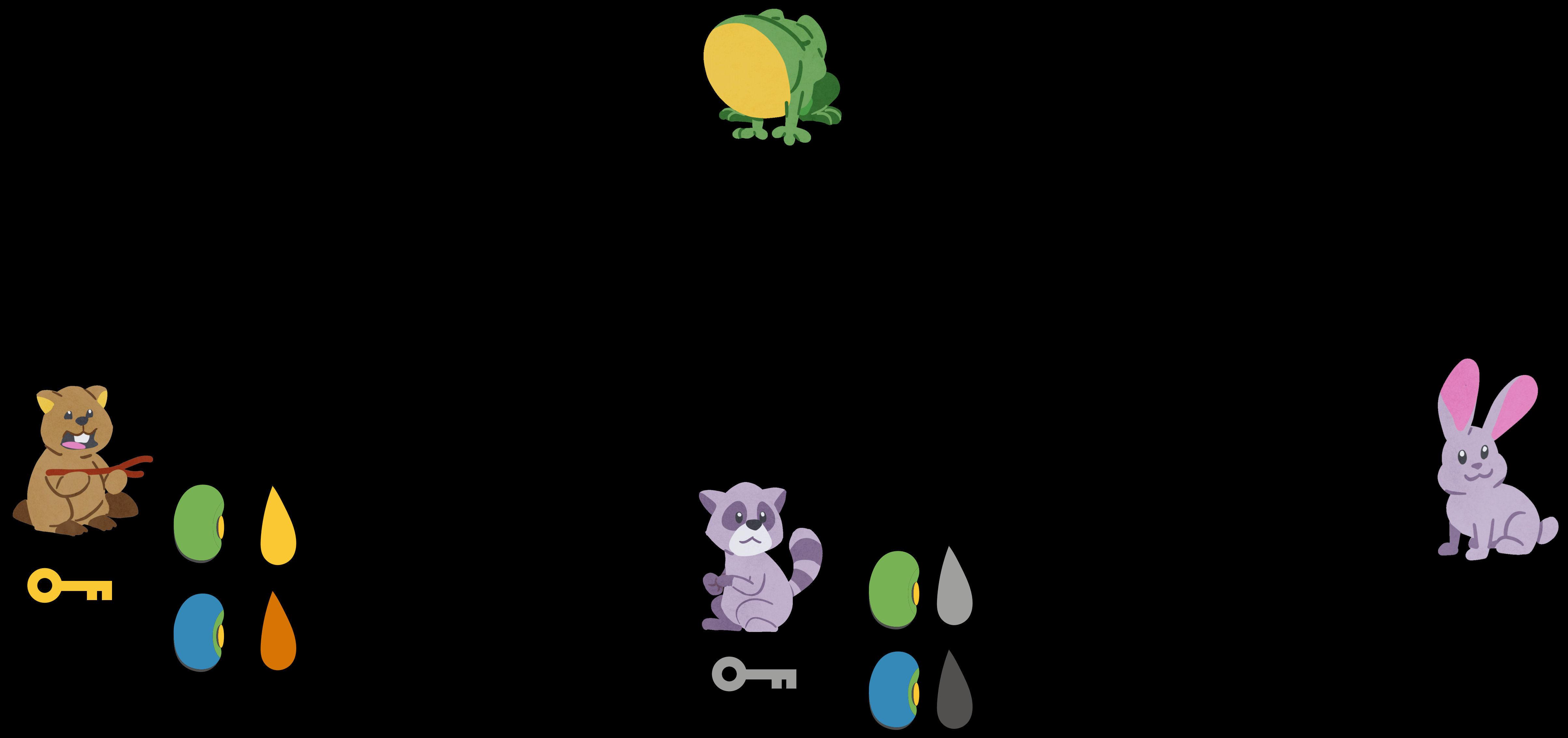
**updatable as before**



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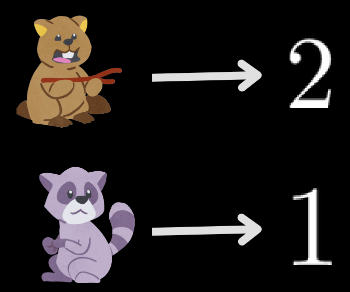


**updatable as before**
**if the cuckoo hashing changes,**
**the commitments and opening change.**

# OUR SCHEME, COMBINING GKMR WITH CUCKOO HASHING

| | Setting | $\mathcal{ID}$ | Compactness | $\lvert\mathsf{ct}\rvert$ | #updates | $\lvert\mathsf{pp}\rvert + \lvert\mathsf{crs}\rvert$ |
|---|---|---|---|---|---|---|
| [HLWW23] | Pairings (C) | $\{0,1\}^*$ | Adaptive | $O(\lambda \log n)$ | $\log n$ | $O(\lambda n^{2/3} \log n)$ |
| [GKMR22] | Pairings (P) | $[1,n]$ | Adaptive | $4 \log n$ | $\log n$ | $O(\sqrt{n} \log n)$ |
| Ours P1 | Pairings (P) | $\{0,1\}^*$ | Adaptive | $6\lambda \log n$ | $\log n$ | $O(\sqrt{\lambda n} \log n)$ |
| Ours P2 | Pairings (P) | $\{0,1\}^*$ | Selective | $12 \log n$ | $\log n$ | $O(\sqrt{n} \log n)$ |
| [DKL+23] | Lattices | $\{0,1\}^*$ | Adaptive | $(2\lambda + 1) \log n$ | $\log n$ | $O(\log n)$ |
| Ours L | Lattices | $\{0,1\}^*$ | Selective | $4 \log^2 n$ | $\log n$ | $O(\log n)$ |

Table 1: Comparison of the schemes resulting from different instantiations of our compiler. $n$ is the maximum number of users to be registered. Parings (P) indicates prime order groups and Pairings (C) composite order groups respectively. $\lvert\mathsf{ct}\rvert$ in the pairing construction is measured in group elements and in the Lattice constructions LWE ciphertexts.

# OTHER CONTRIBUTION

**KEY-VALUE MAP COMMITMENTS**

**for large keys, with updates, using pairings**

# OTHER CONTRIBUTION

**KEY-VALUE MAP COMMITMENTS**
**for large keys, with updates, using pairings**

**equivalence of vector commitments**
**and universal accumulators**

# THANK YOU

WORK BY DARIO FIORE [1], DIMITRIS KOLONELOS [1, 2] & PAOLA DE PERTHUIS [3,4]

FULL VERSION: HTTPS://EPRINT.IACR.ORG/2023/1389
PUBLISHED AT ASIACRYPT 2023

PRESENTATION BY PAOLA DE PERTHUIS

1: institute iMdea software
2: UNIVERSIDAD POLITÉCNICA MADRID
3: cosmian
4: ENS ÉCOLE NORMALE SUPÉRIEURE