Anamorphic-Resistant Encryption

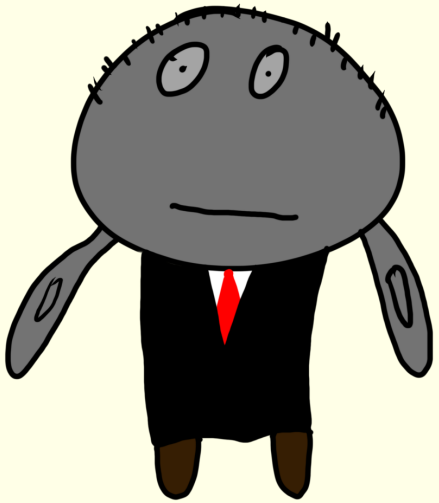
Or, why the encryption debate is still alive

Yevgeniy Dodis, **Eli Goldin**

Encryption Debate

Privacy Advocate

Mr. Government



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- Everything should be encrypted

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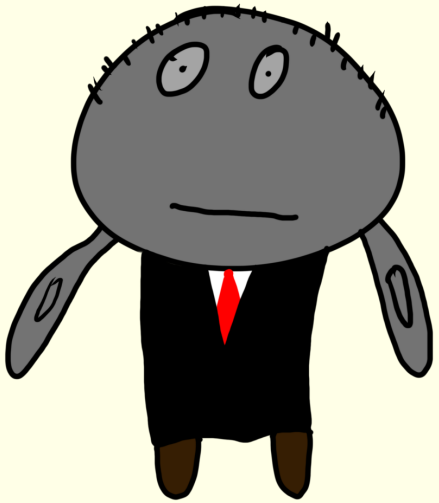

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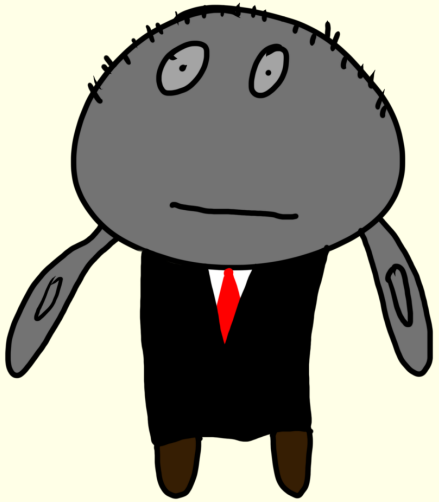

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Add backdoor?

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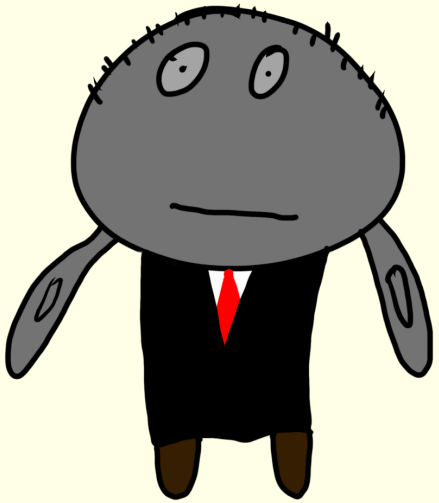

Encryption Debate

Privacy Advocate

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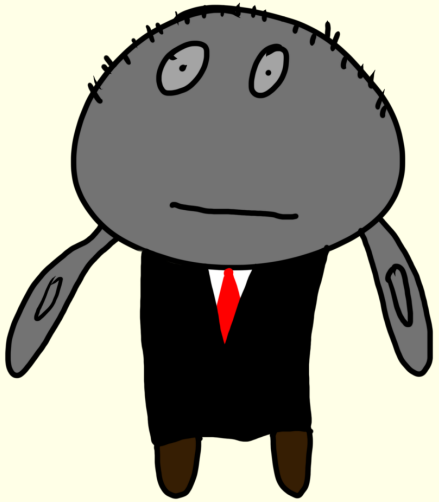
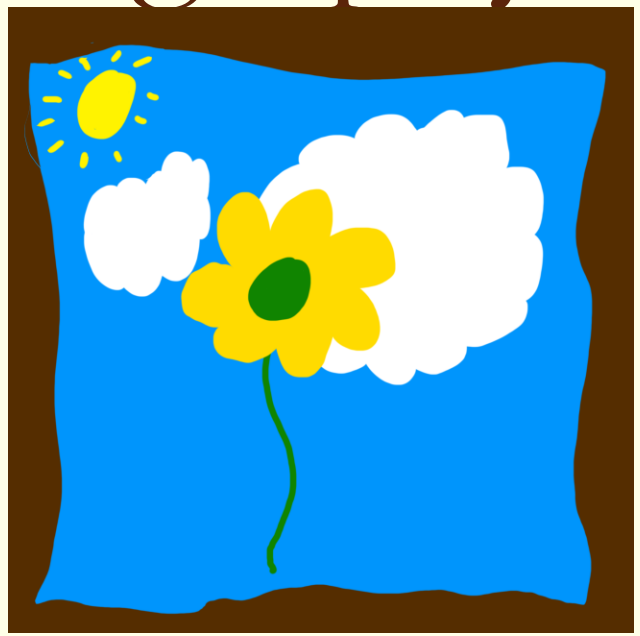
Add backdoor?

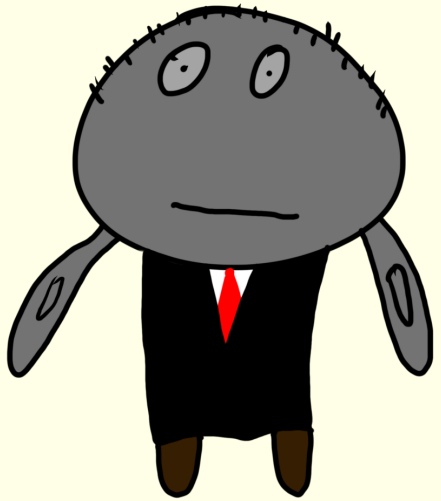
- No way, bad idea

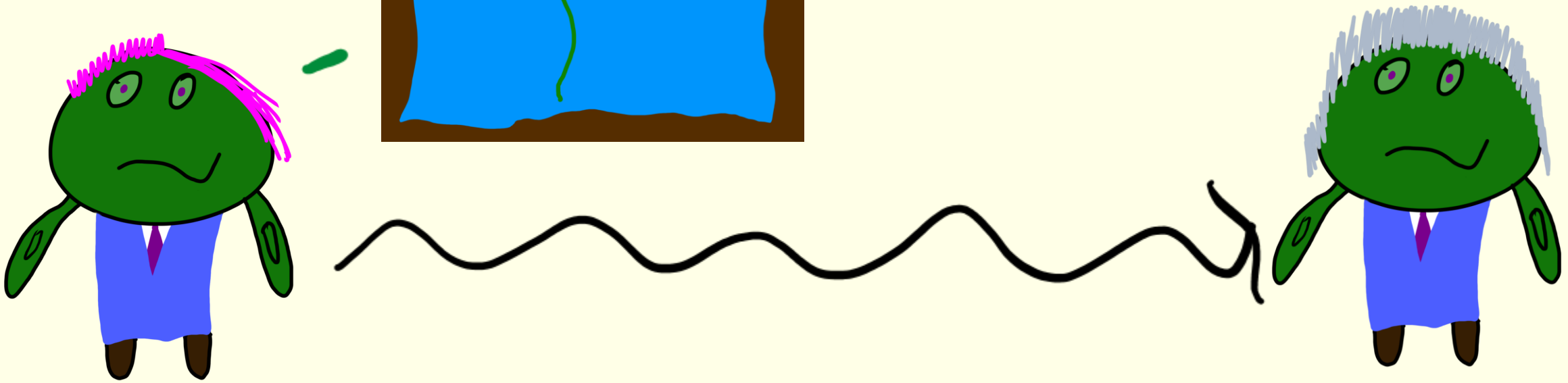
Mr. Government



Steganography







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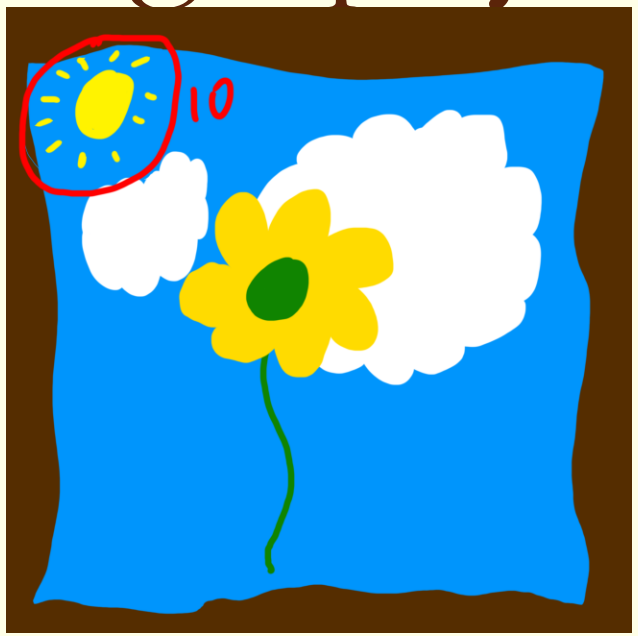
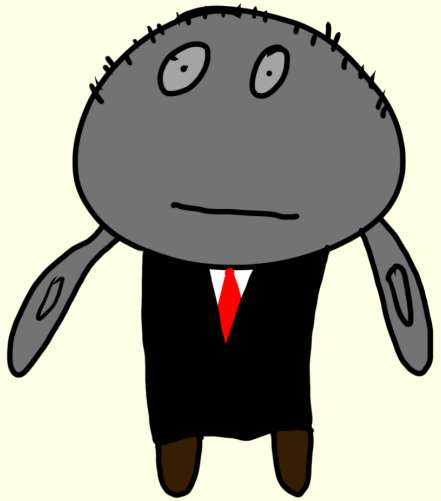
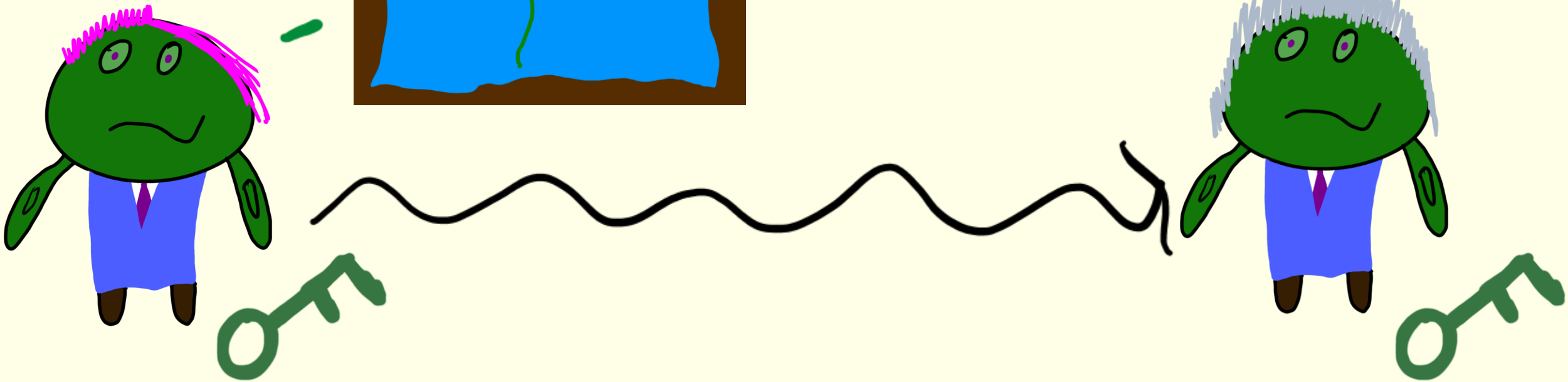




Overthrow the govt. at midnight



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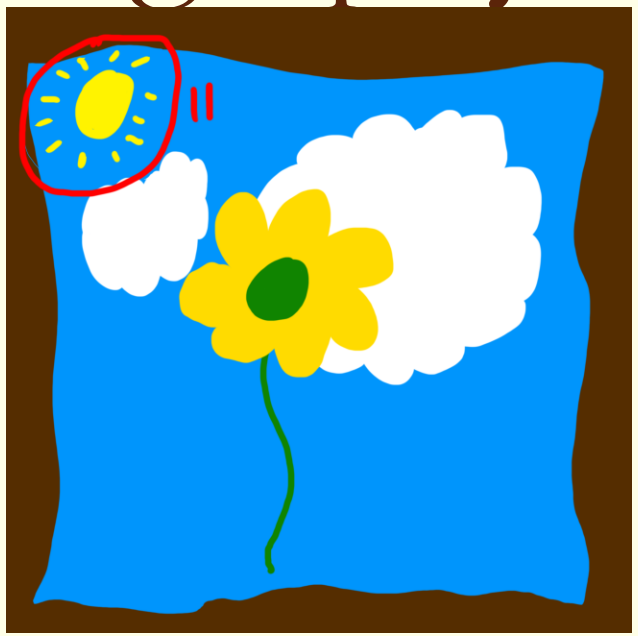
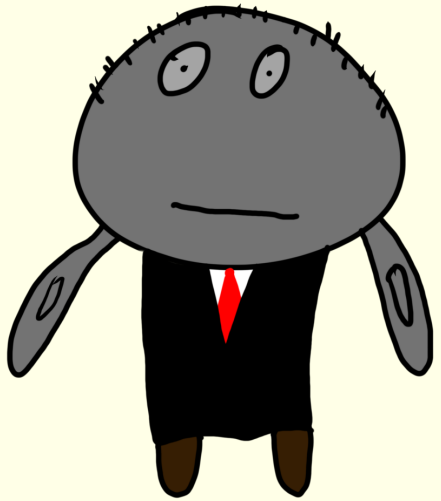
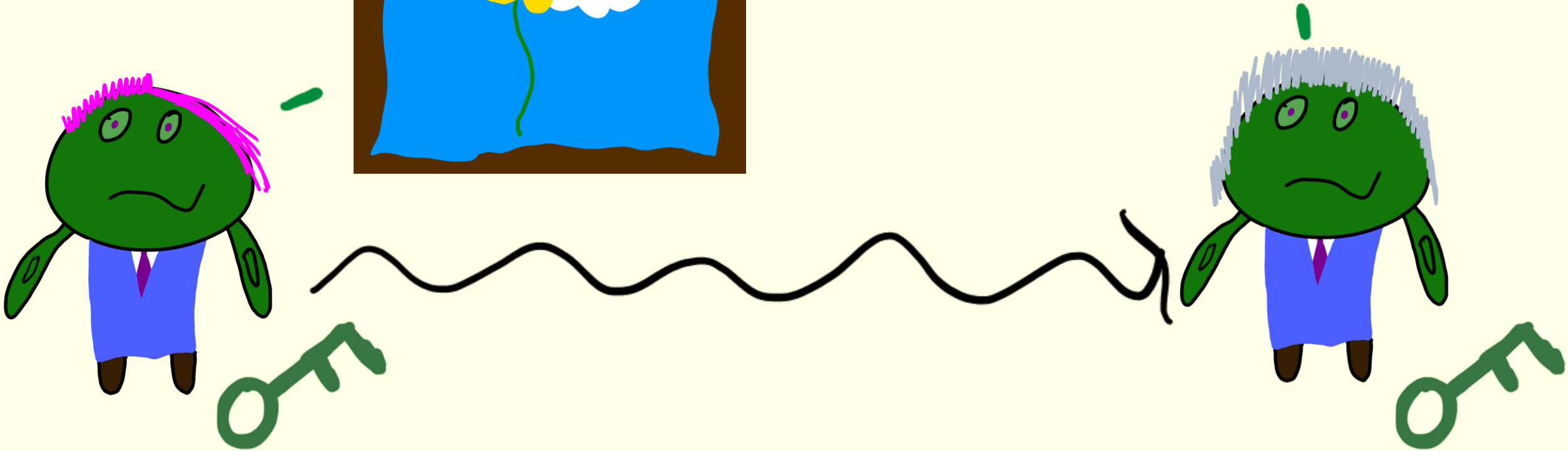
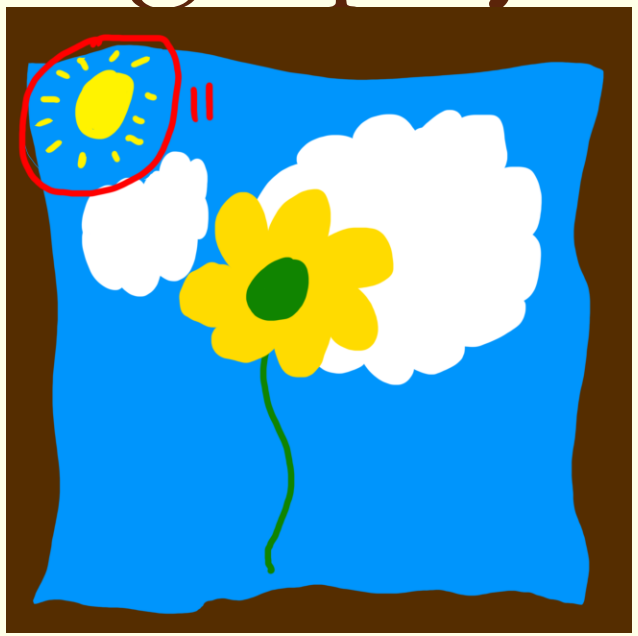


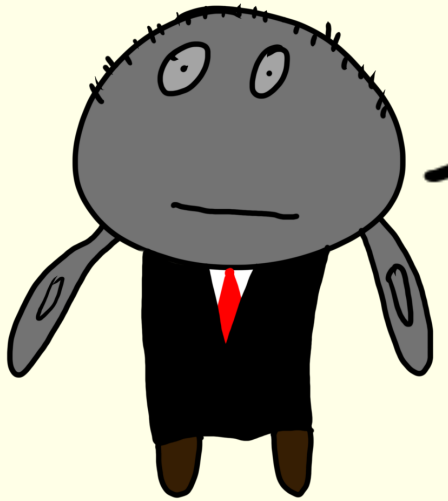


Overthrow the govt. at noon

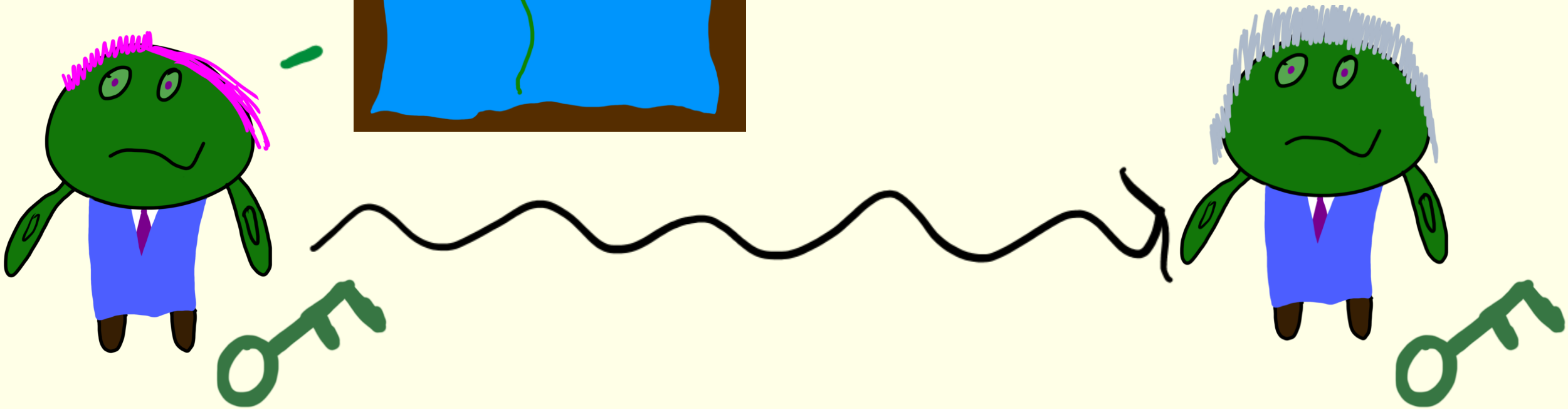


Steganography





Looks like (comp. indis.) an honest photo to me.



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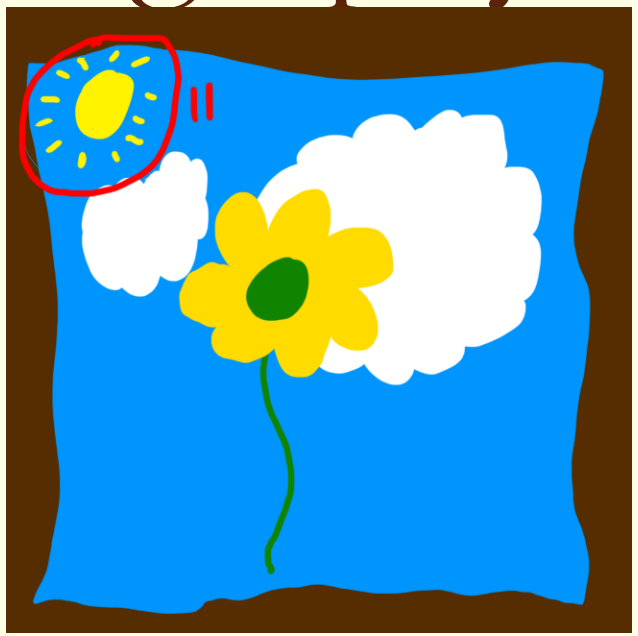

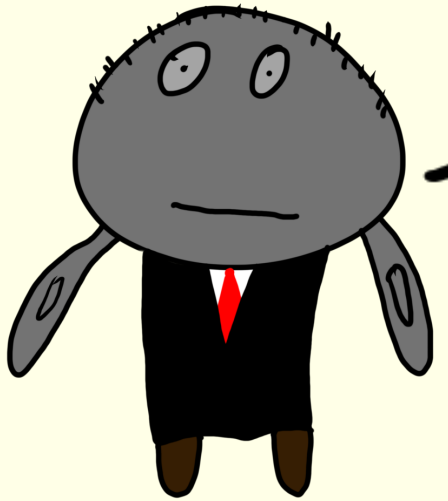

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ALWAYS possible (w/ enough randomness)

Steganography

What must always be random?

Steganography

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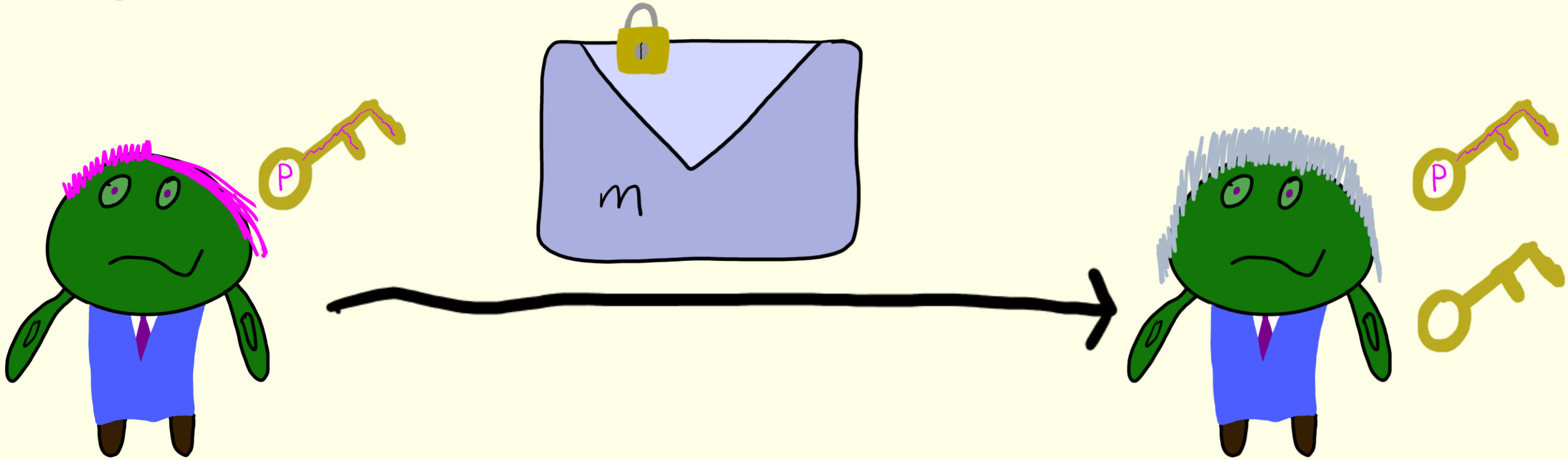


Anamorphic Encryption

If you backdoor encryption, people will just use the subliminal channel.

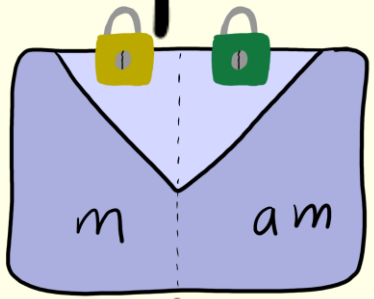
[HPRV19, PPYZ22]

Anamorphic Encryption

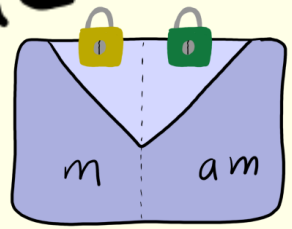
Given encryption scheme
(Gen, Enc, Dec)
Anamorphic instantiation is protocol
(AGen, AEnc, ADec) formalizing
steganographic channel

Anamorphic Encryption (Gen, Enc, Dec)

$A(Gen) \rightarrow$ 

$AEnc(m, am) \rightarrow$ 

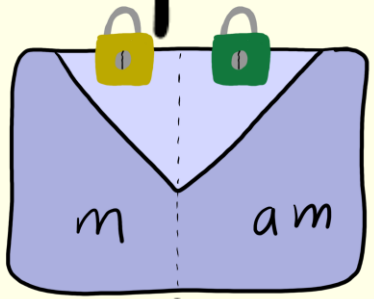
act

$ADec($  , 

dk, act $) \rightarrow am$

Anamorphic Encryption $(Gen, \widetilde{Enc}, \widetilde{Dec})$

$A(Gen) \rightarrow$ 

$AEnc(m, am) \rightarrow$ 

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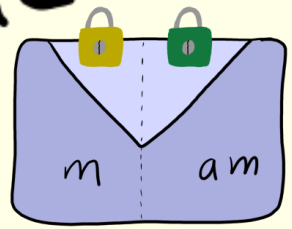
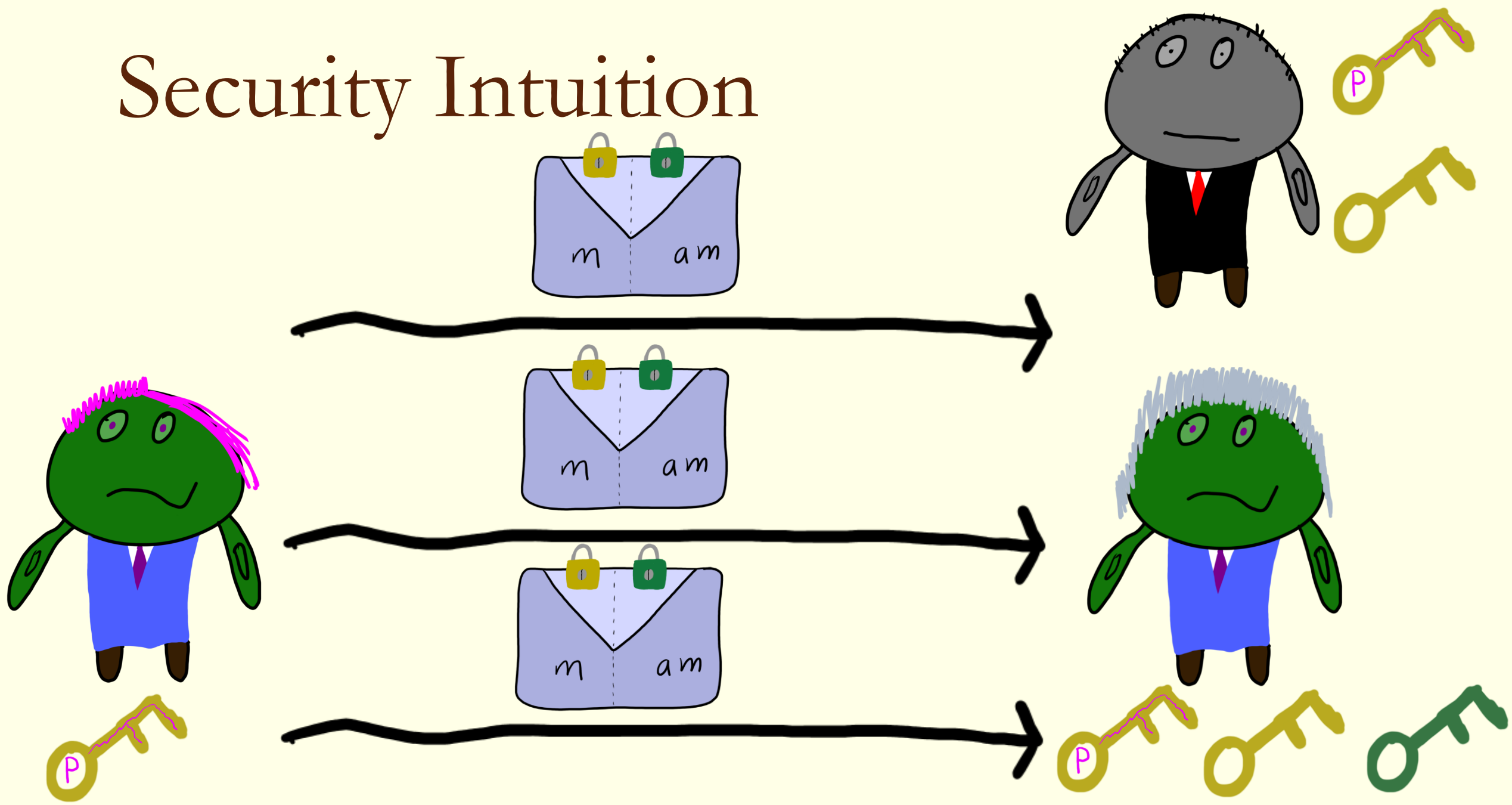
$ADec($  $,$ 

$) \rightarrow am$

dk, act

"anamorphic instantiation of (Gen, Enc, Dec)"

Security Intuition



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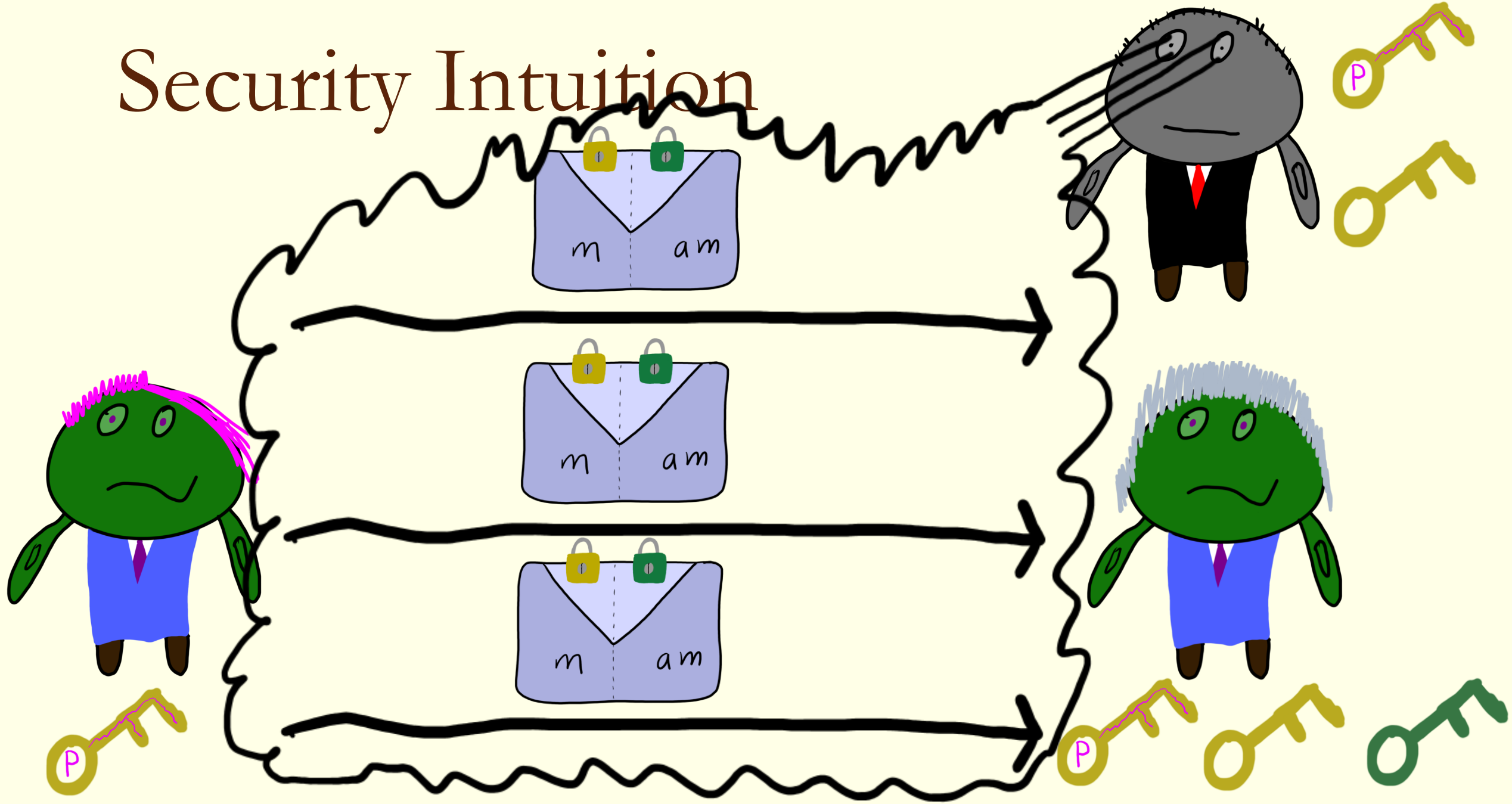

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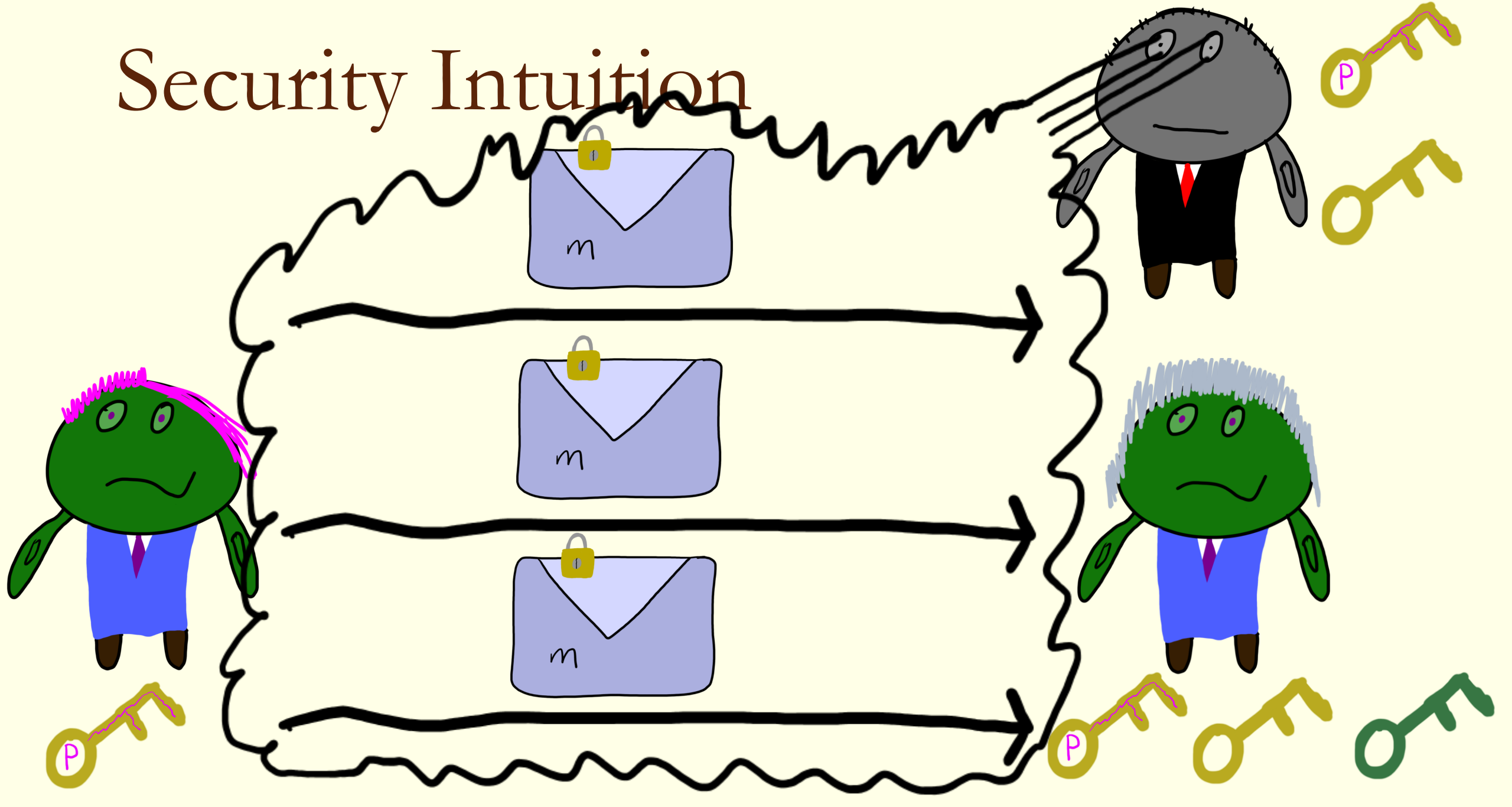

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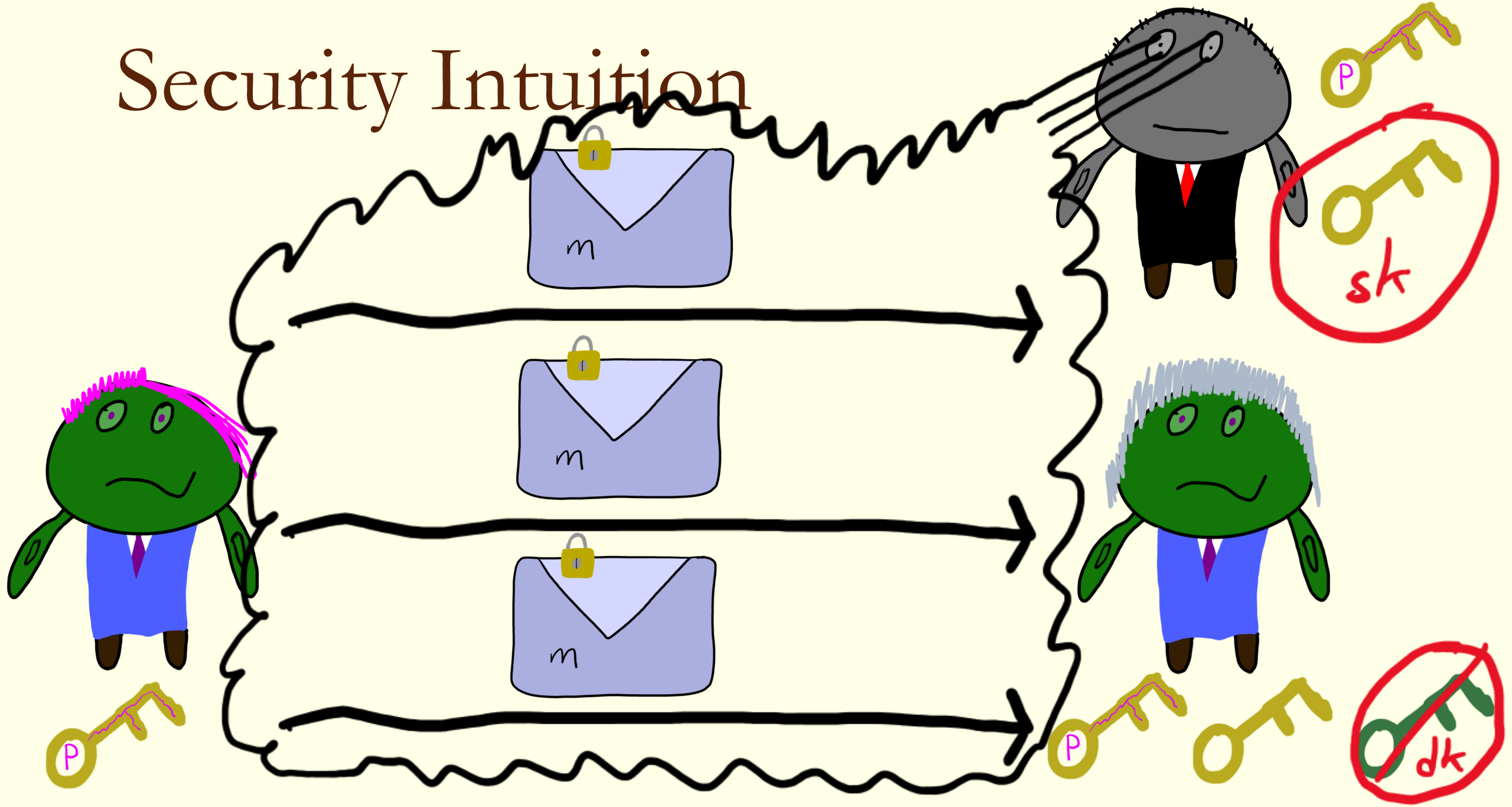
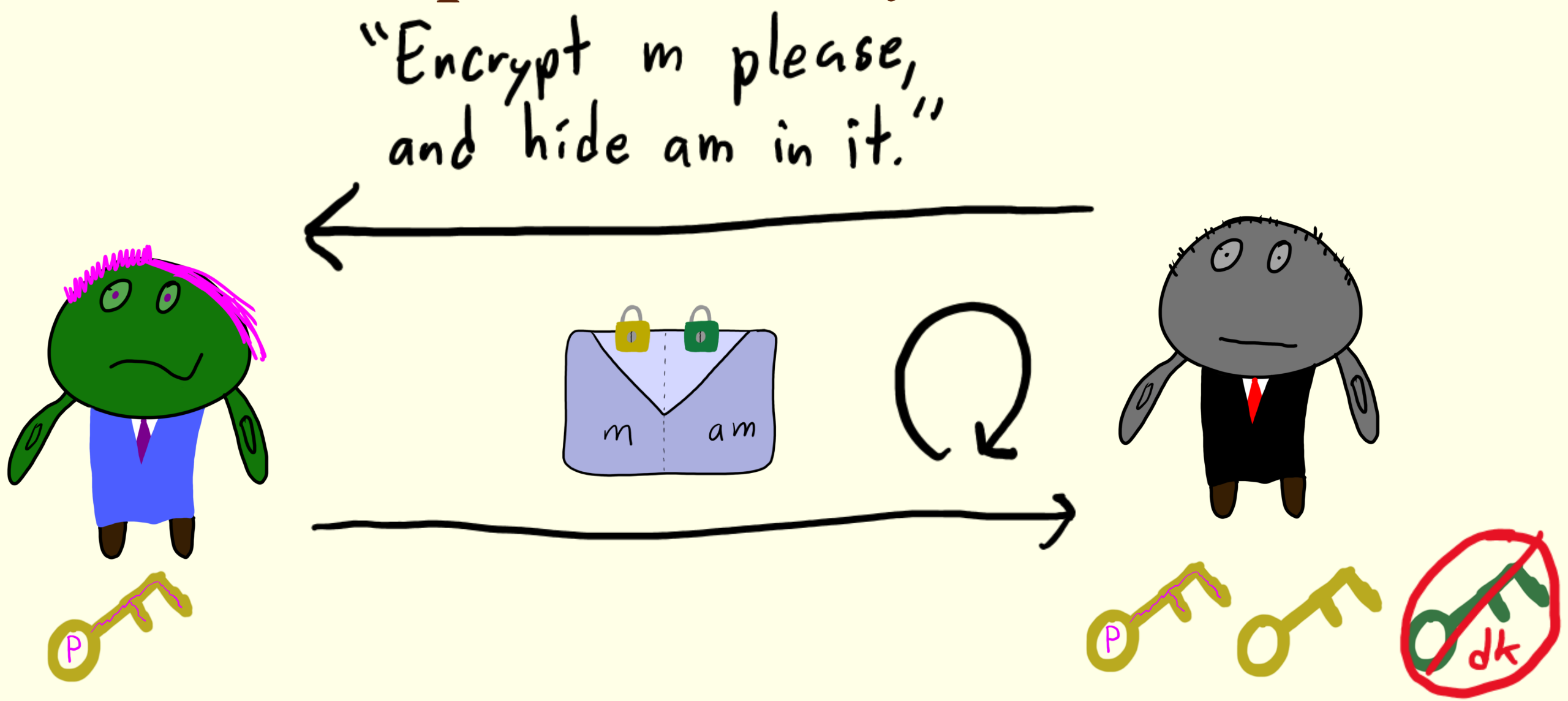


Anamorphic Security



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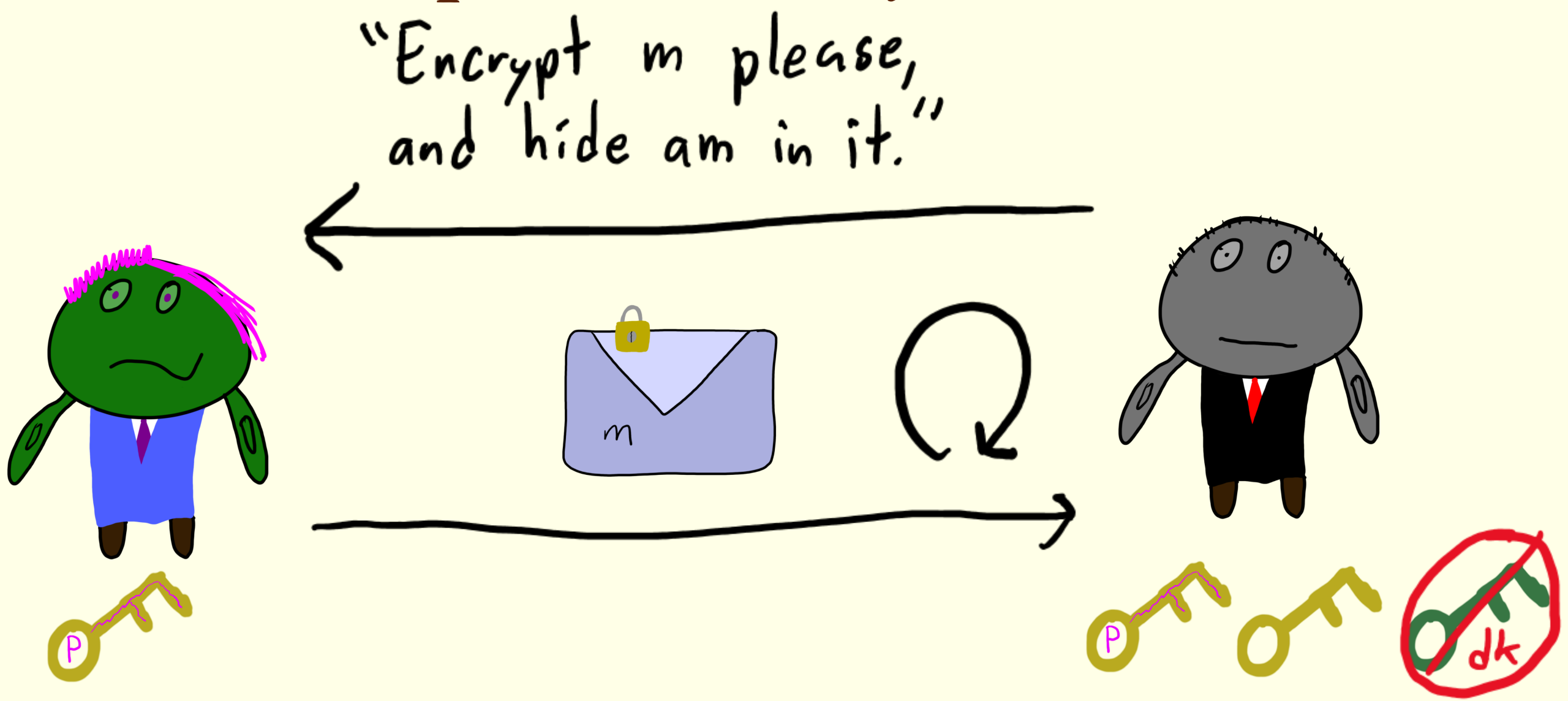

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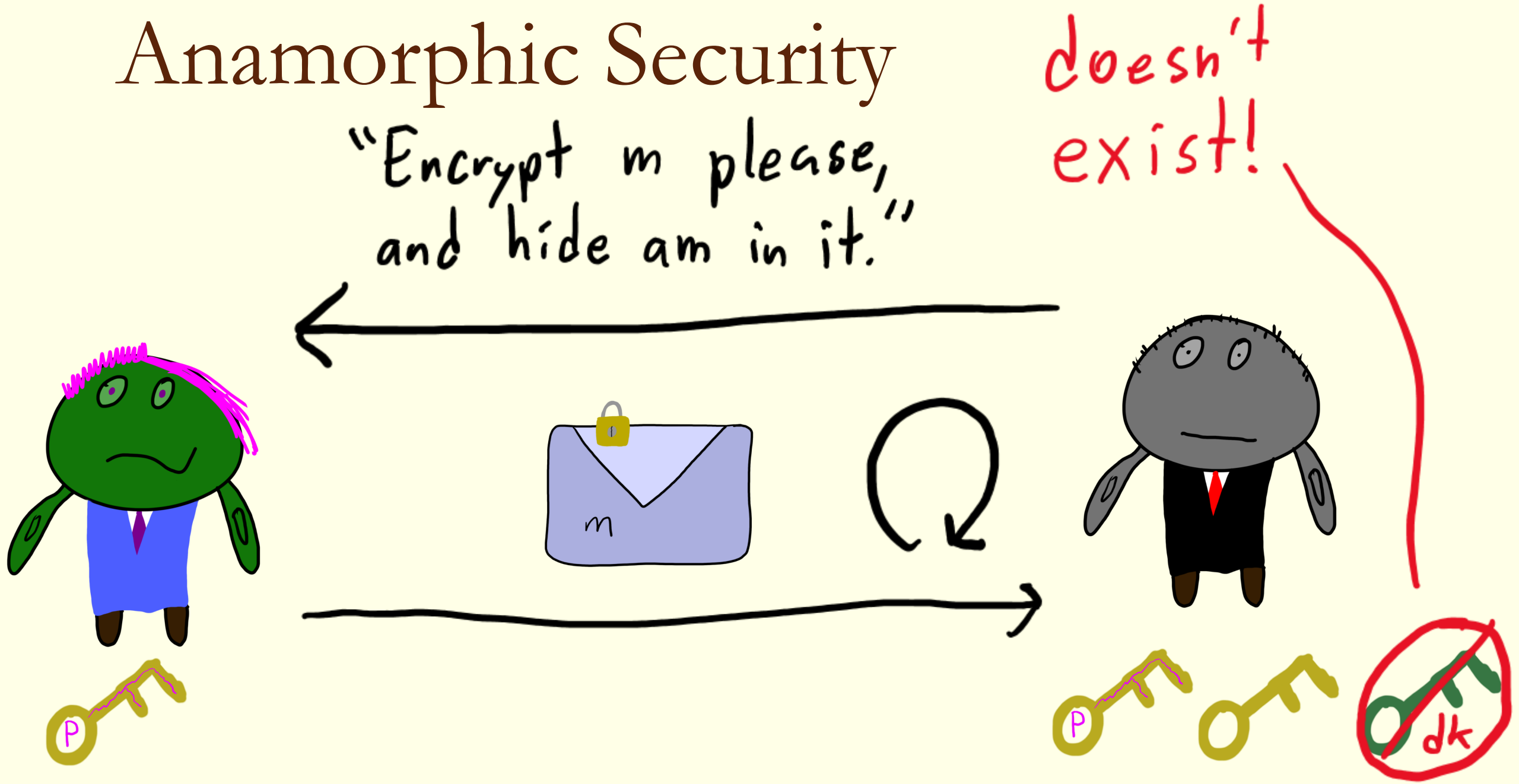
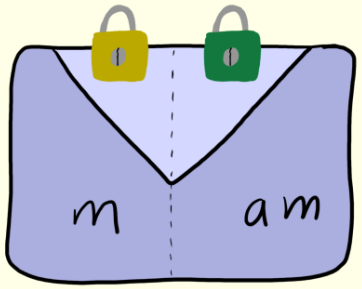
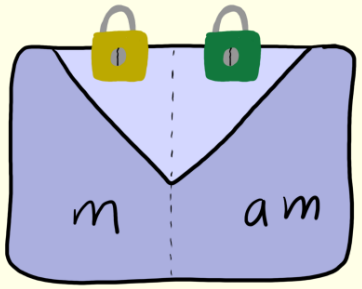


Anamorphic Encryption



always possible by rejection sampling

Anamorphic Encryption



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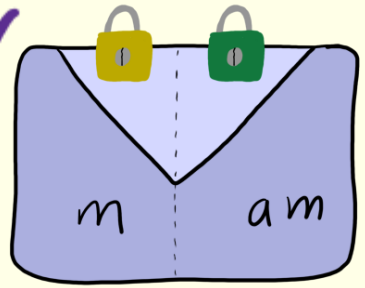
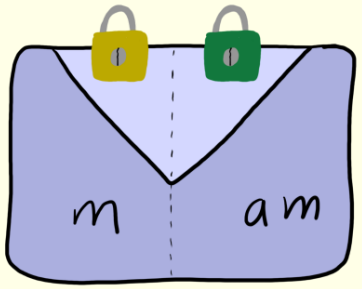
$H_{\text{🔑}}$(

) = am

Anamorphic Encryption



always possible by rejection sampling

Bandwidth: $O(\log \lambda)$

Anamorphic Encryption

Generic	Linear Bandwidth
$O(\log \lambda)$ bandwidth [PPY22]	

Anamorphic Encryption

Generic

$O(\log \lambda)$ bandwidth [PPY22]

Linear Bandwidth

Paper	Applicable Schemes	Properties
[PPY22]	Naor-Yung	

Anamorphic Encryption

Generic	Linear Bandwidth		
	Paper	Applicable Schemes	Properties
$O(\log \lambda)$ bandwidth [PPY22]	[PPY22]	Naor-Yung	robust
	[BGH+24]	randomness recoverable	

Anamorphic Encryption

Generic

$O(\log \lambda)$ bandwidth

[PPY22]

Linear Bandwidth

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[PPY24]	many CCA PKEs	public-key anamorphism
⋮		

Anamorphic Encryption

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$O(\log \lambda)$ bandwidth

[PPY22]

Linear Bandwidth

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⋮	([KPP+23]×2, [CGM24], ...)	

Anamorphic Encryption

Hypothesis: linear bandwidth anamorphic instantiations are always possible.

Anamorphic Encryption

Hypothesis: linear bandwidth anamorphic instantiations are always possible.

Spoiler: NO

Philosophy

Philosophical Question

Who picks what PKE schemes are legal?

Dictatoria

Wants to read all messages (universal backdoor)

Dictatoria

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Privacy against foreign nations

Dictatoria

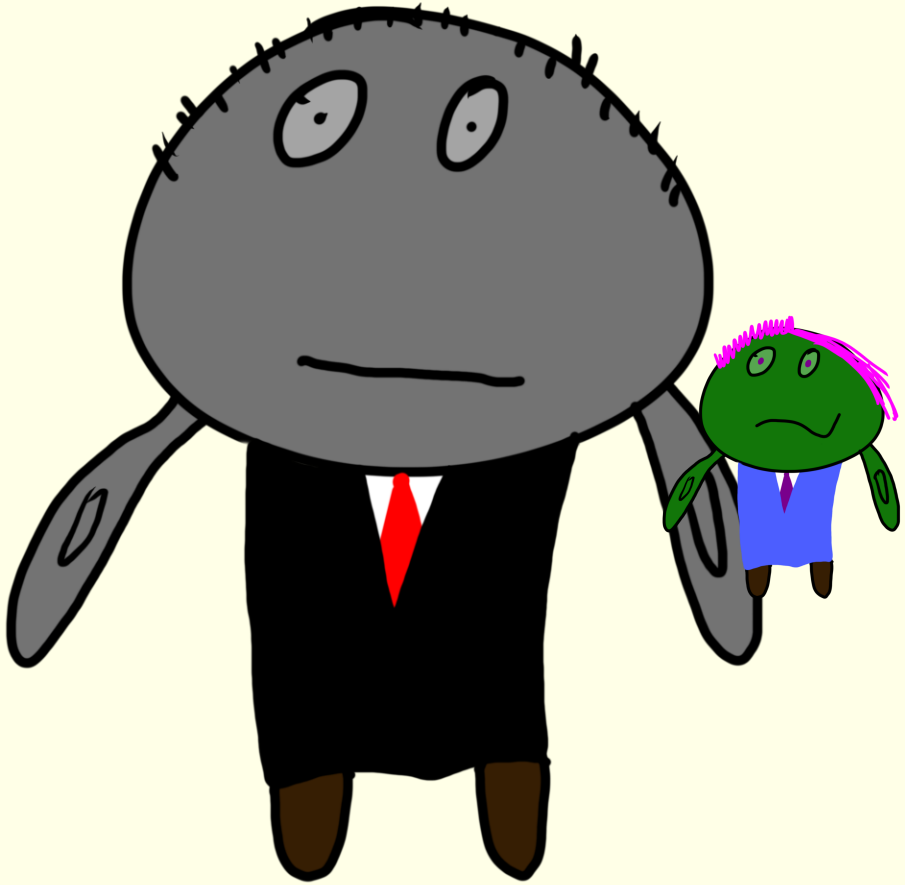
Wants to read all messages (universal backdoor)

Privacy against foreign nations

Outlaw non-trivial anamorphism

Warrantland

Wants to read messages when warrant issued



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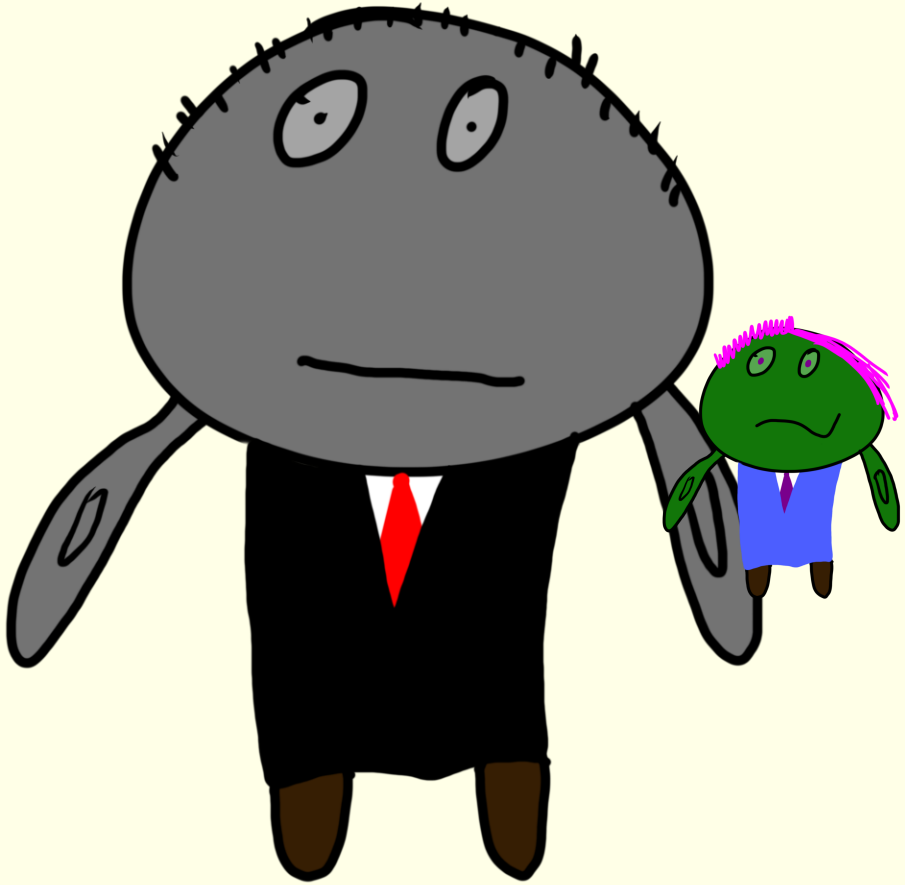
Wants to read messages when warrant issued

Privacy against itself with no warrant



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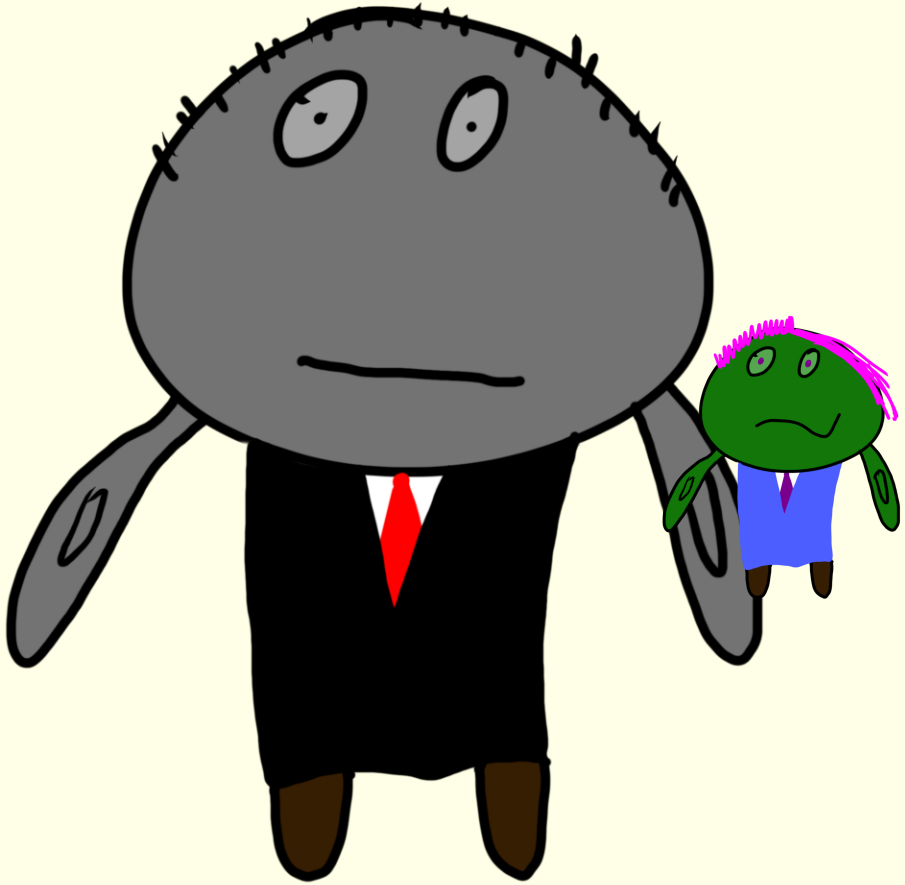


Privatopia

Privacy against itself now and in the future

Privatopia

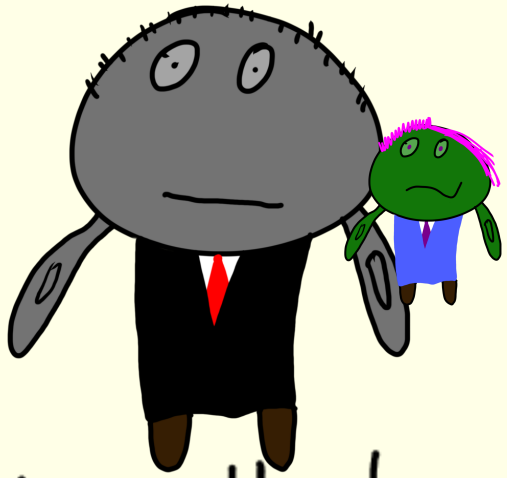
Privacy against itself now and in the future

Wants to standardize anamorphic encryption

Main Philosophical Question

Are there schemes which make

Dictatoria



Warrantland

Privatopia

happy?

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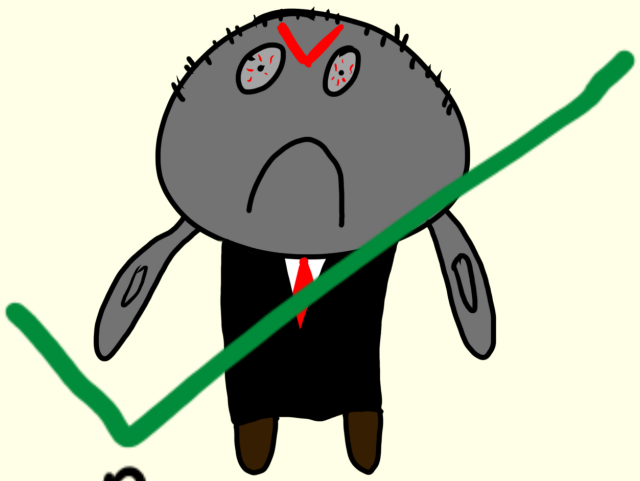

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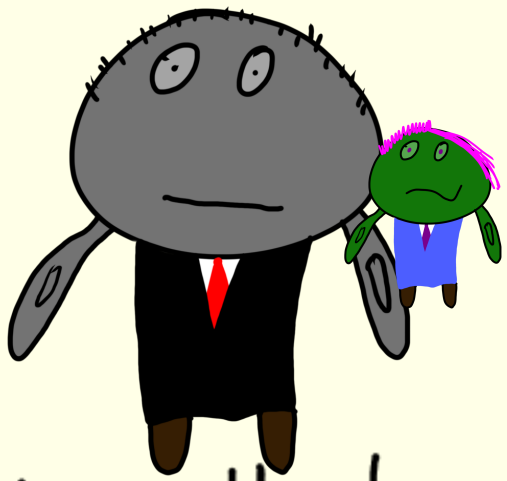

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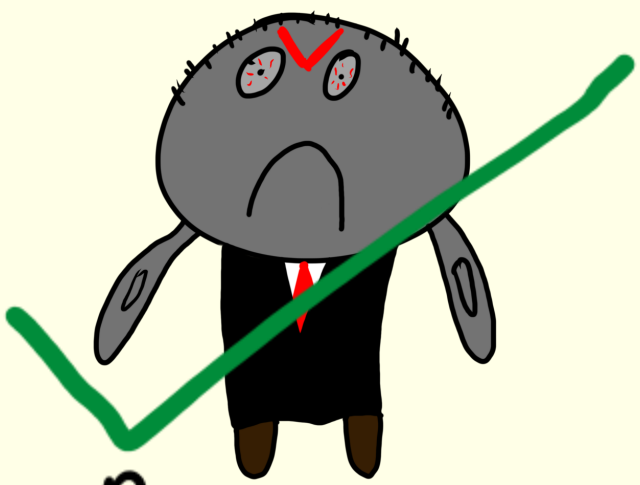

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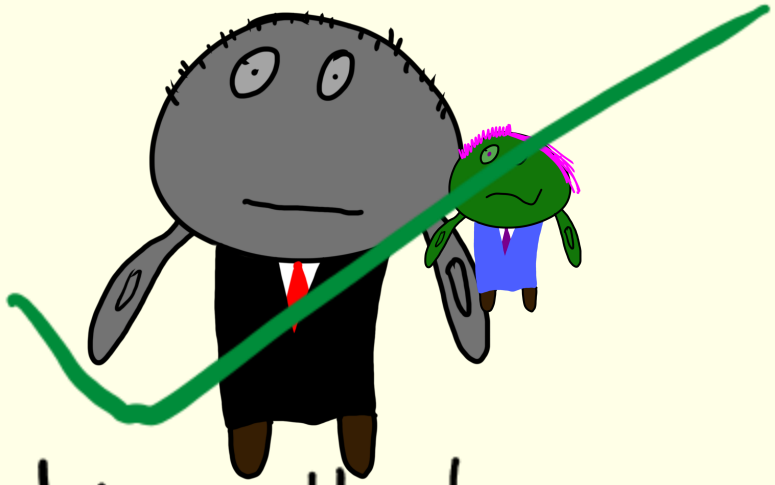

Warrantland

Primstopia

happy?

Results

Anamorphic Resistant Encryption

(Gen, Enc, Dec) such that no non-trivial anamorphic instantiation exists.

Anamorphic Resistant Encryption

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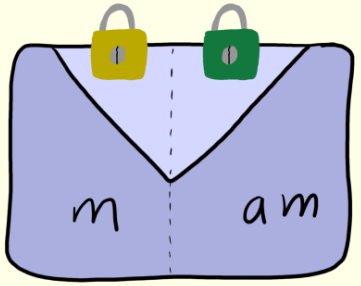
ALL (AGen, AEnc, ADec)

have $|am| = O(\log \lambda)$



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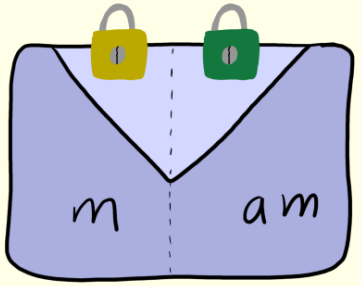


have $|am| = O(\log \lambda)$

ARE

Dictatoria

Dictatoria

ARE w/ universal backdoor.

Dictatoria

ARE w/

universal backdoor.

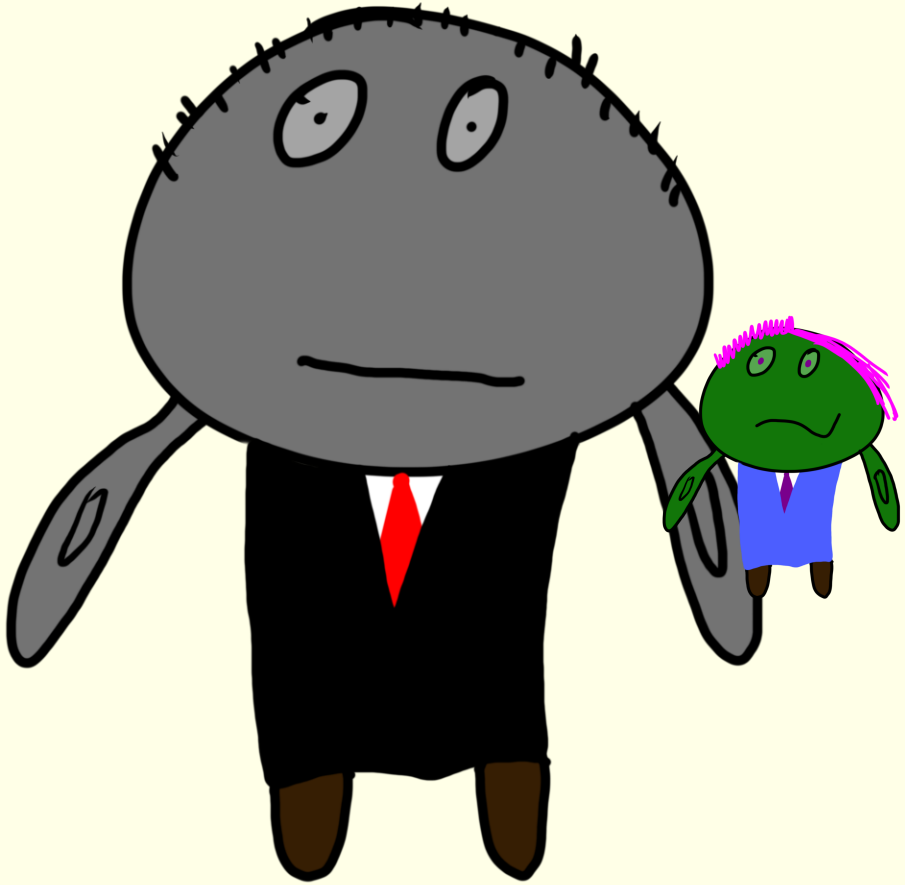
Dictator can read all messages & detect anamorphism without secret-key access

Dictatoria ~~ARE~~ in ROM

universal backdoor.

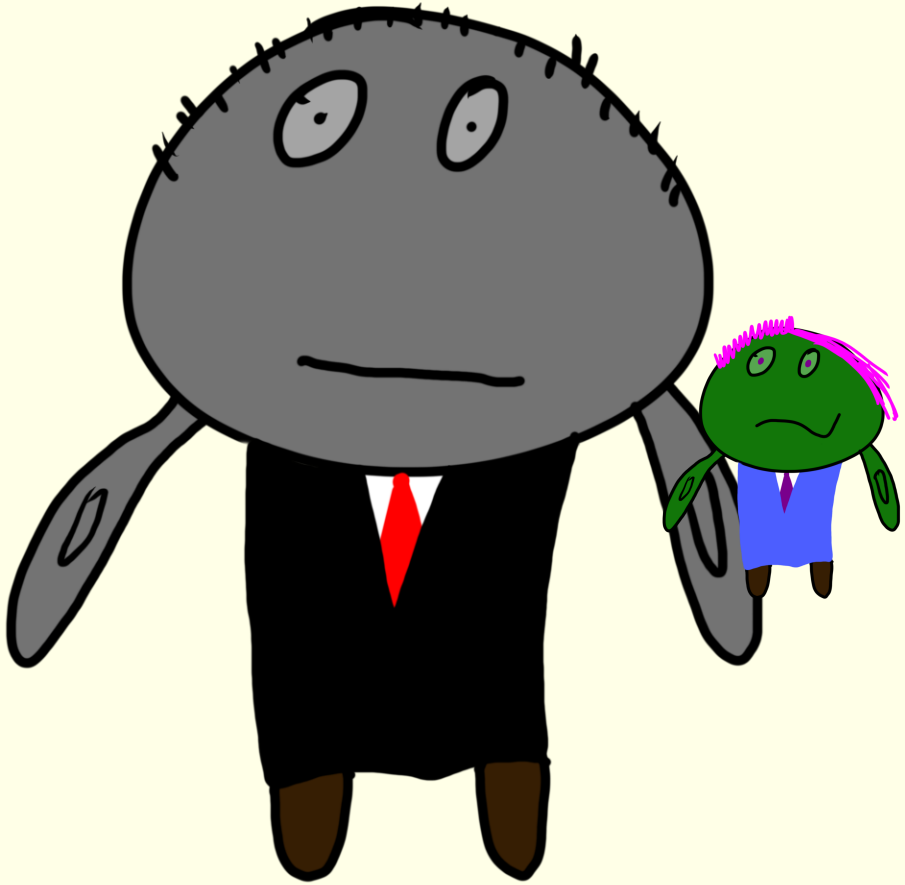
Dictator can read all messages & detect anamorphism <u>without</u> secret-key access

Warrantland



Warrantland

ARE which needs secret key access.



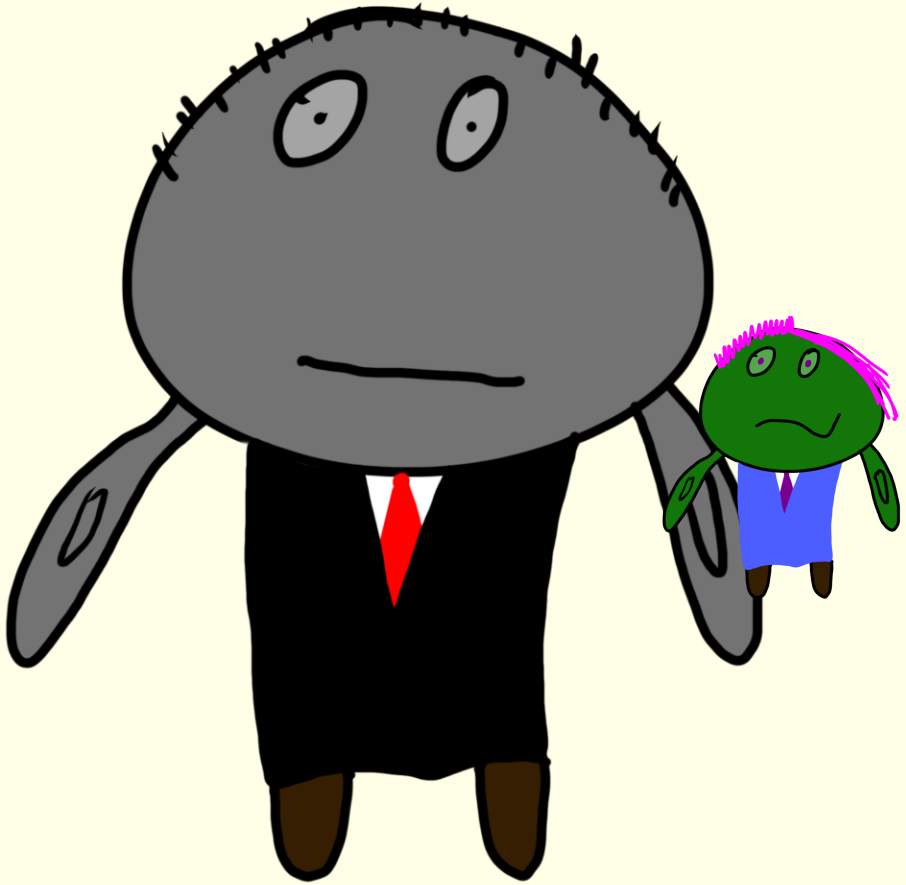
Warrantland

ARE which needs secret key access.

If  hidden, secure against govt. w/ 

sk

backdoor



Warrantland in ROM

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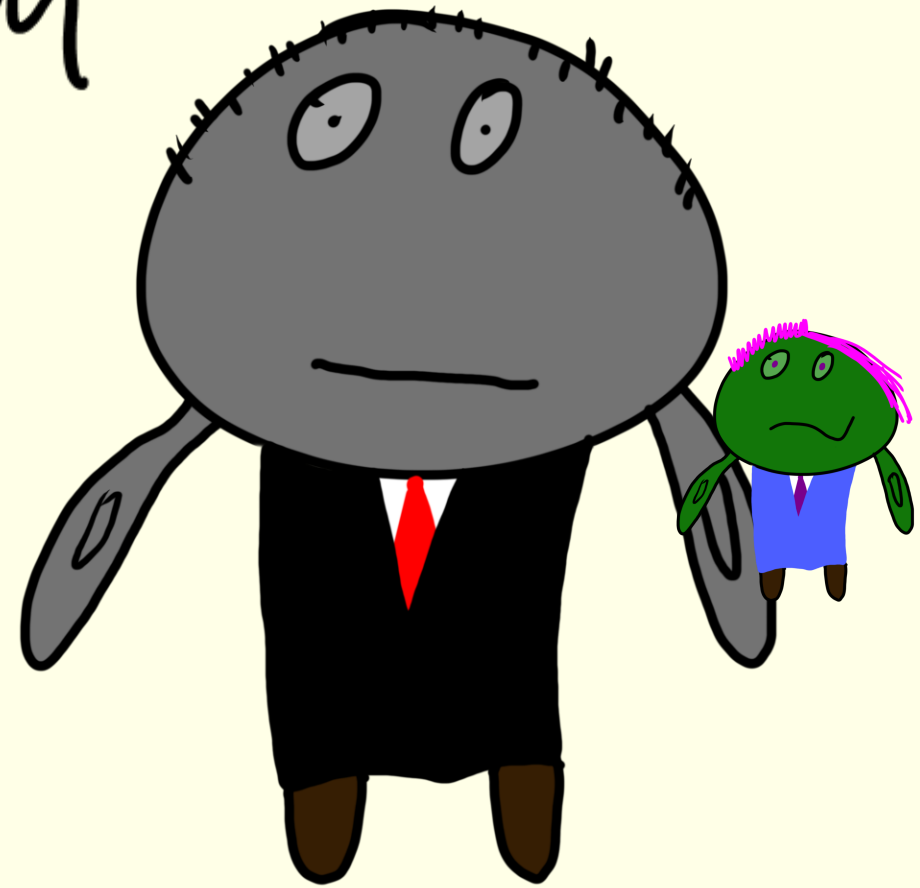
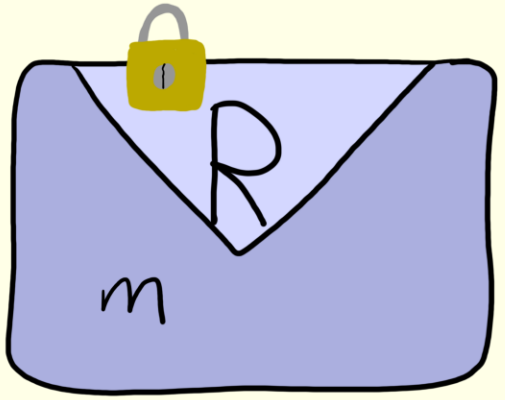


ARE

Construction

Anamorphic Resistant Encryption

Key plan: "only way to bias

$Enc(pk, m; R) \rightarrow$ 

is to do rejection sampling"

Anamorphic Resistant Encryption

Idea #1: Replace R w/ RO(R)

$$Enc(pk, m; R) = E(pk, m; RO(R))$$

Anamorphic Resistant Encryption

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(Only way to bias RO(R) is rej. sampling)

$$Enc(pk, m; R) := E(pk, m; RO(R))$$

Anamorphic Resistant Encryption

If

$AEnc(m, am) =$

Anamorphic Resistant Encryption

If

$AEnc(m, am) =$ 

then $RO(R_{am})$ can only provide

$\approx \log \lambda$ bits of info on am

Anamorphic Resistant Encryption

If

$AEnc(m, am) =$

might not be the case.

then $RO(R_{am})$ can only provide

$\approx \log \lambda$ bits of info on am

Anamorphic Resistant Encryption

Key question: how to force

$AEnc(m, am) =$ 

?

Anamorphic Resistant Encryption

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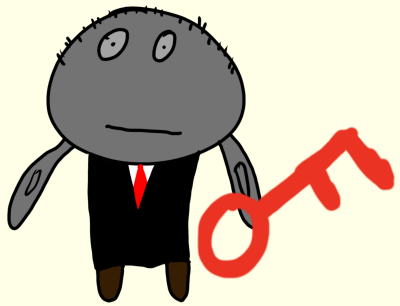
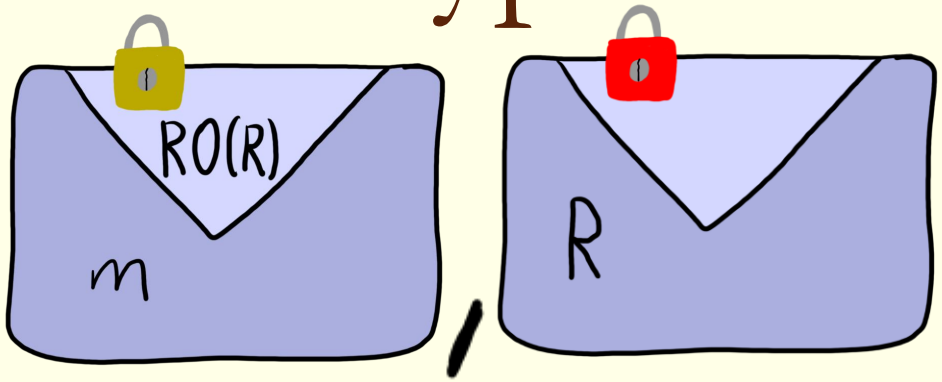
$AEnc(m, am) =$ 

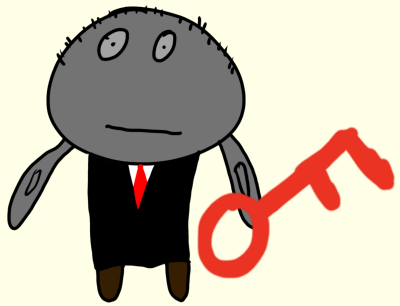
?

Idea 2: tell  R

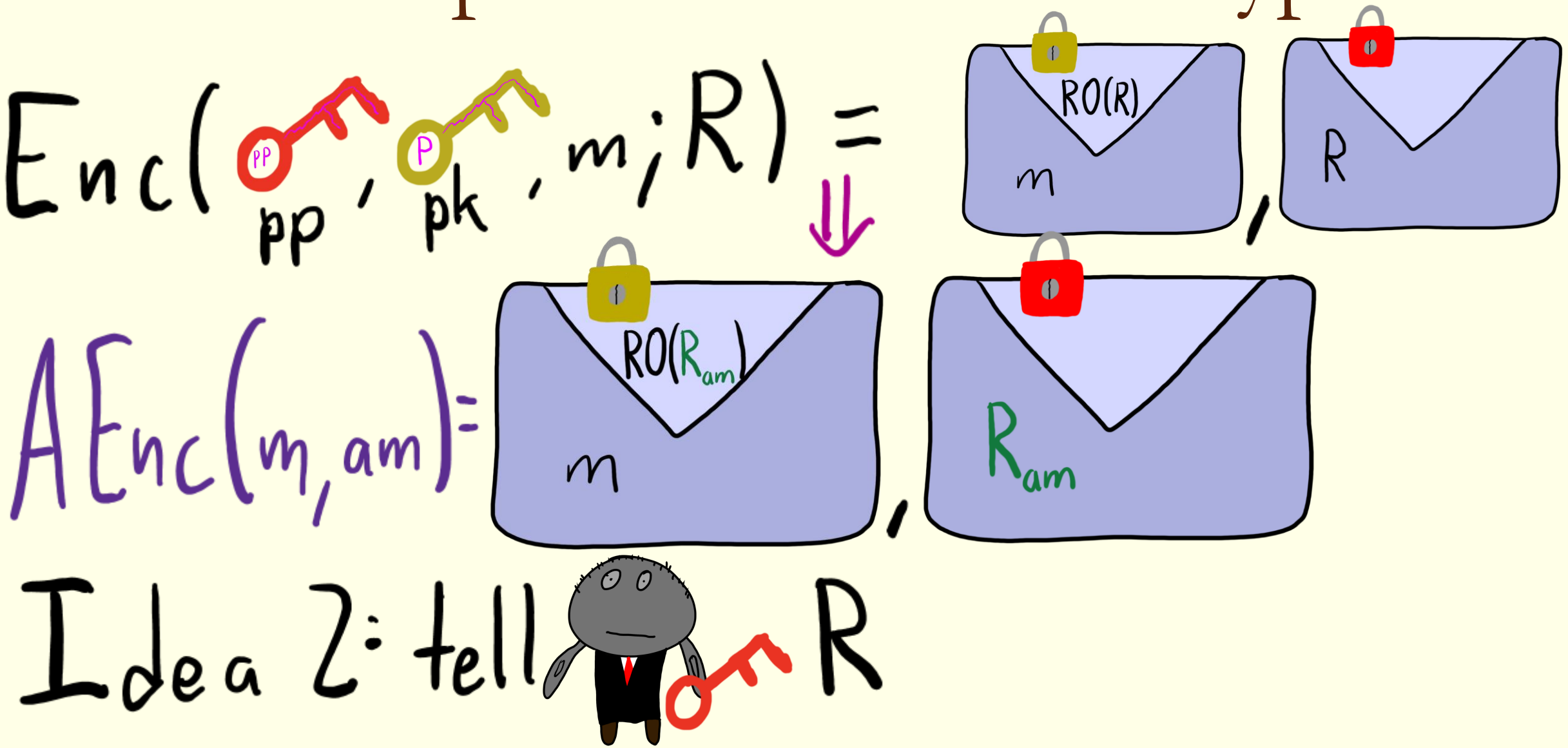
Anamorphic Resistant Encryption

$Enc(pp, pk, m; R) =$

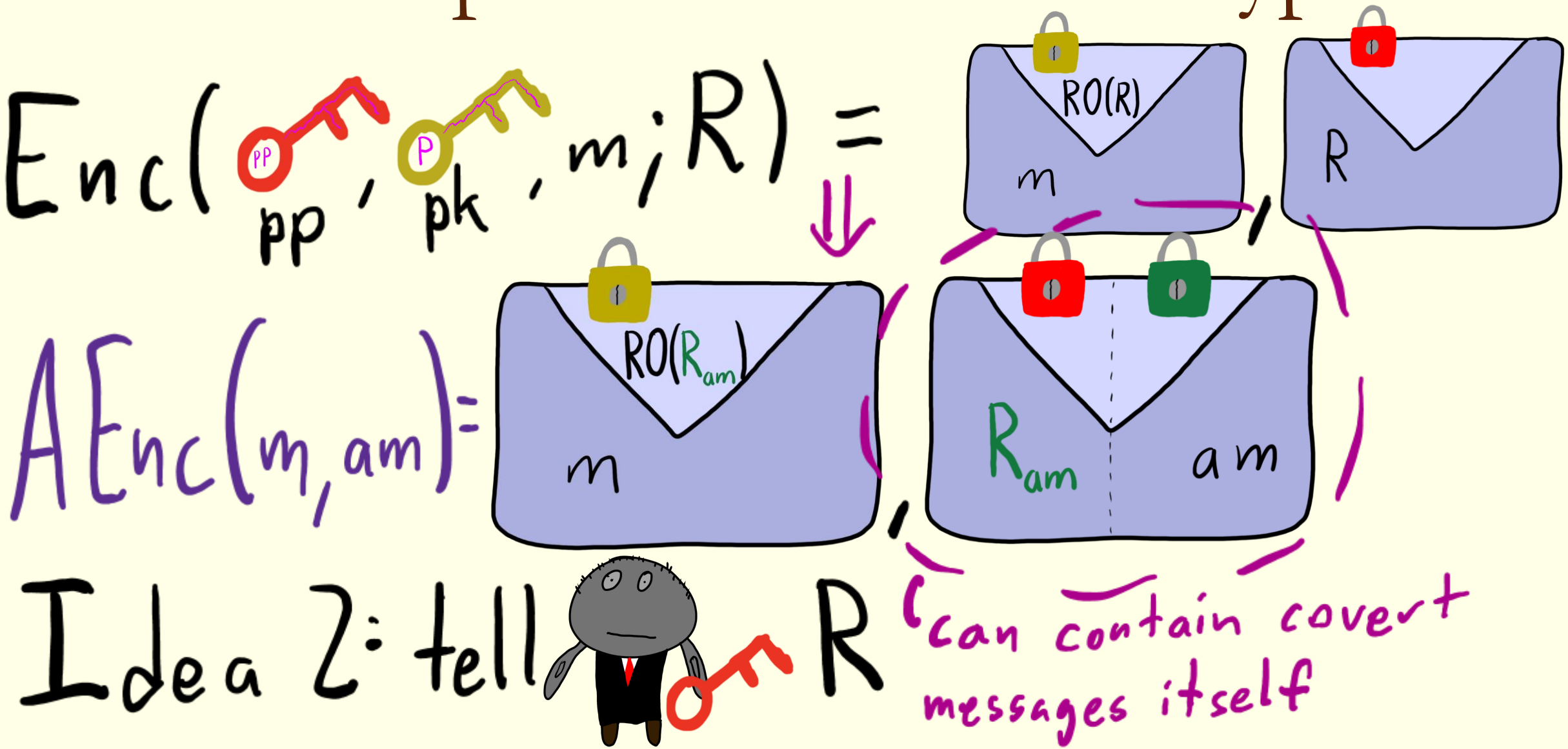


Idea 2: tell  R

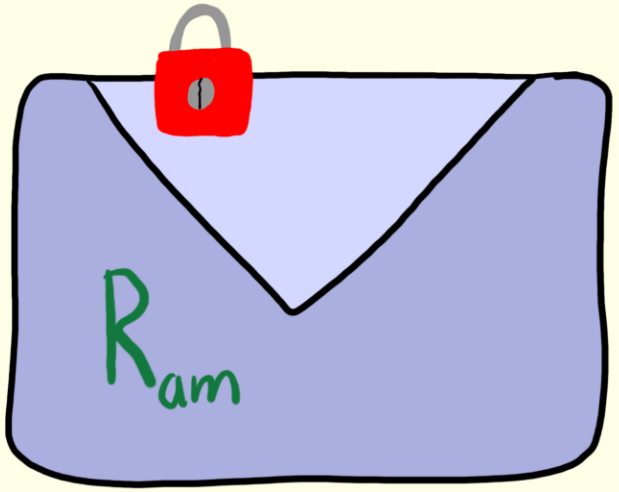
Anamorphic Resistant Encryption



Anamorphic Resistant Encryption



Deterministic Encryption

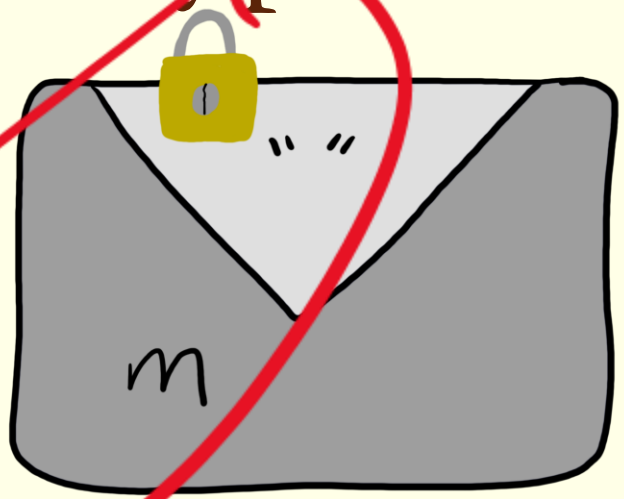
If 

is not random,

can't contain any anamorphic message.

Deterministic Encryption

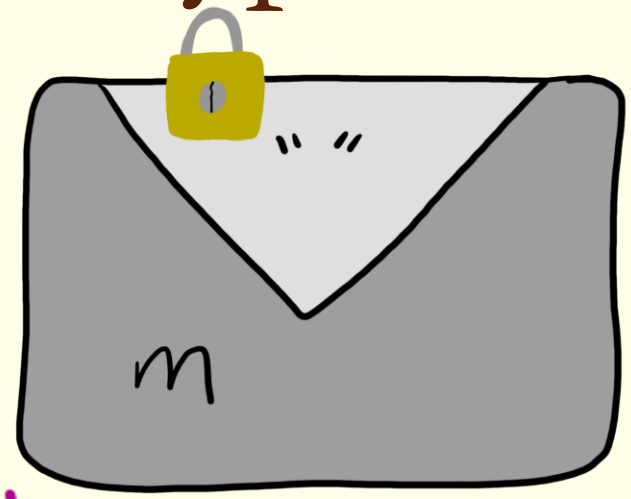
$DEnc(pk, m) :=$



usually impossible

Deterministic Encryption

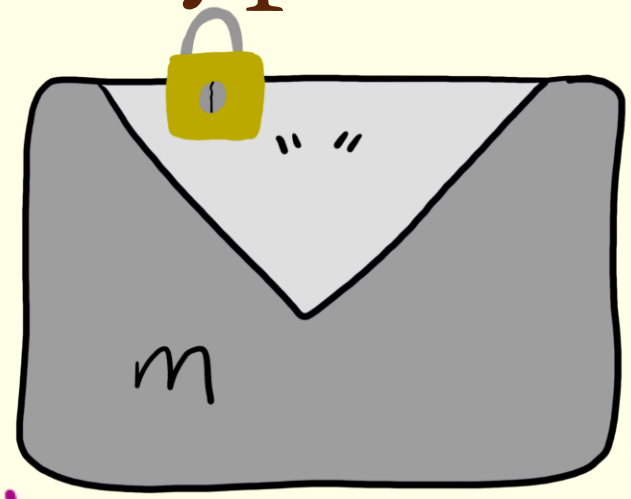
$DEnc(pk, m) =$



Possible in restricted circumstances

Deterministic Encryption

$DEnc(pk, m) =$

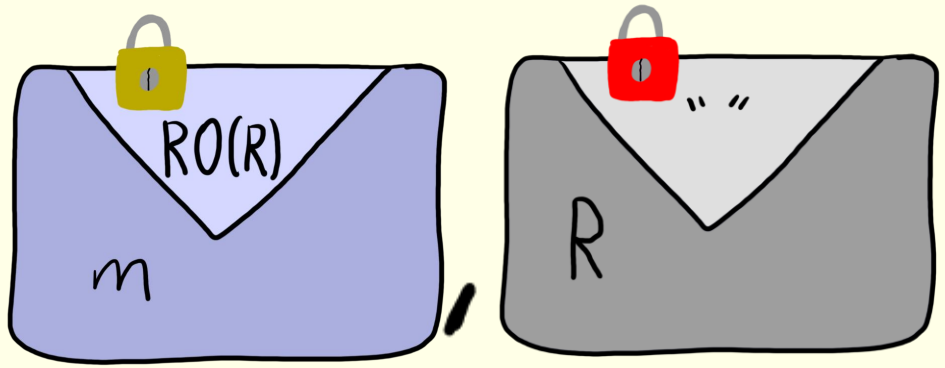


Possible in restricted circumstances

Including this one! (with work)

Final Construction

$Enc(pp, pk, m; R) =$



Final Construction

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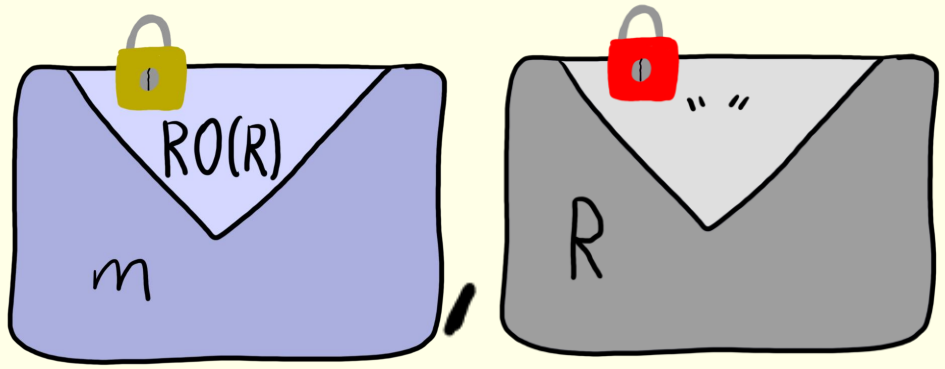
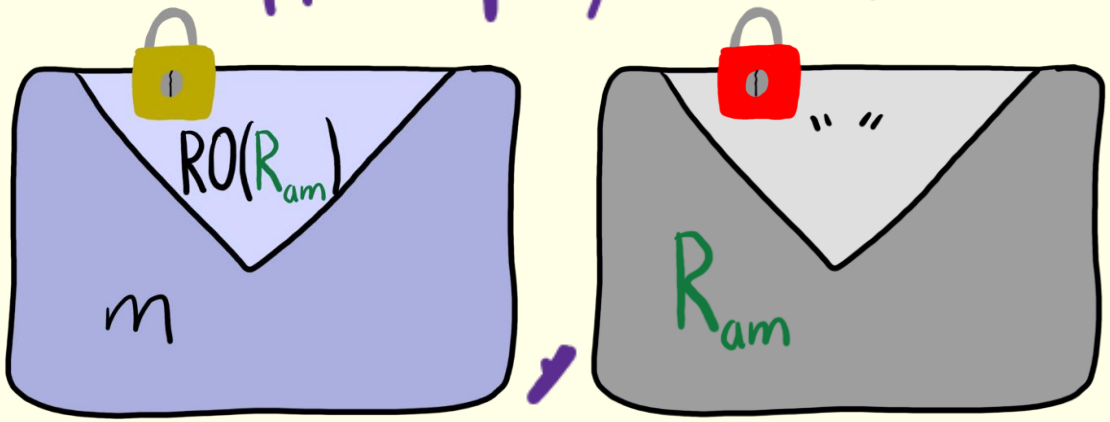


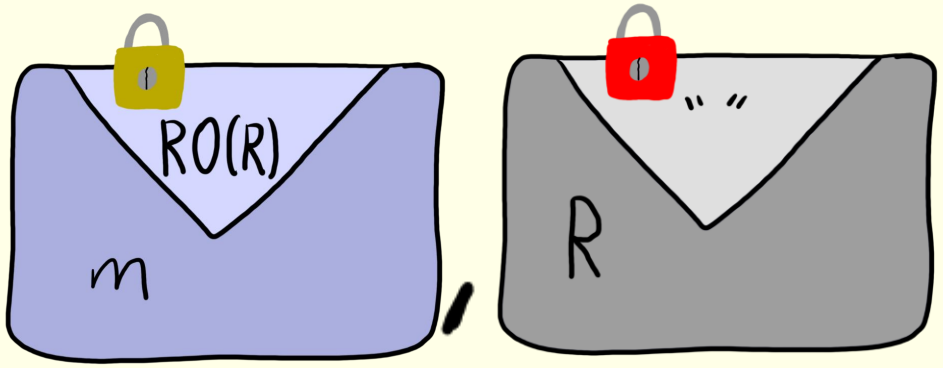
$AEnc(pp, pk, ak, m, am)$

$=$

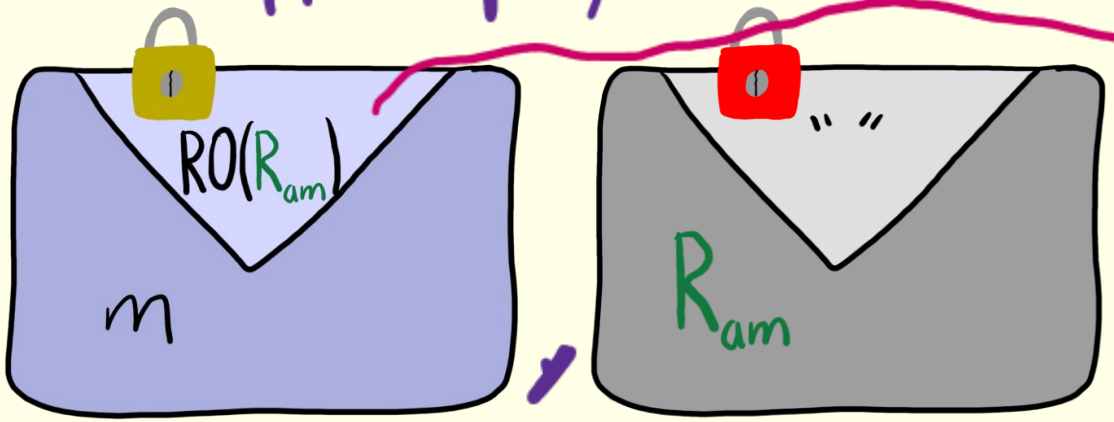


Final Construction

$Enc(pp, pk, m; R) =$



$AEnc(pp, pk, ak, m, am) =$



only info on am, $< \log \lambda$ bits of info

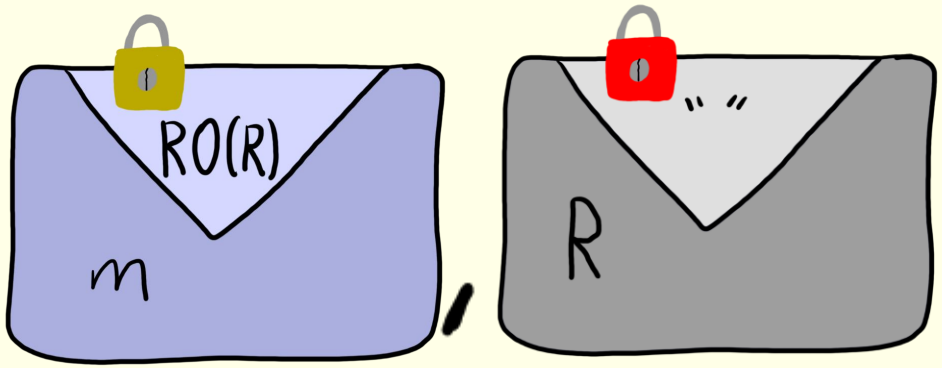
Dictatoria ~~ARE~~ in ROM

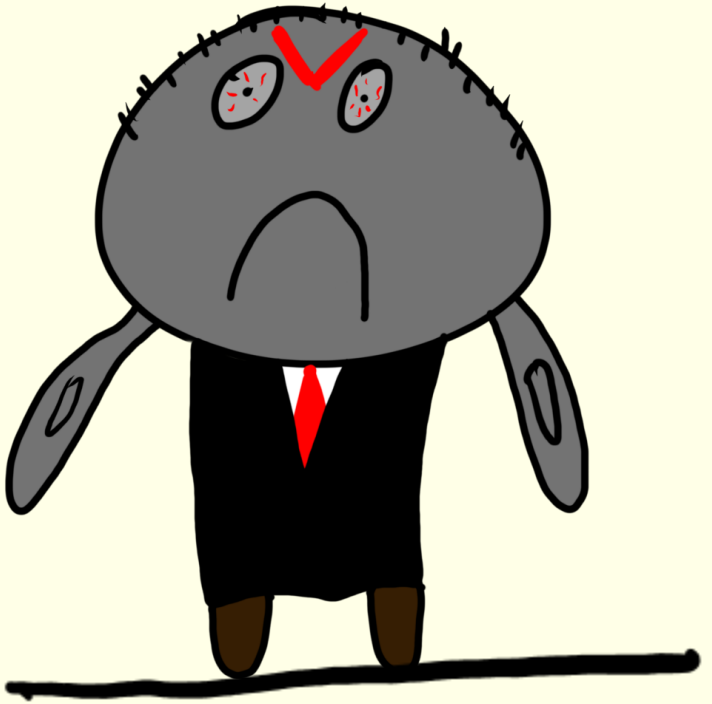
universal backdoor.

Dictator can read all messages & detect anamorphism <u>without</u> secret-key access

Dictatoria

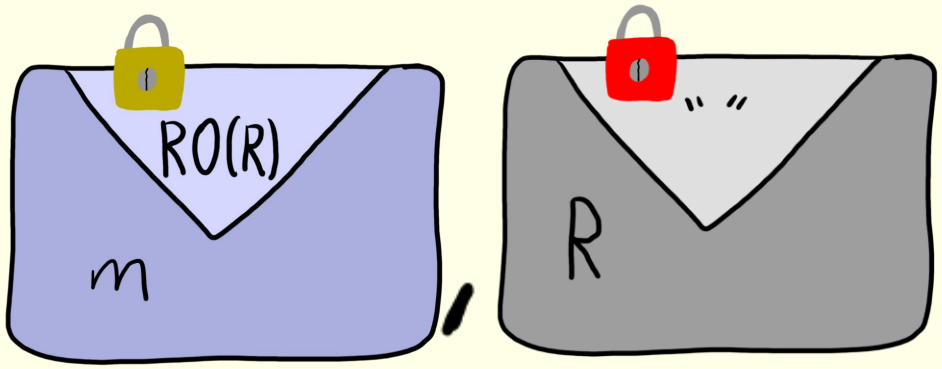
ARE

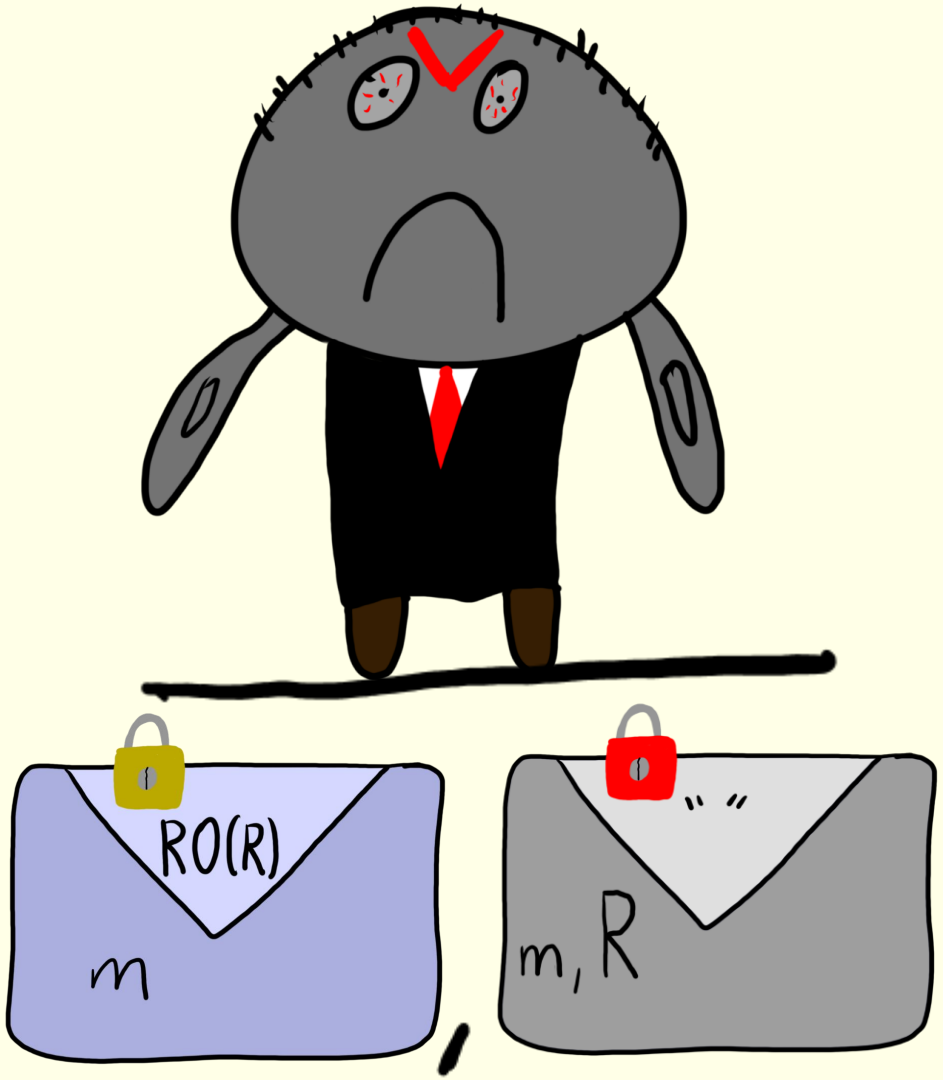




Dictatoria

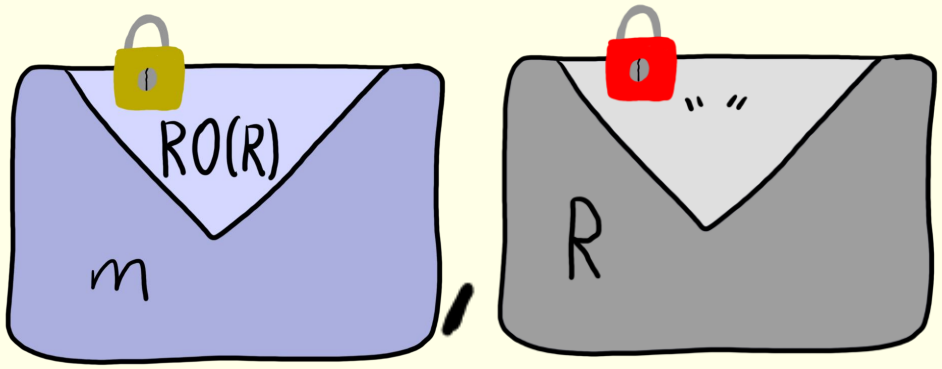
ARE

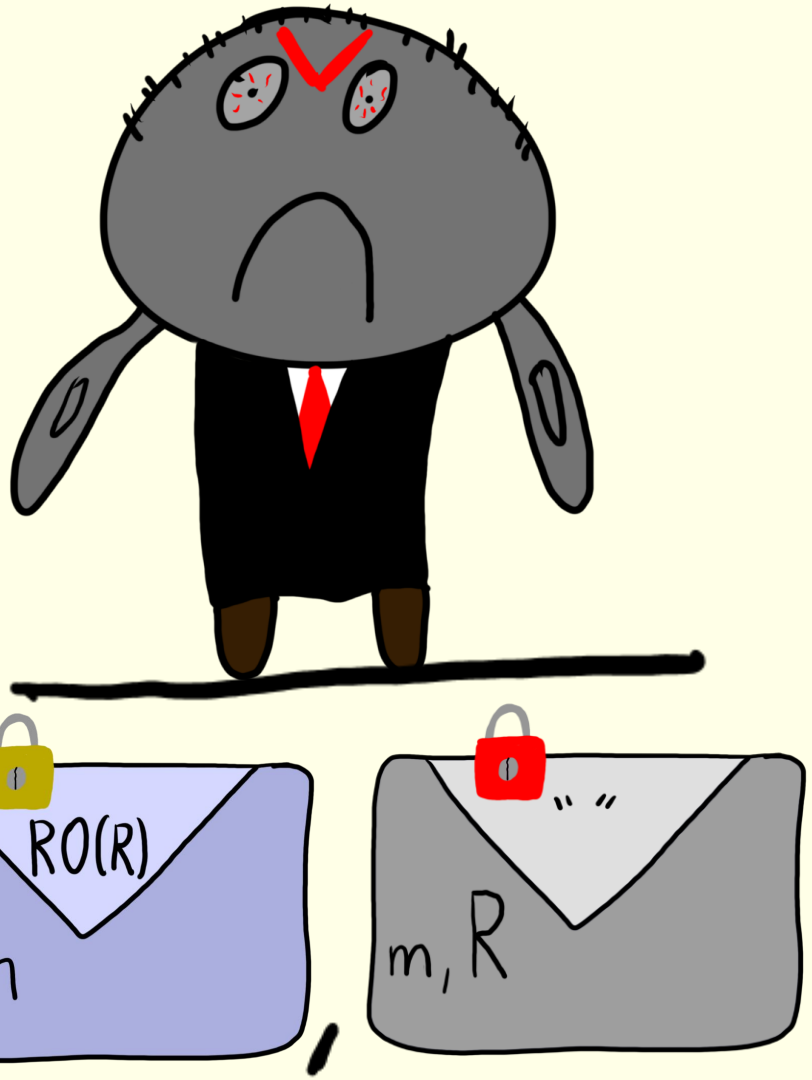




Dictatoria

ARE





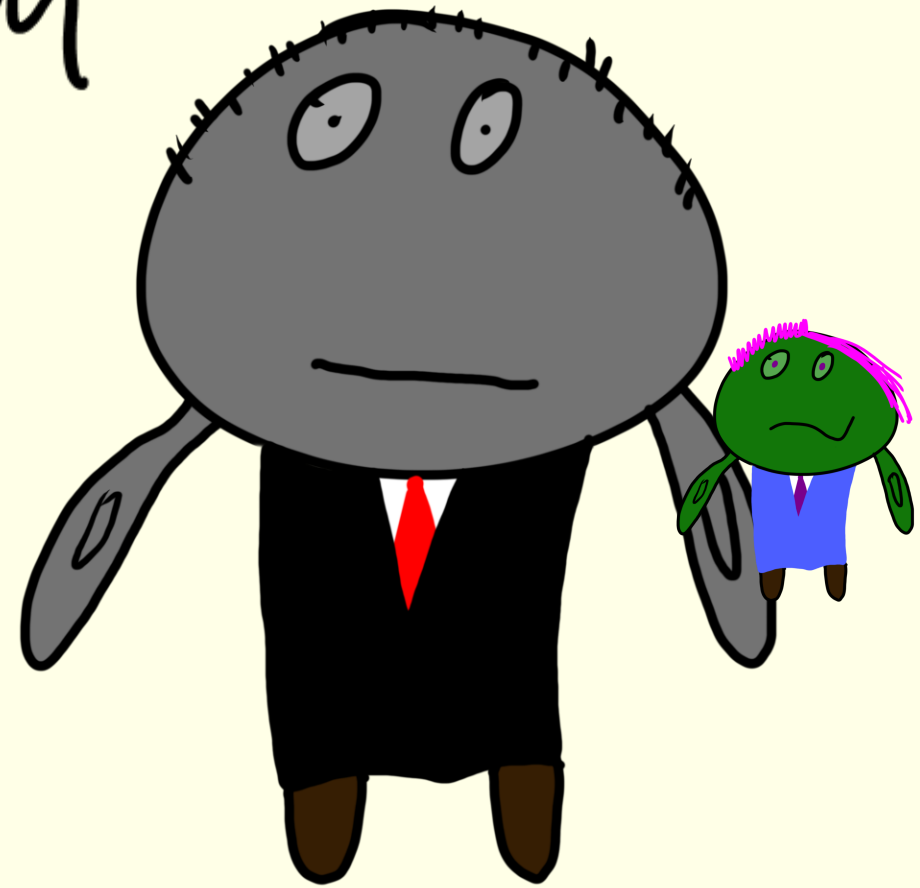
Dictator can read all m to detect covert messages

Warrantland in ROM

ARE which needs secret key access.

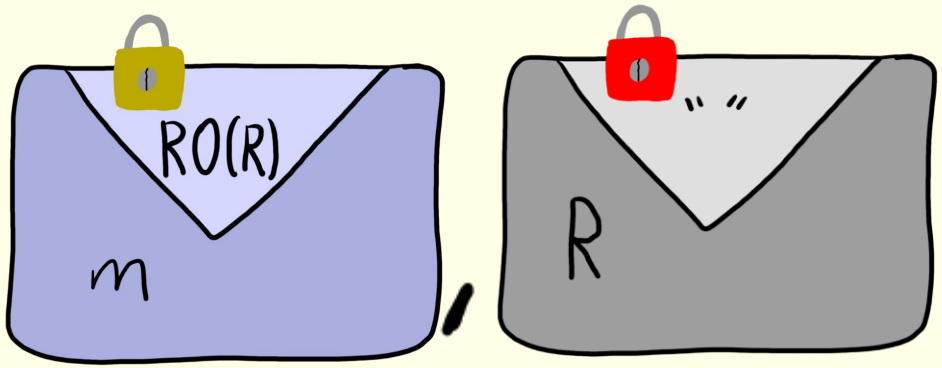
If  hidden, secure against govt. w/ 

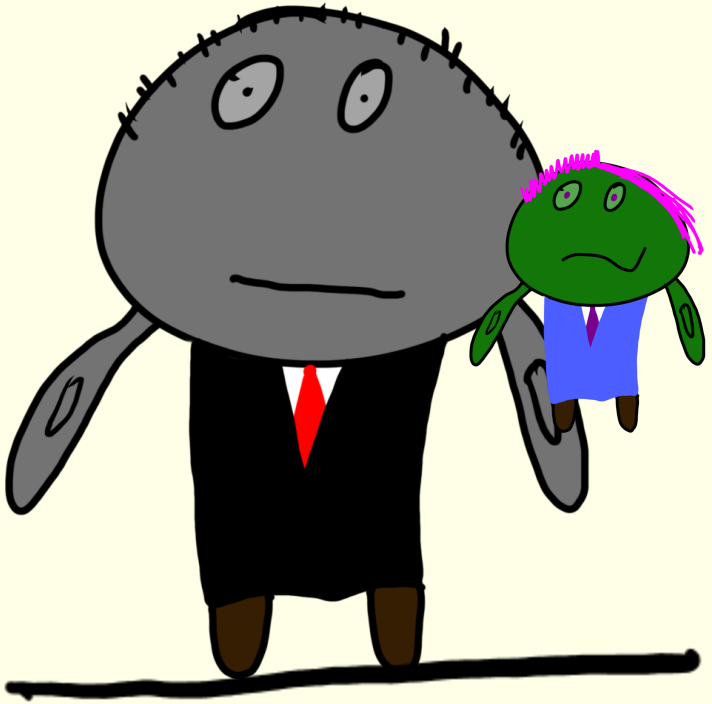
backdoor



Warrantland

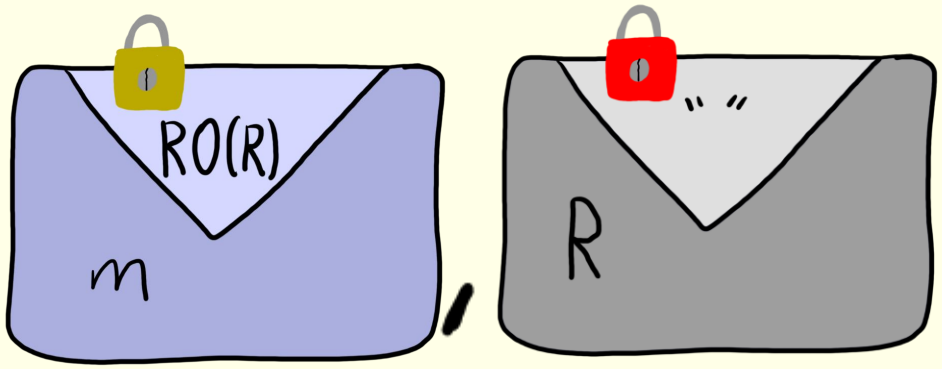
ARE

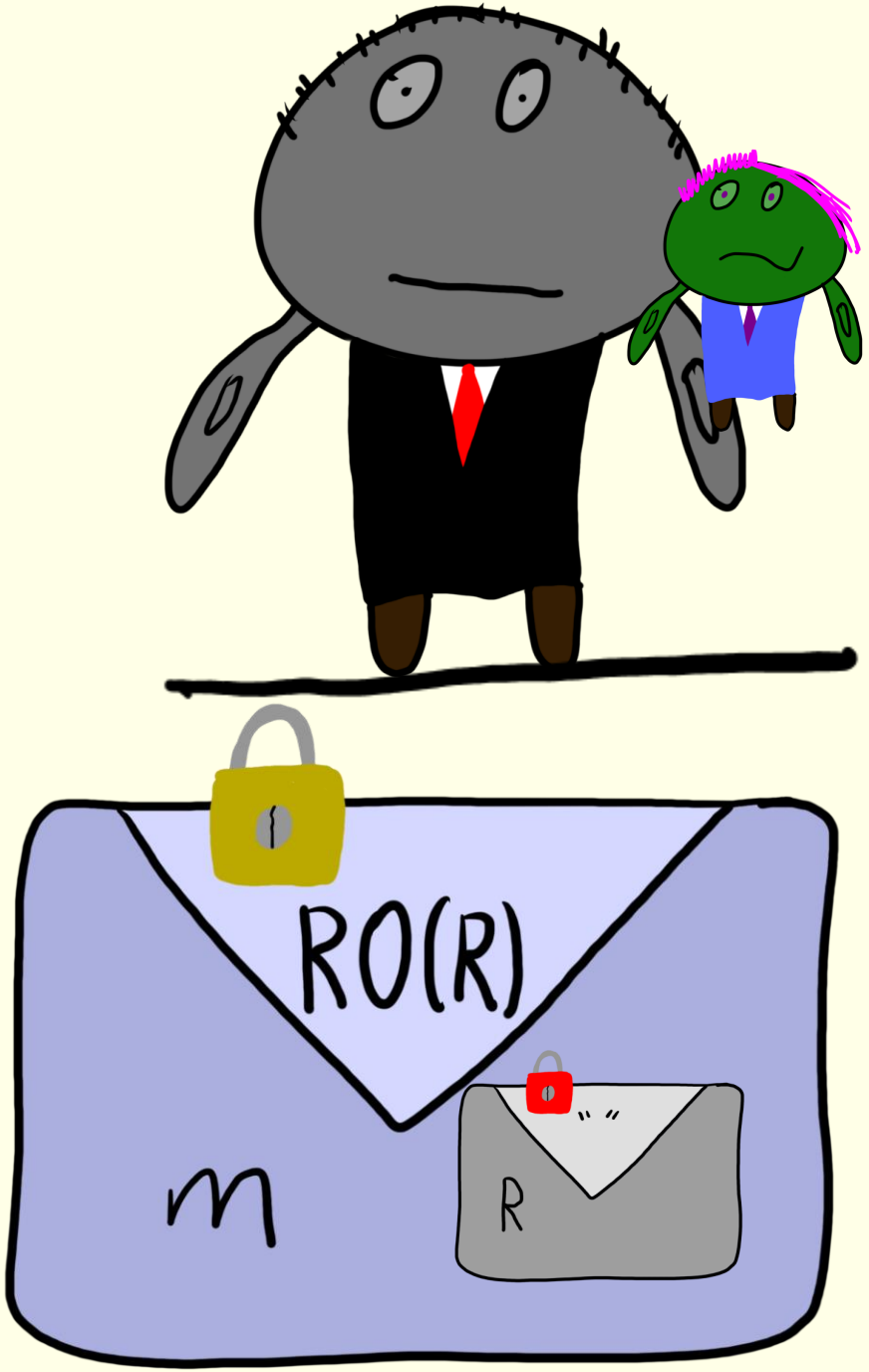




Warrantland

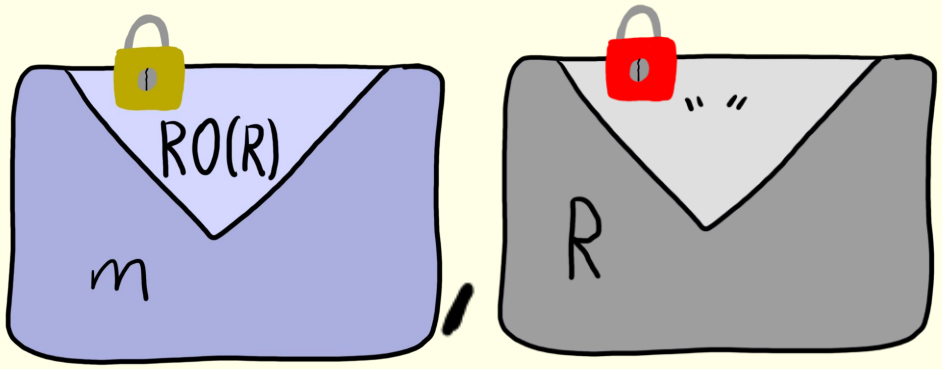
ARE



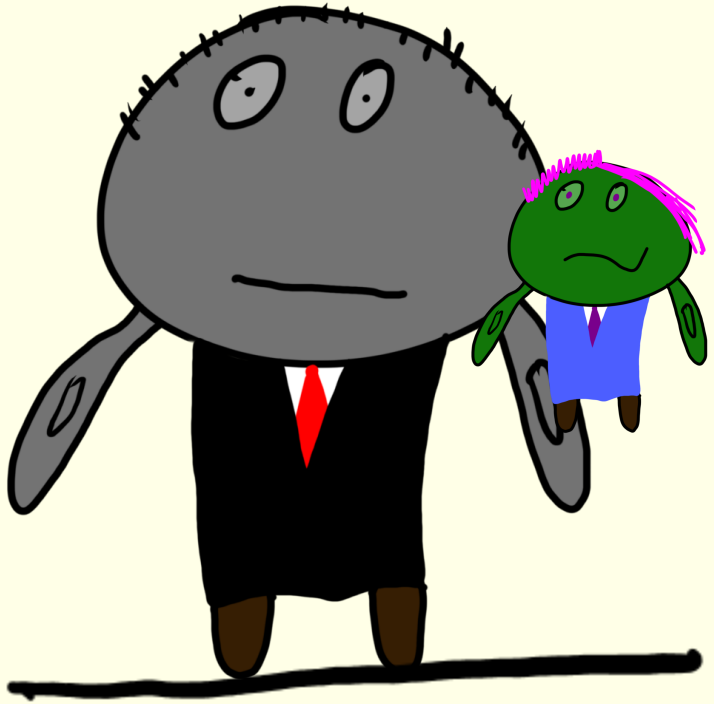


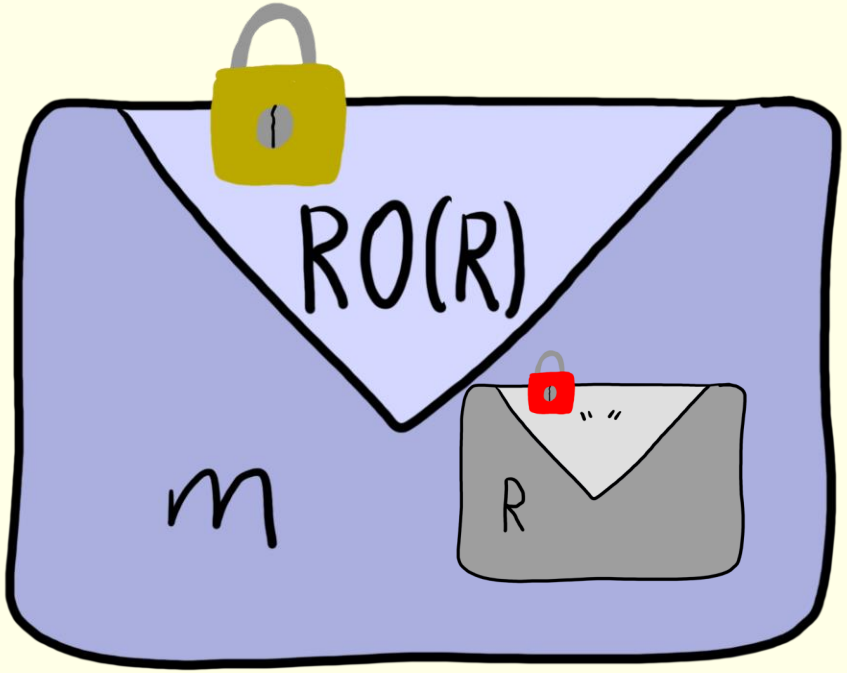
Warrantland

ARE



Govt. needs  to detect anamorphism or break PKE.





Open Questions

1. Standard Model ARE
   [ABG+25] from exponential DDH
2. Getting rid of public parameters.
   [CCGM25] does for weaker notion of ARE
3. Can we bypass this impossibility?
   Is a weaker notion always possible?

Thanks
for
listening!