Why security? What security? How security?

Suraaj Kanniwadi

The AI4AI retreat @ Cornell Tech

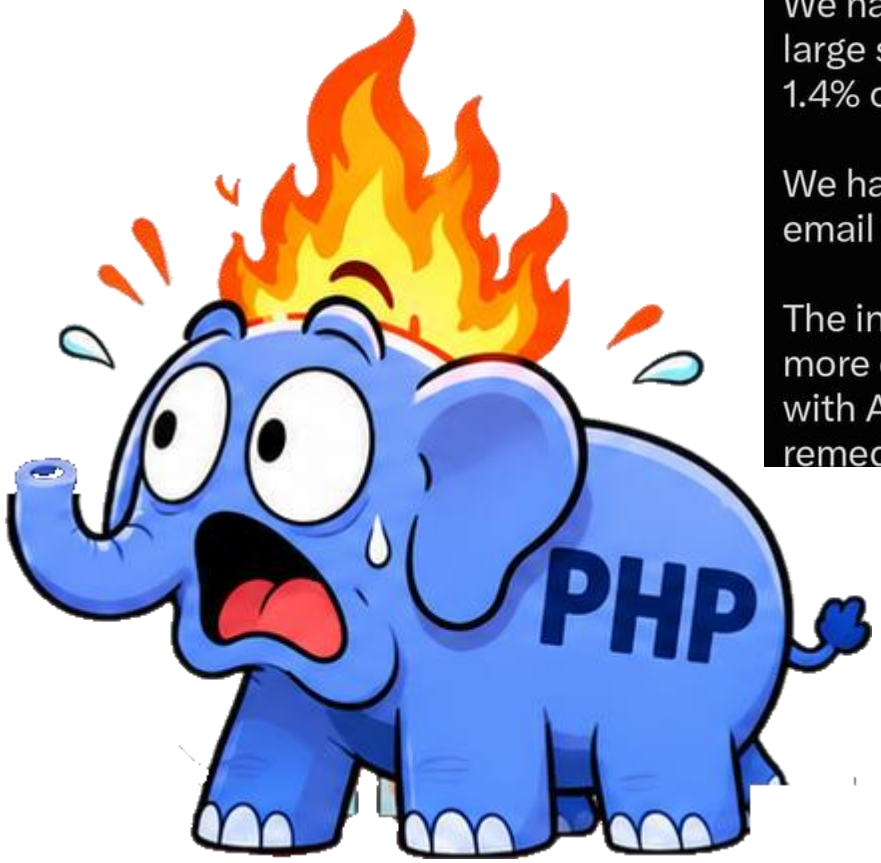
October 27 2026

We need secure systems

We need secure systems



We need secure systems



OpenCode
@opencode

Message

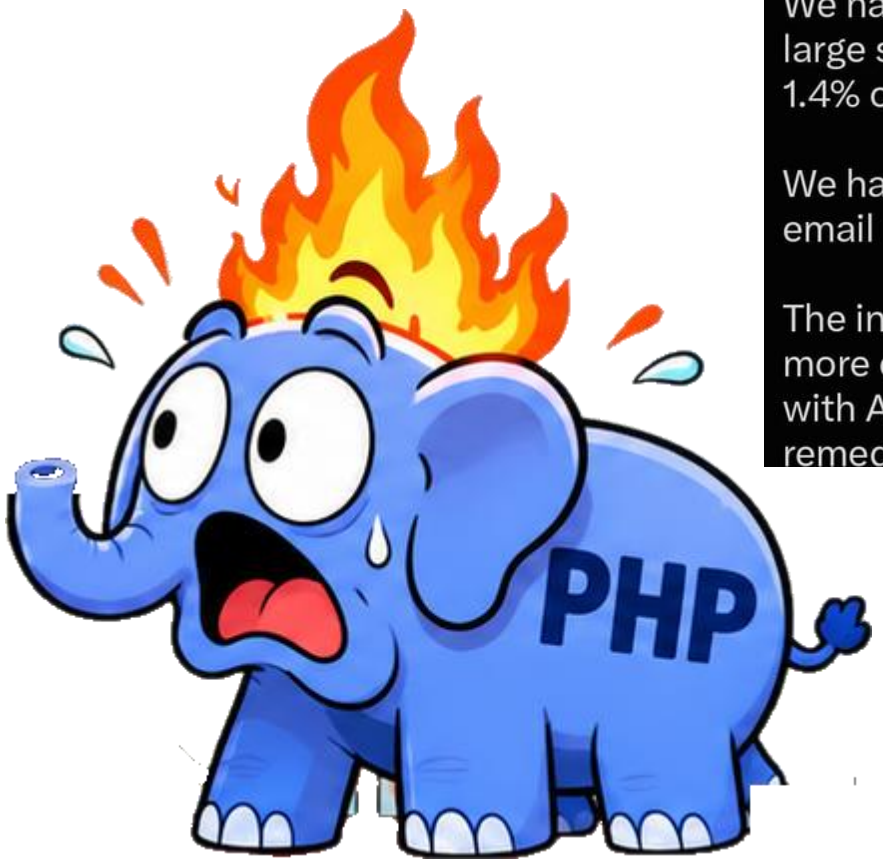
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We have notified them all this morning via email

The incident is ongoing so we cannot share more details at this point but we are working with Anthropic, OpenAI, and Google to remediate

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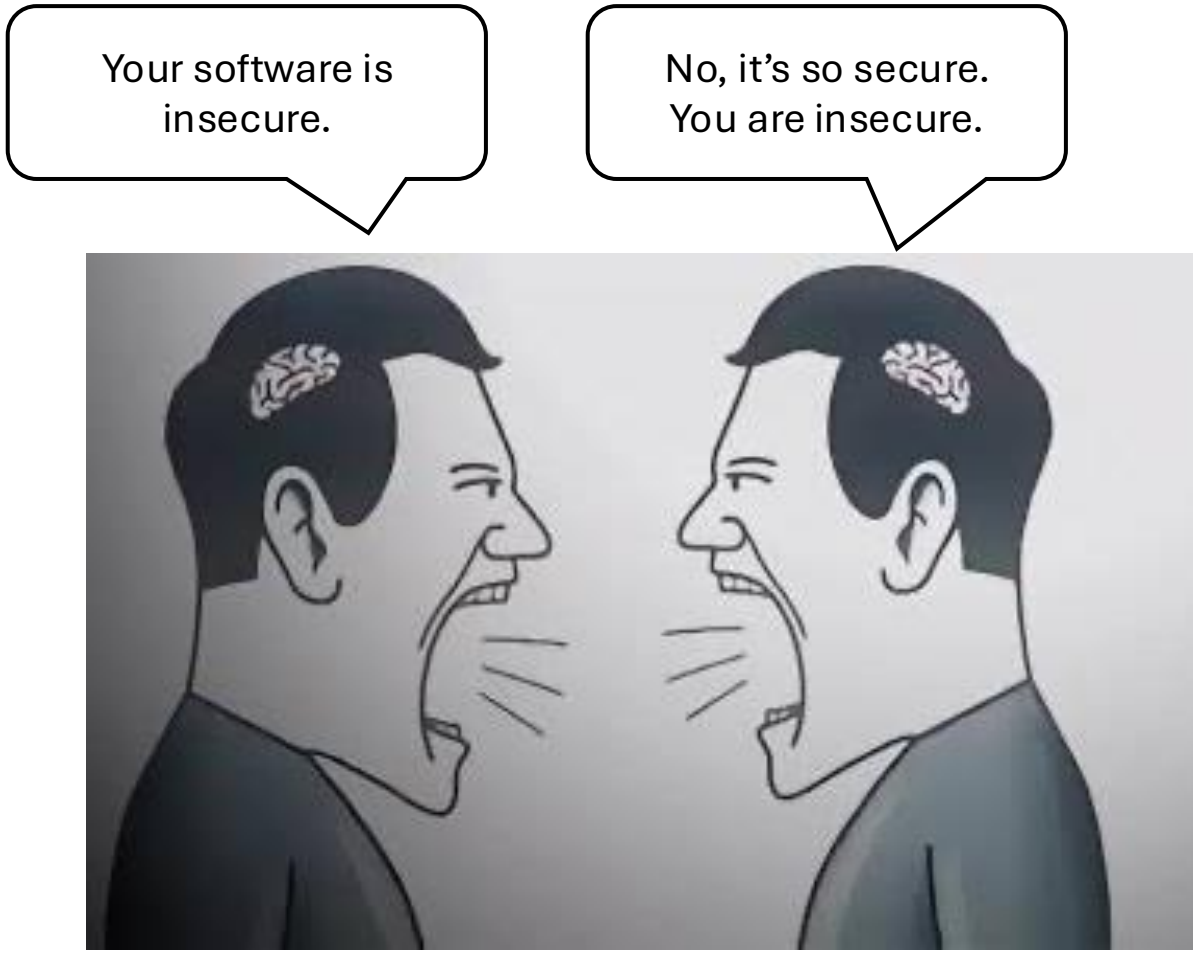
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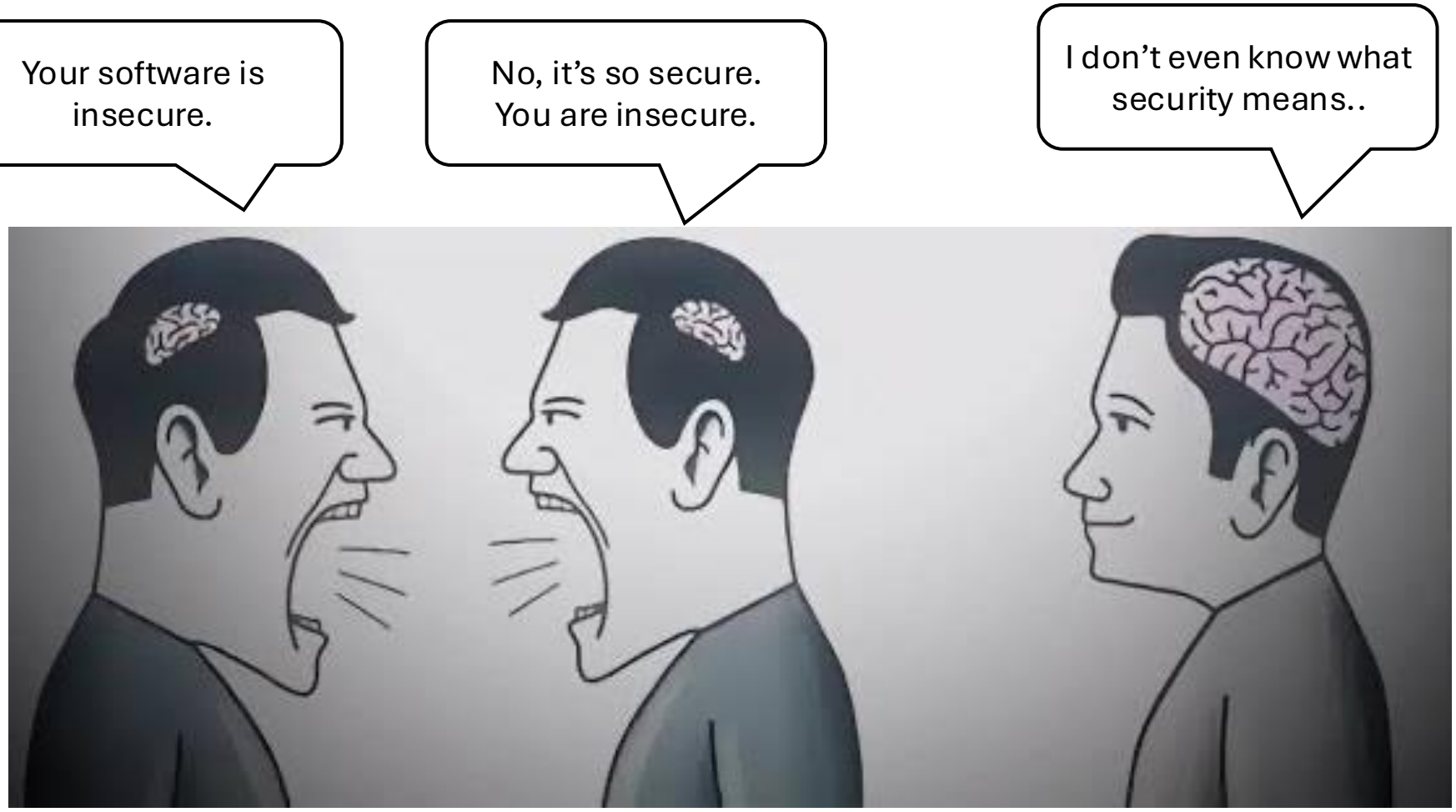


What is security?

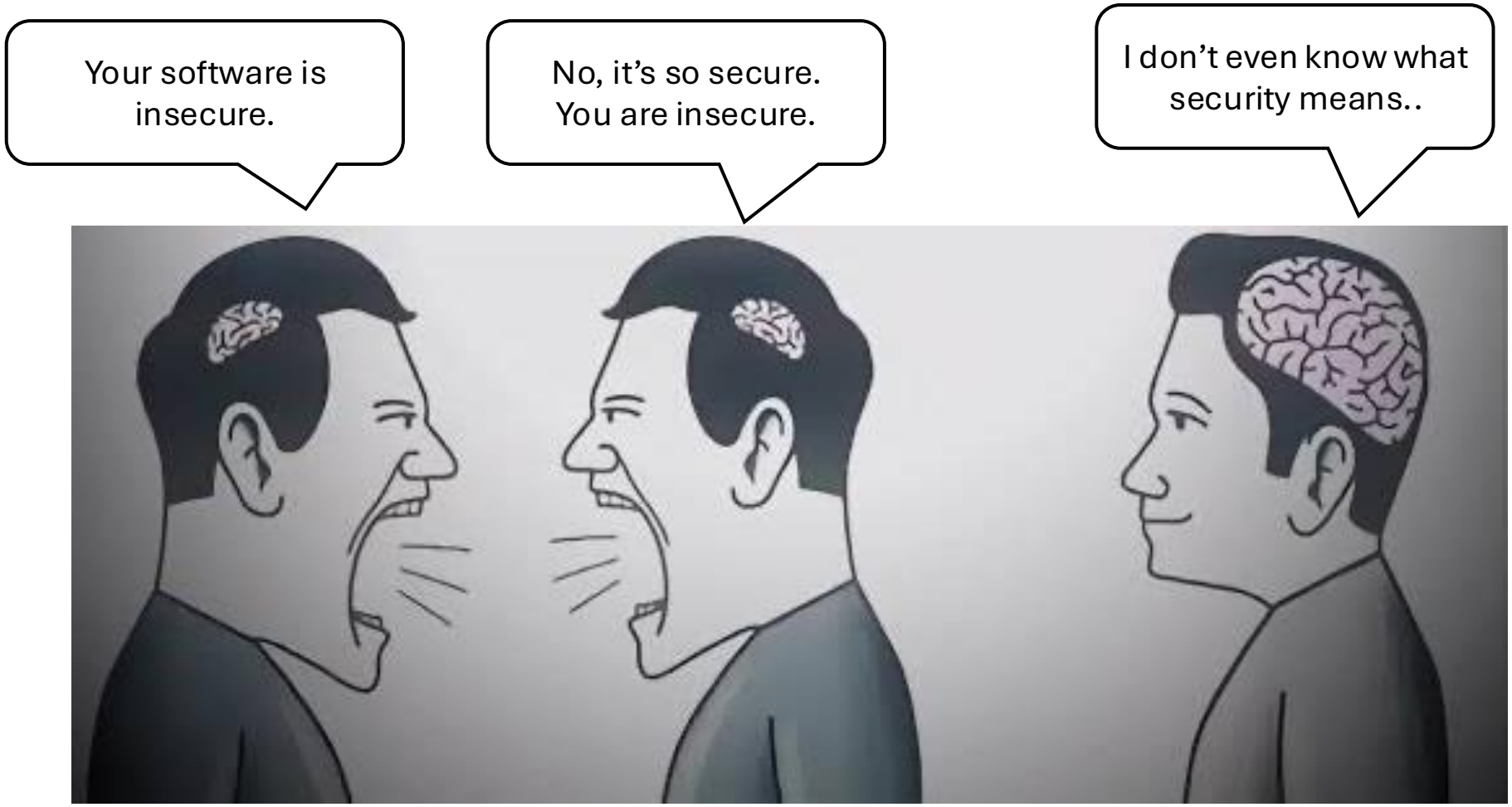
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The first step in building secure systems is to specify precisely what security means!

Why? Surely, we know how to do this…

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The existence of refinement mappings
Marin Abadi, Leslie Lamport

A lattice of information
Jaisook Landauer, Tmothy Redmond

Hyperproperties
Micheal R. Clarkson, Fred B. Schneider

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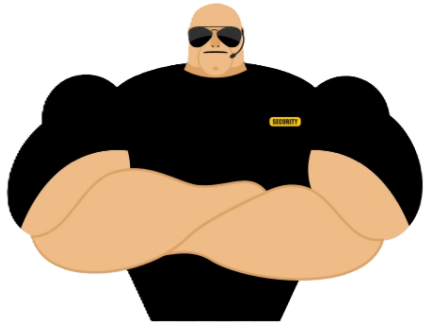
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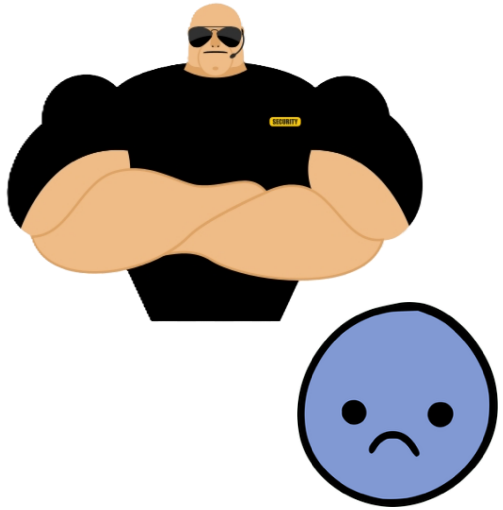
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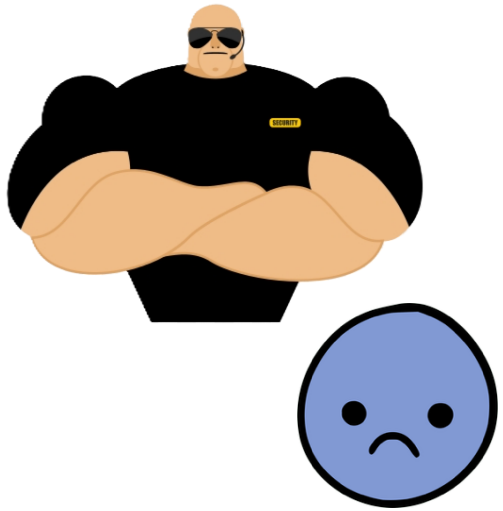
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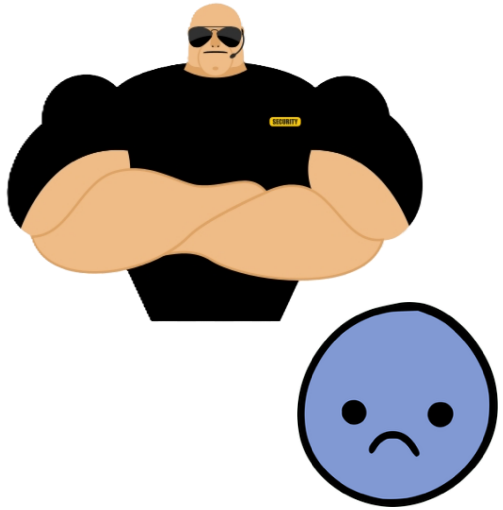
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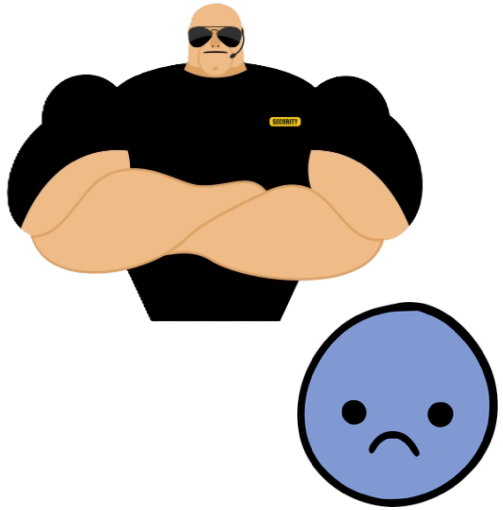
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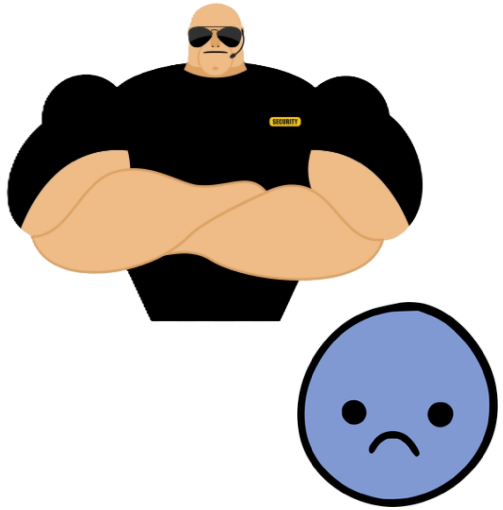
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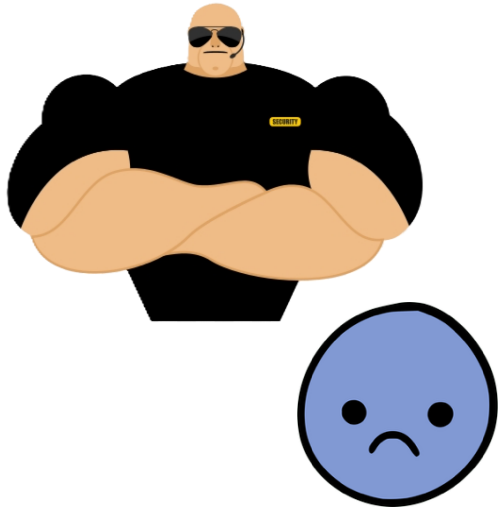
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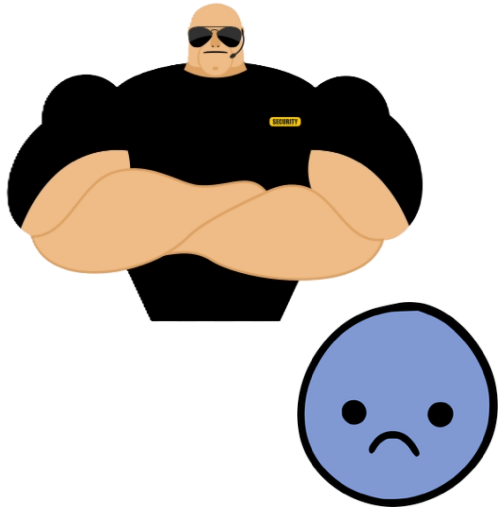
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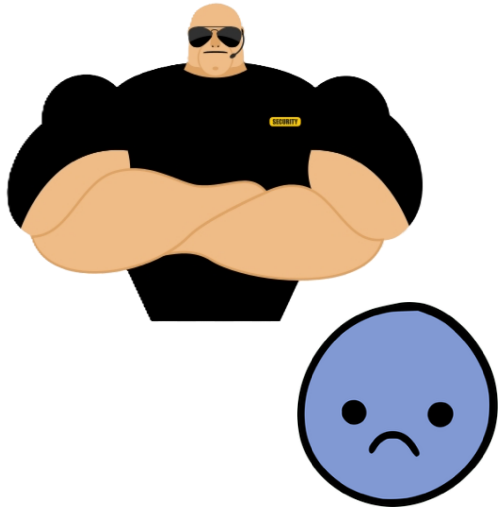
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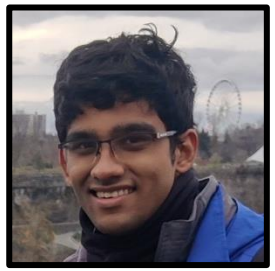
Too general: “A system is secure if it is in the set of secure systems”

Hyperproperties

Our research: getting and enforcing the right specs

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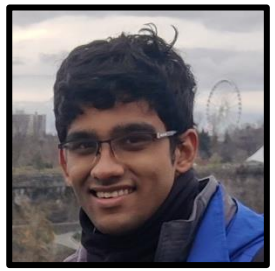
A theoretical basis for **information flow downgrading**



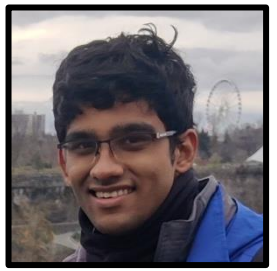


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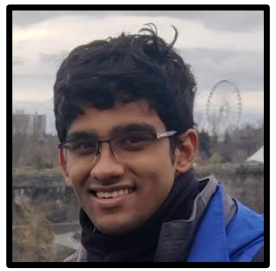

Auditable, refinable, and enforceable security for **AI prompts**






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Motivation: making sense of NMIF

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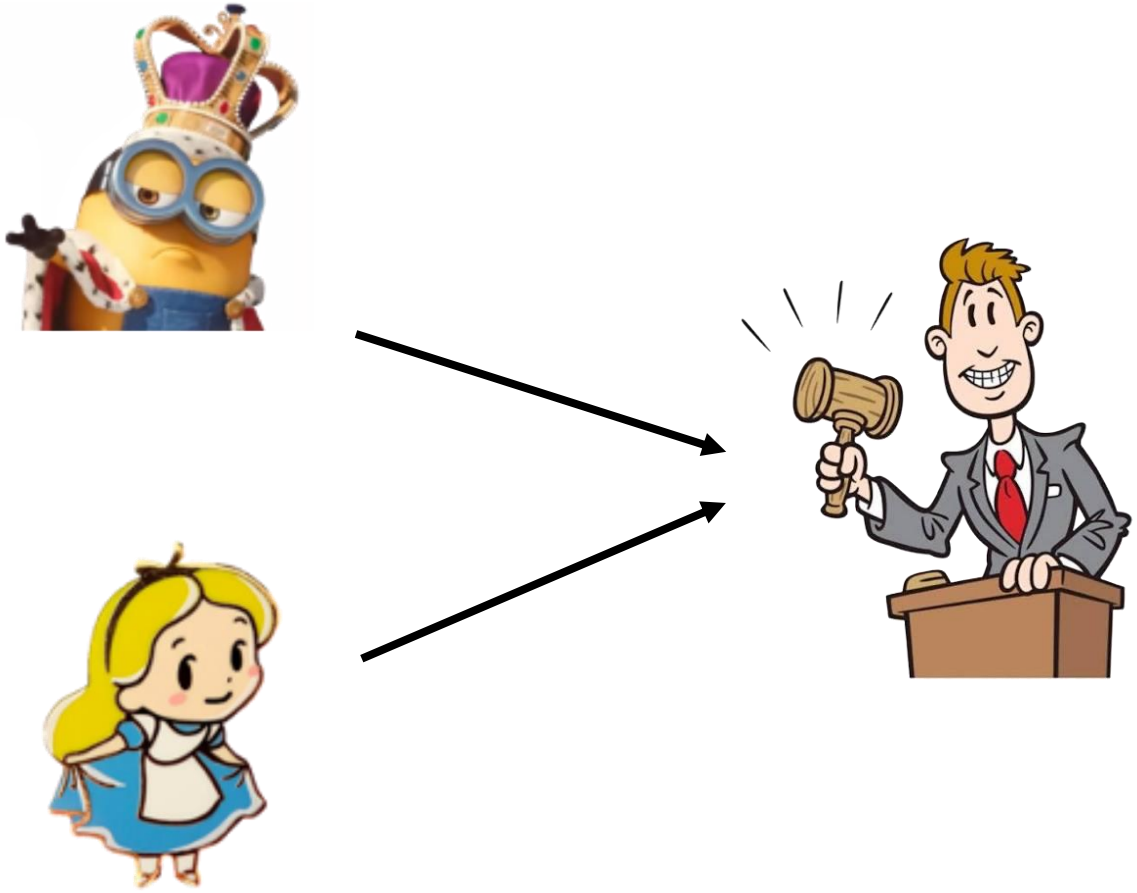
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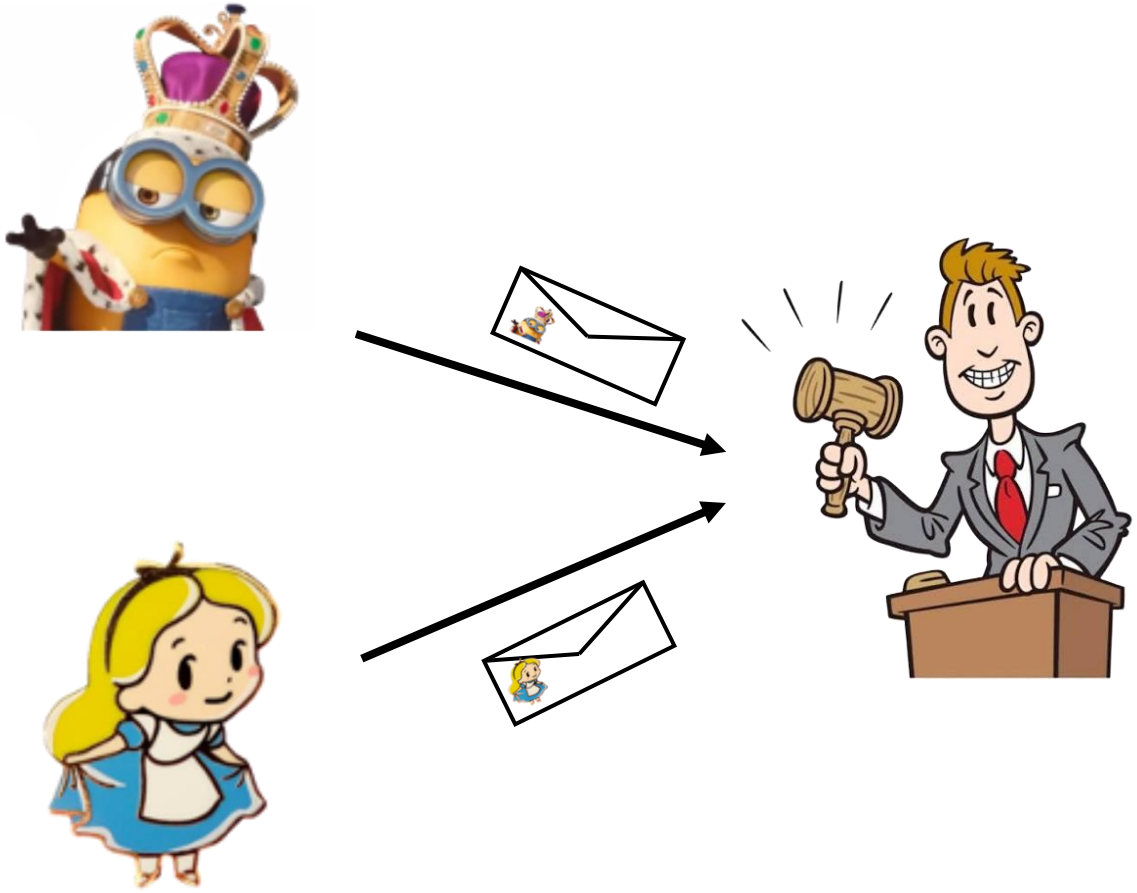
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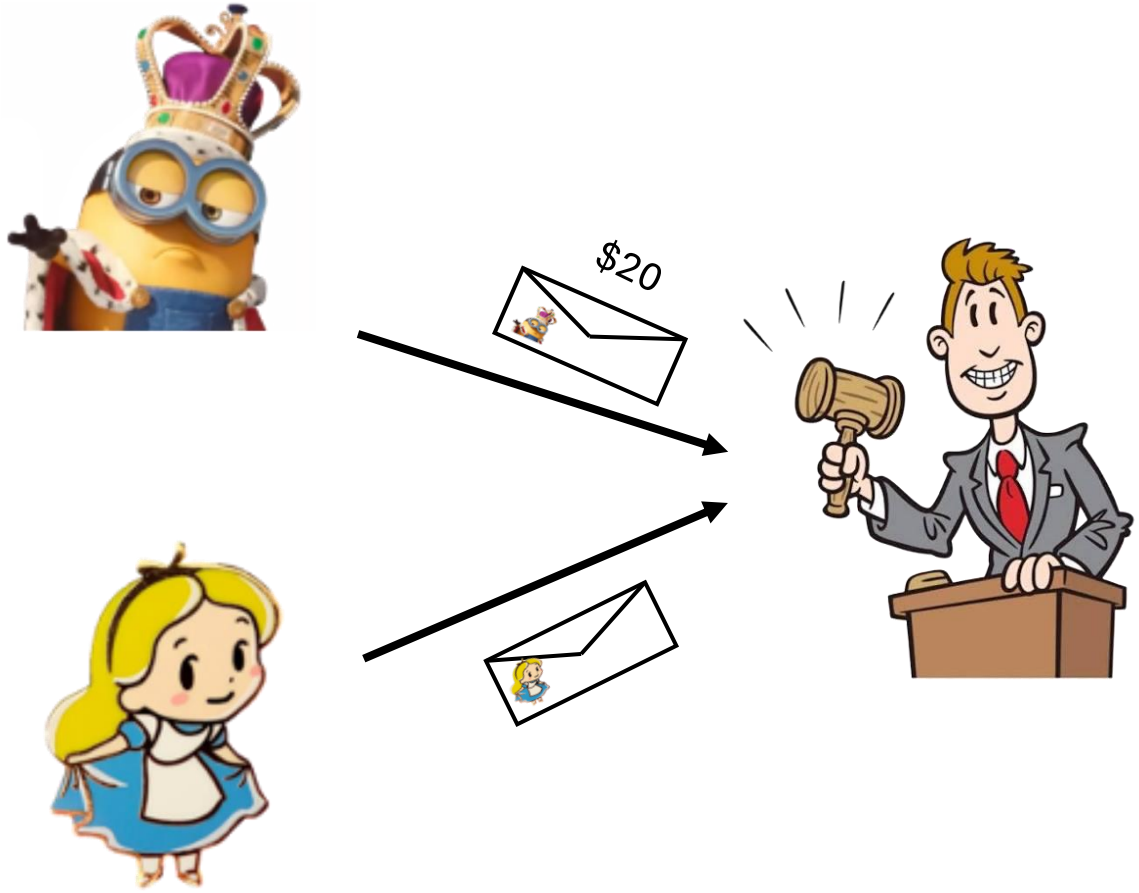


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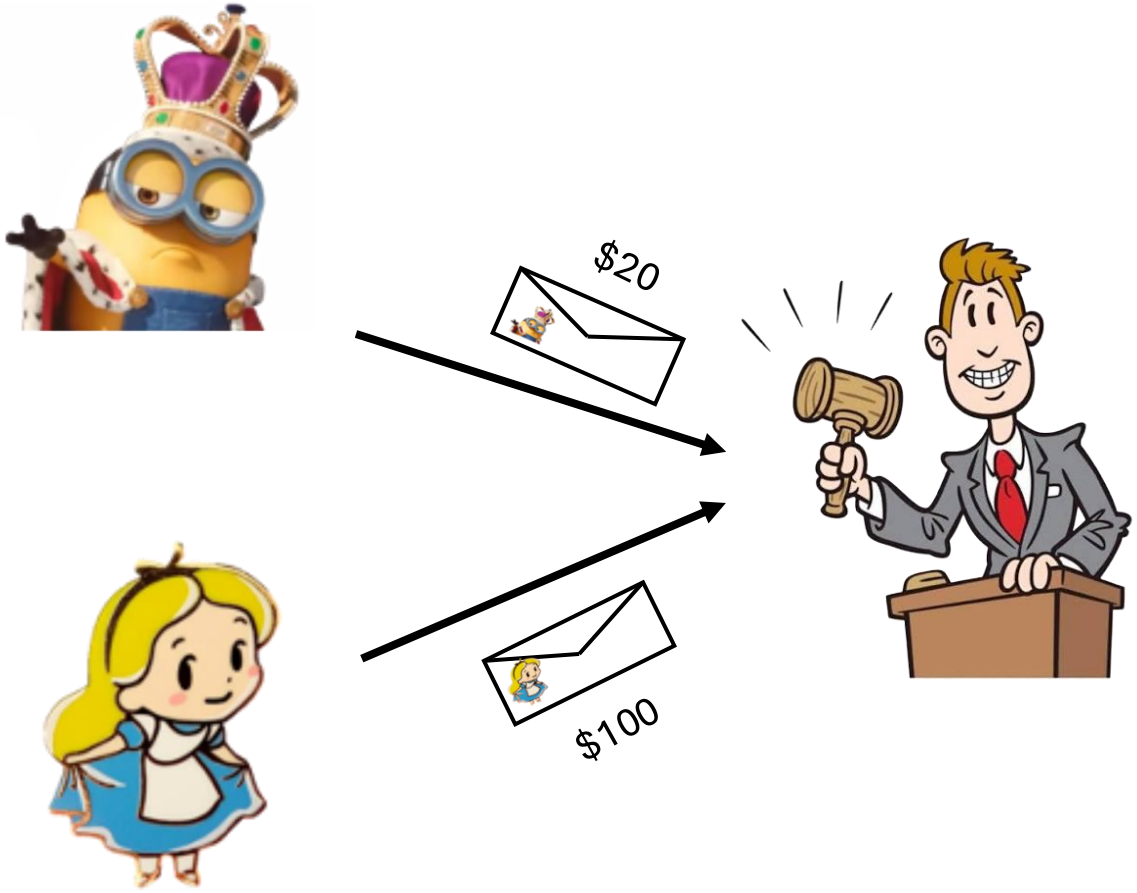


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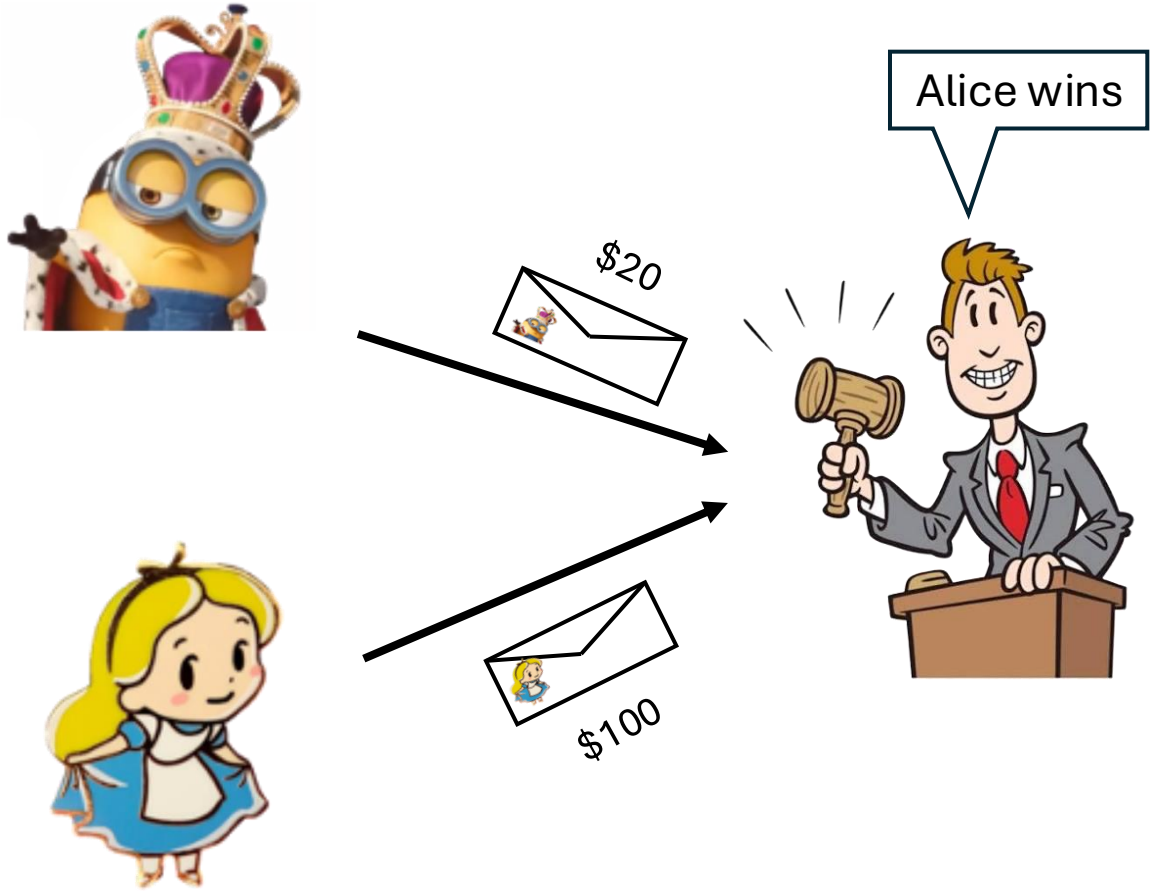


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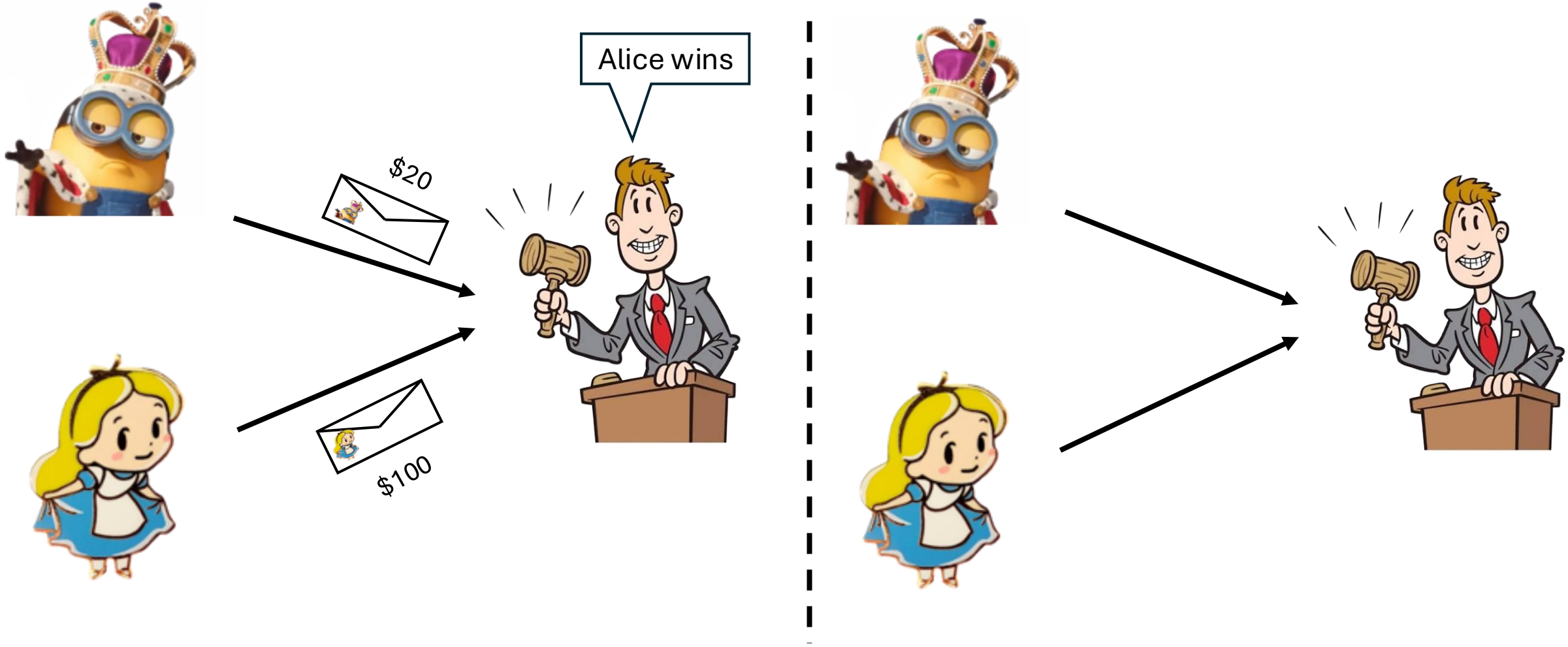


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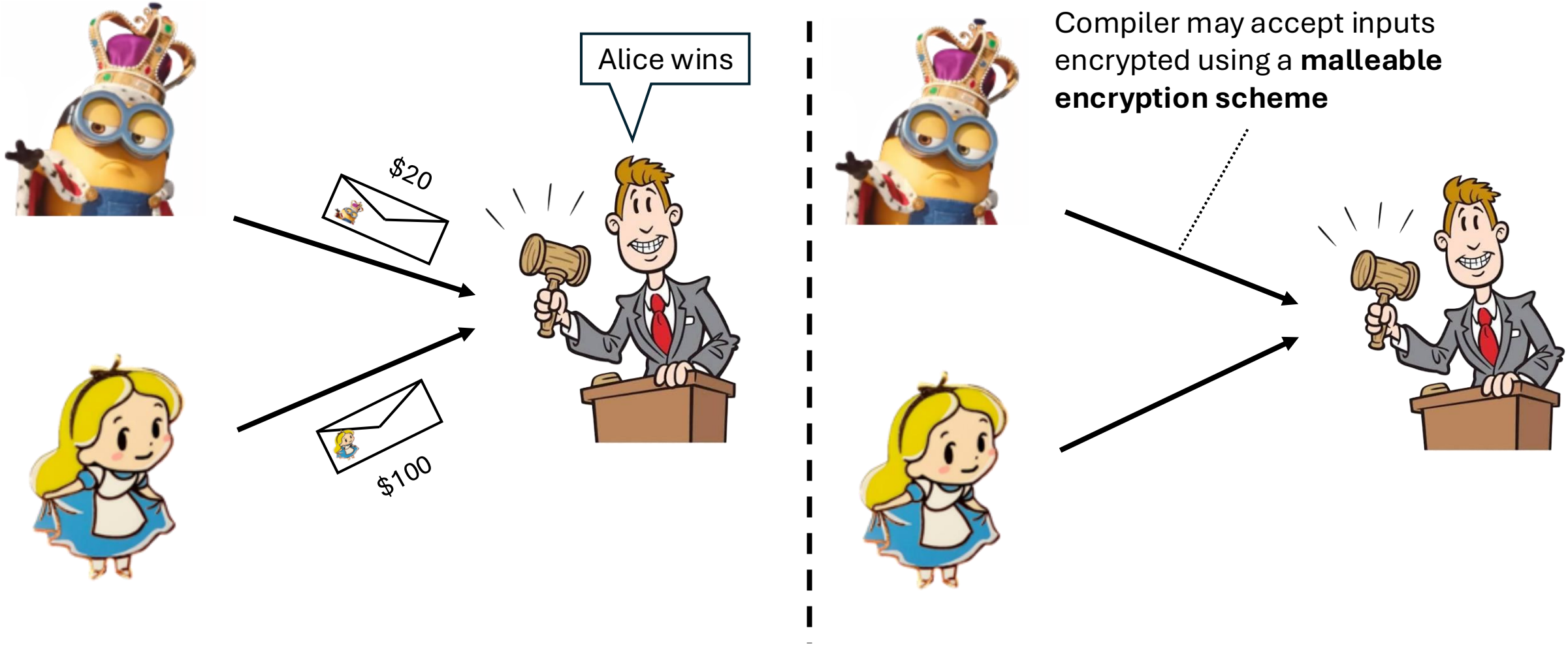
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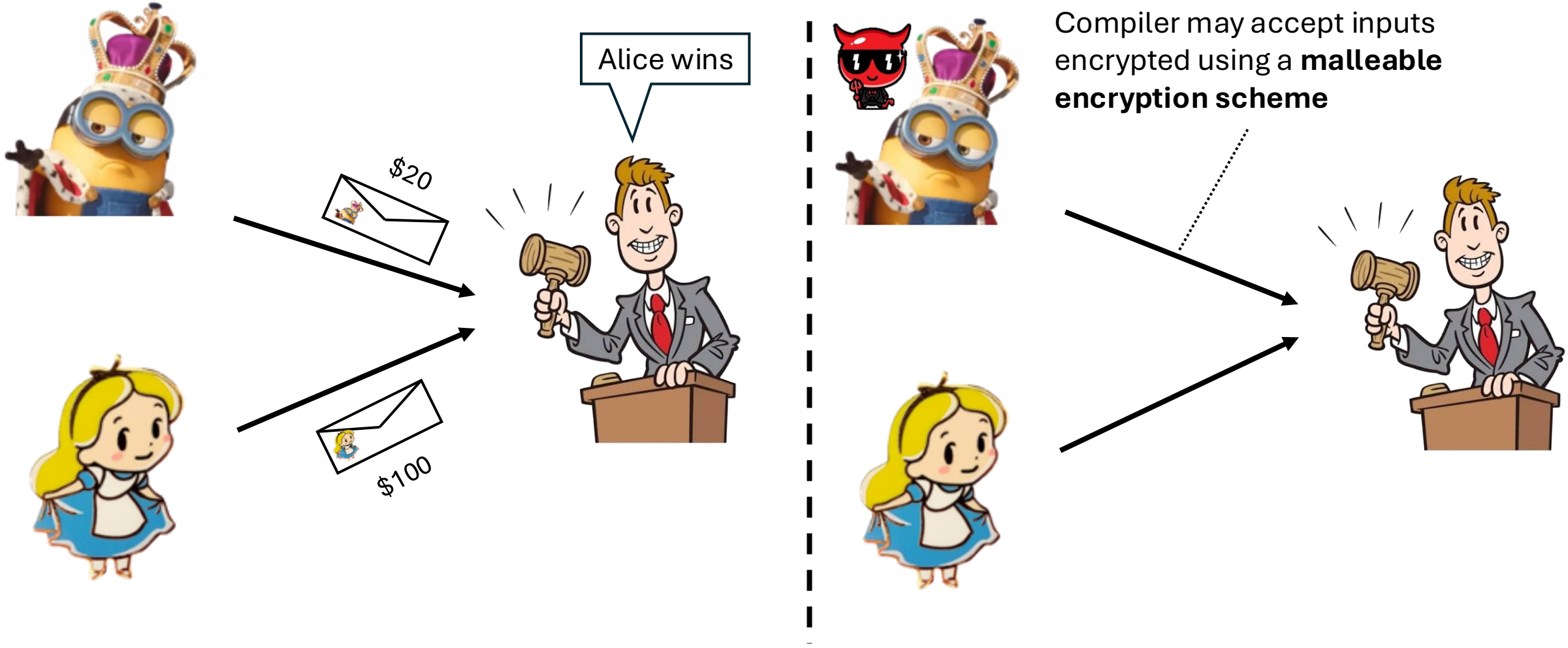
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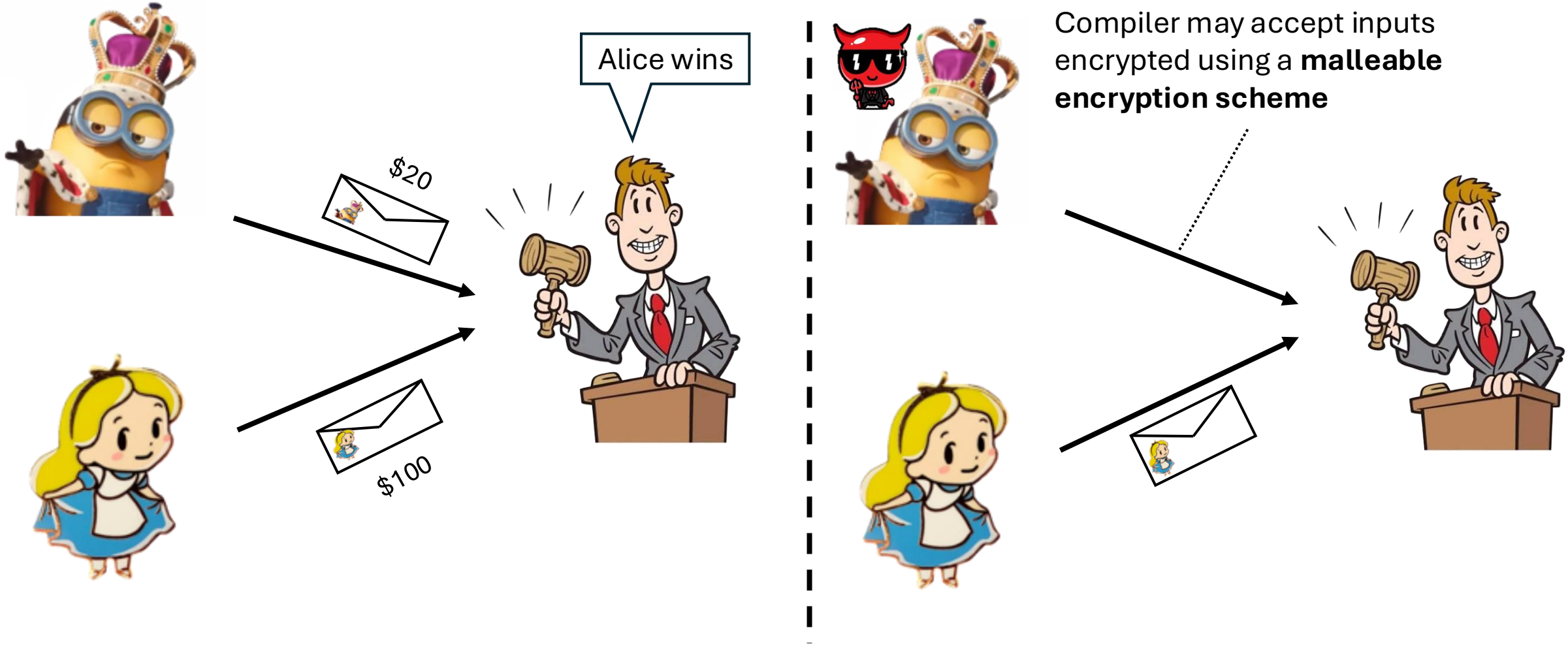
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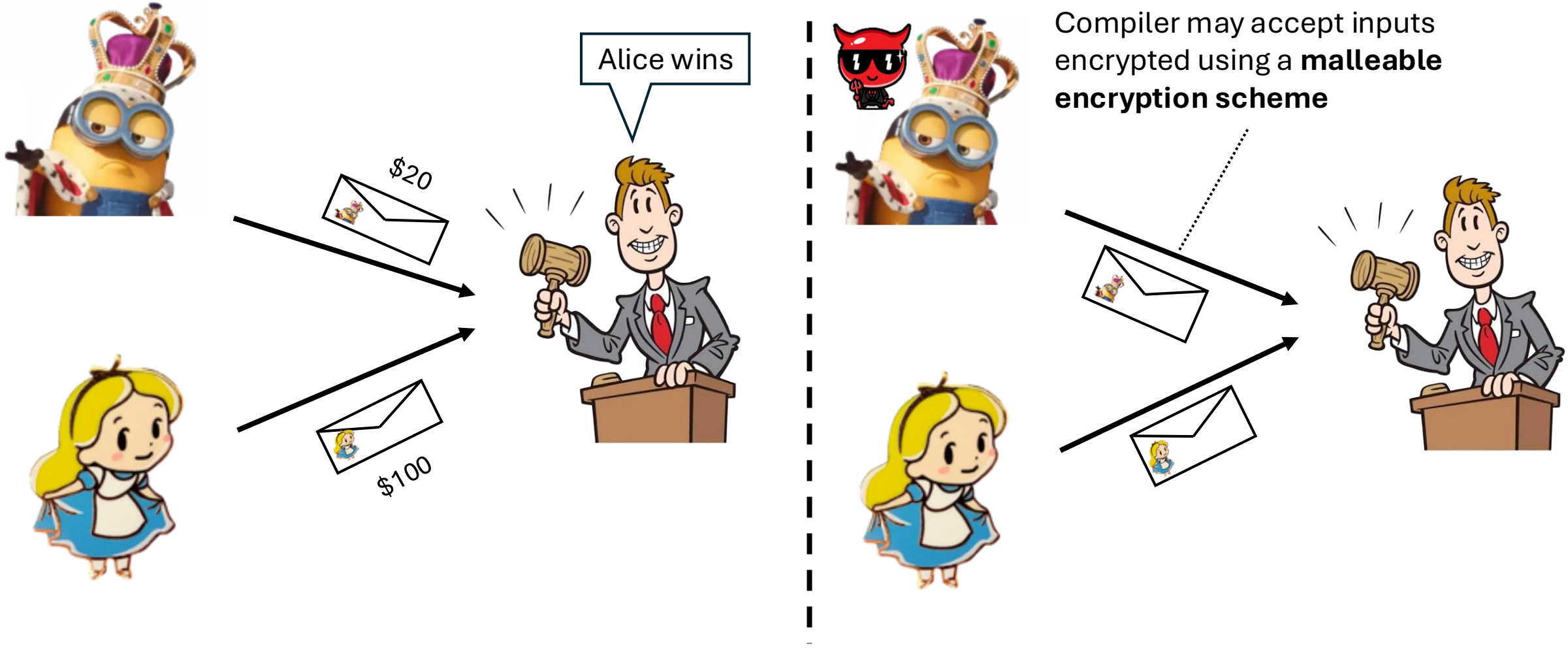
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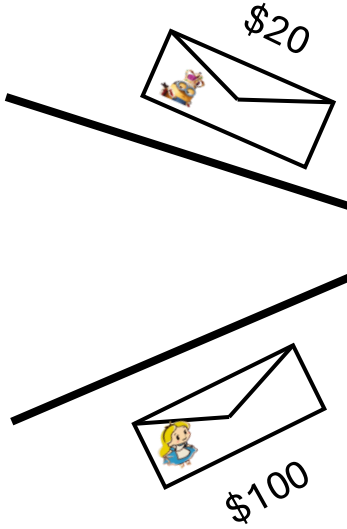


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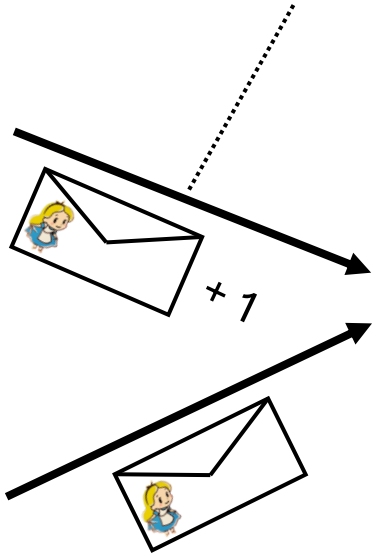








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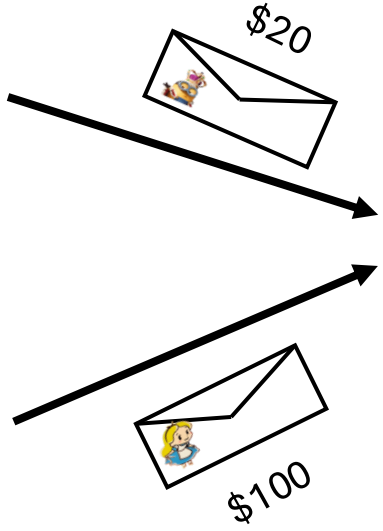


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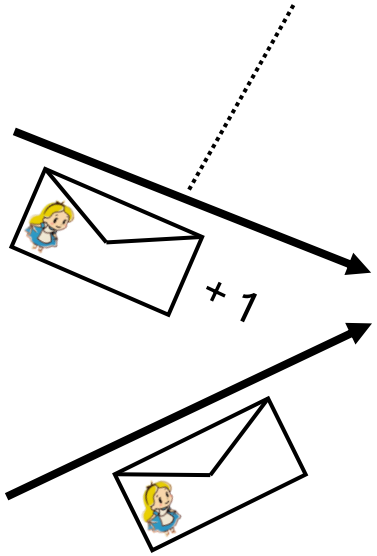








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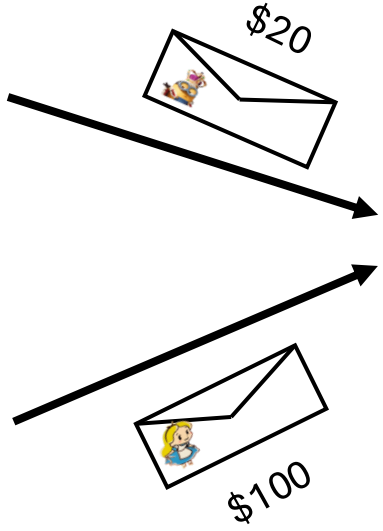


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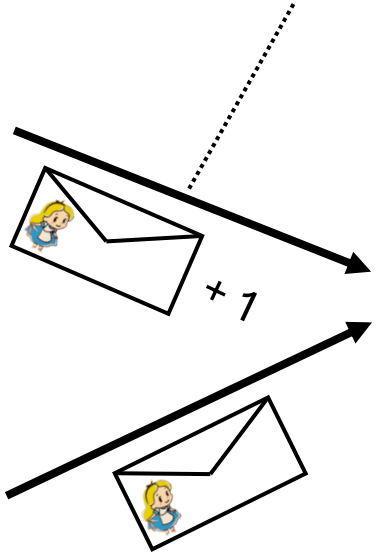












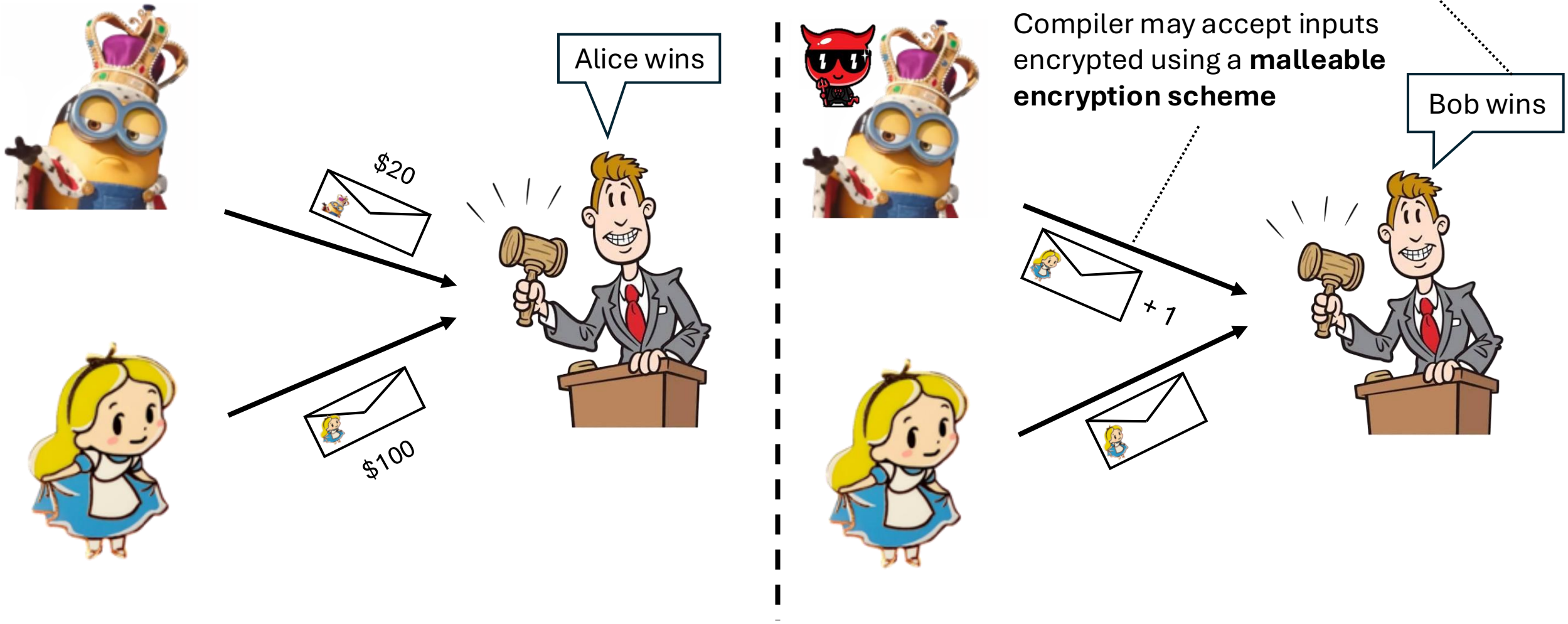


Bob does not even know the value of this bid!

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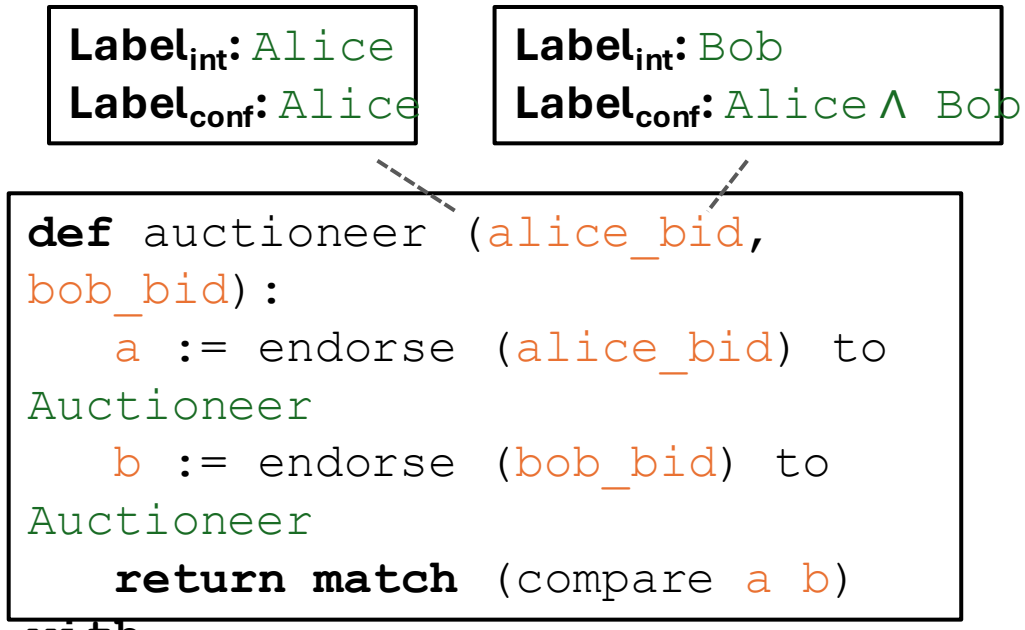
Nonmalleable information flow disallows such insecurities

CCS’17 4-hyperproperty is unsatisfactory

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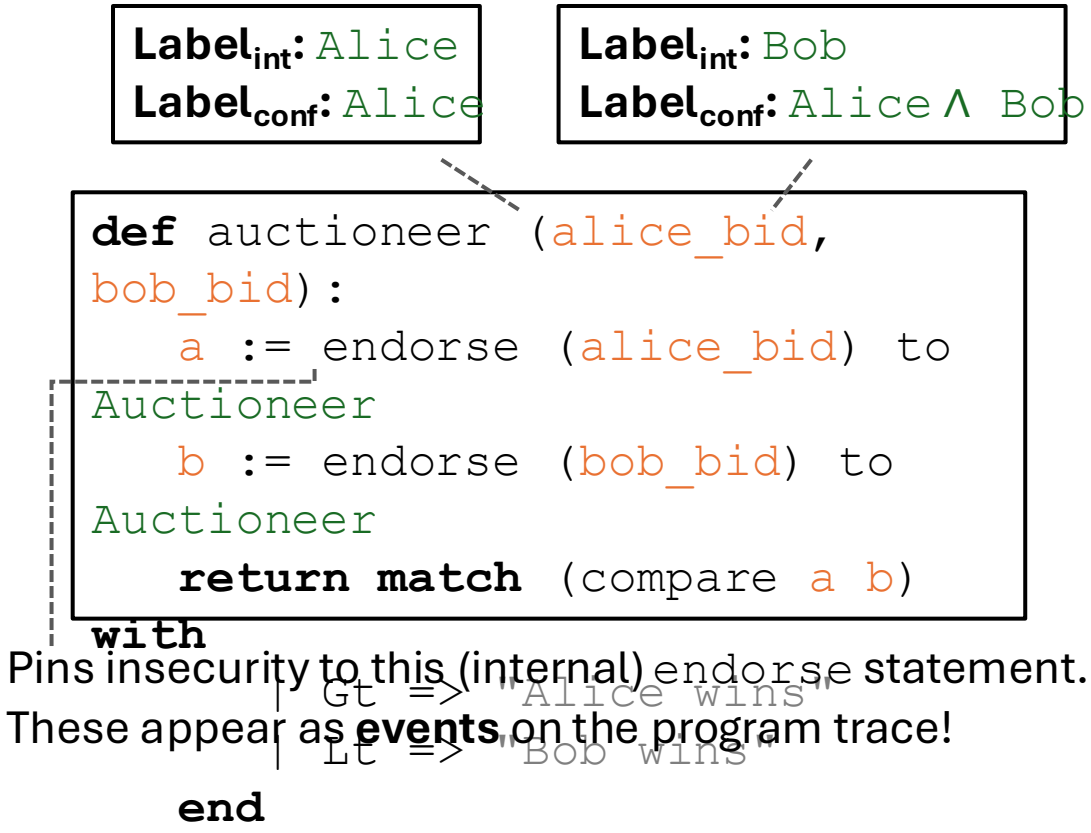
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   return match (compare a b)
with
      | Gt => "Alice wins"
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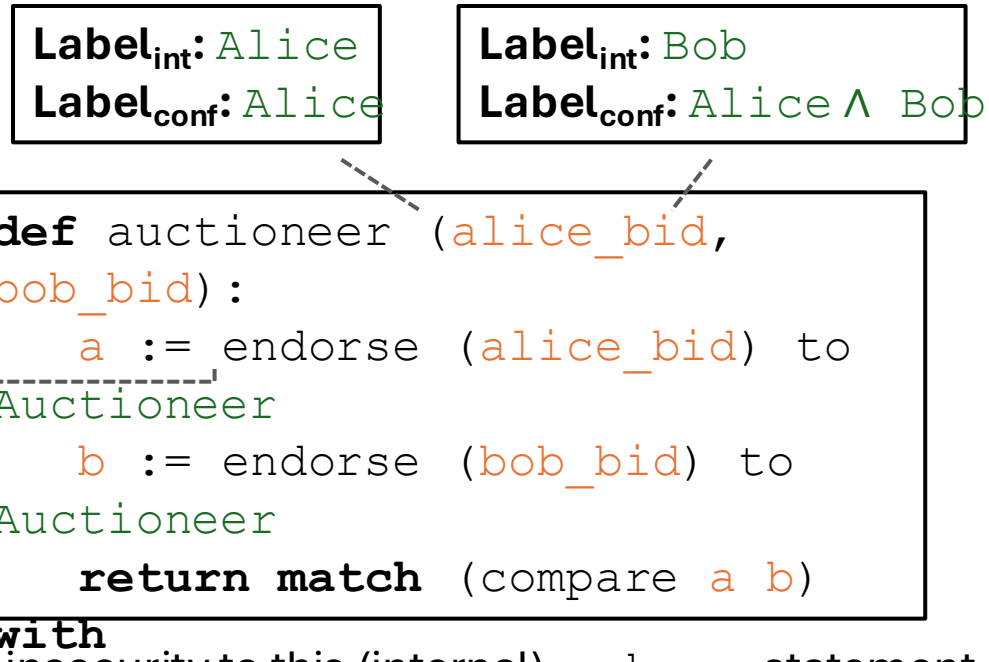
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Pins insecurity to this (internal) `endorse` statement.

These appear as **events** on the program trace!

CCS'17 4-hyperproperty is unsatisfactory

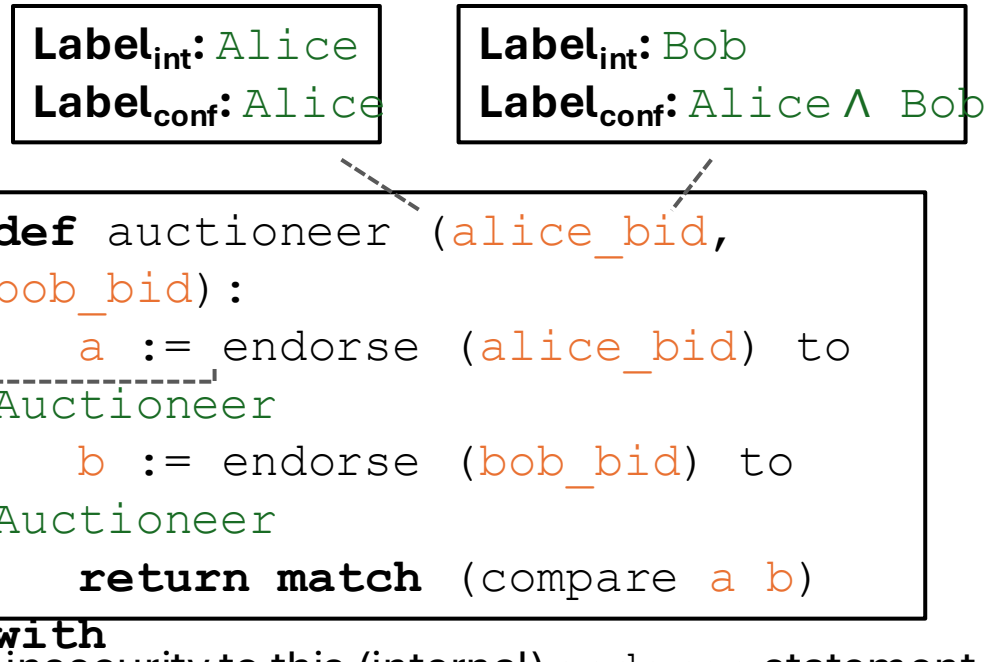


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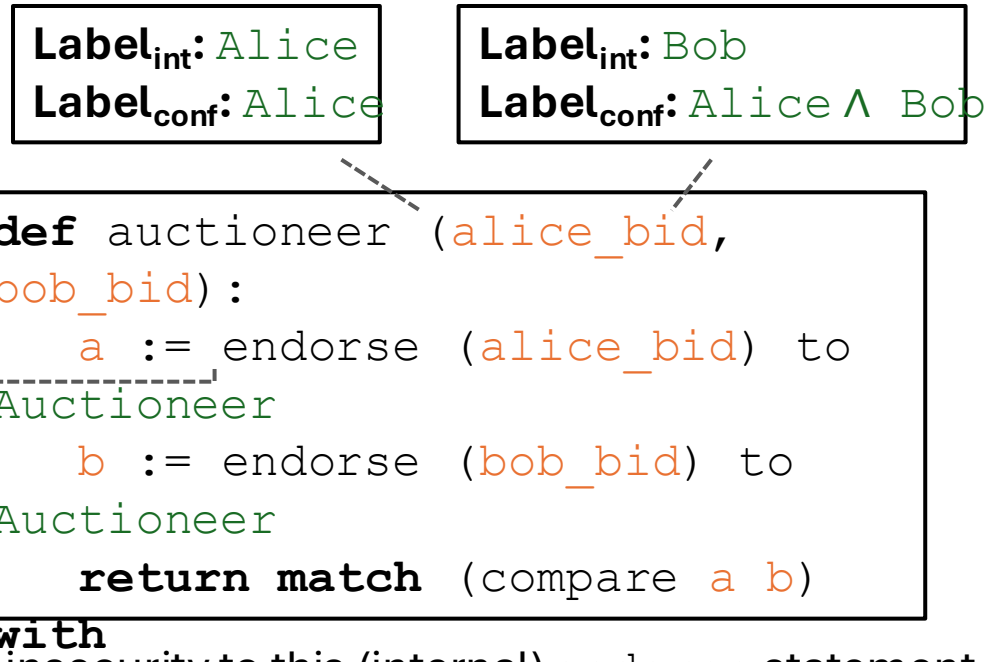


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Our insight: adapt a cryptographic paradigm

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Use the **real–ideal paradigm** from cryptography

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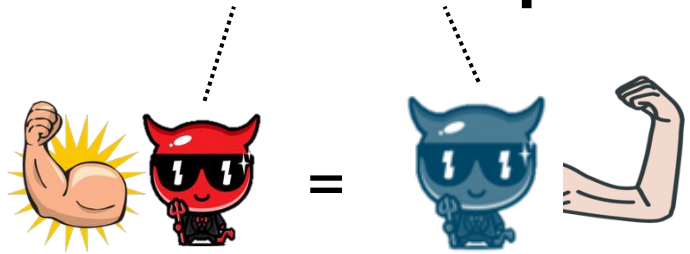
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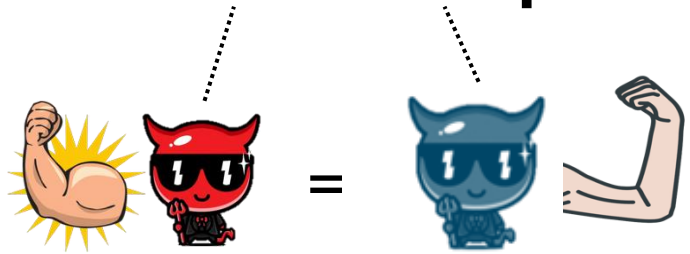
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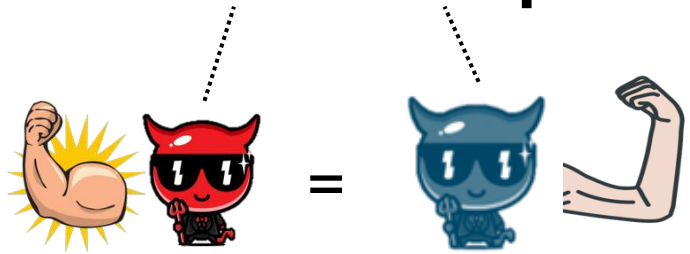


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Confidentiality noninterference

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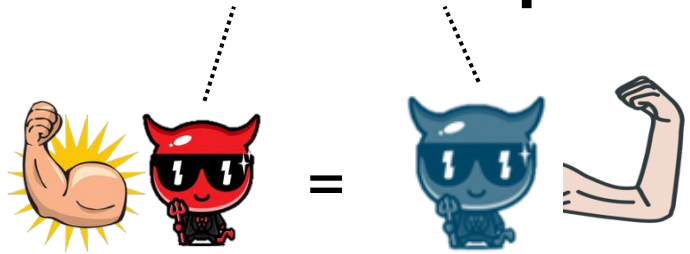


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Confidentiality noninterference
“Adversaries do not learn secrets”

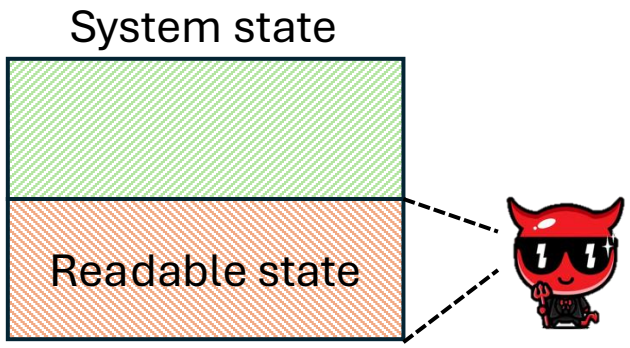
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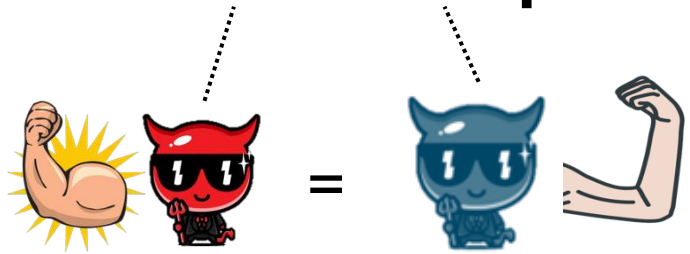
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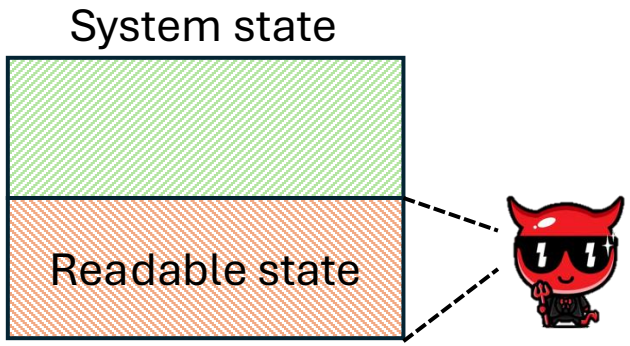
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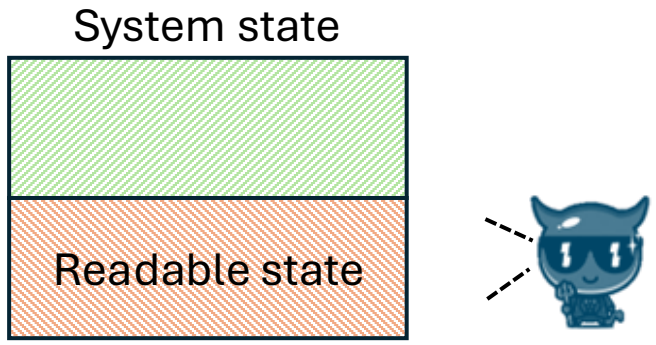
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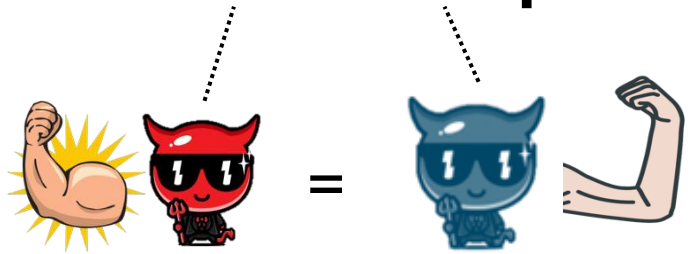
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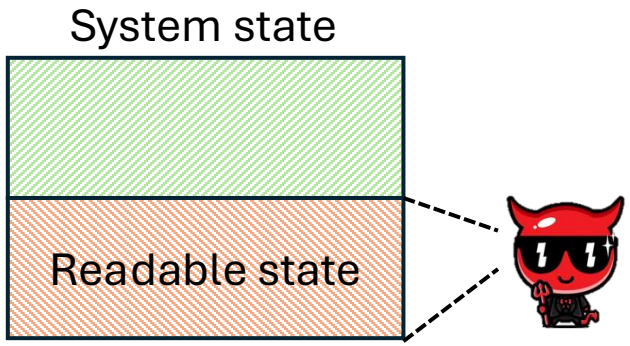
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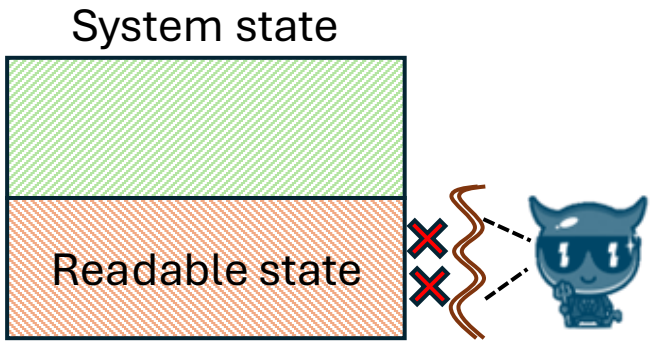
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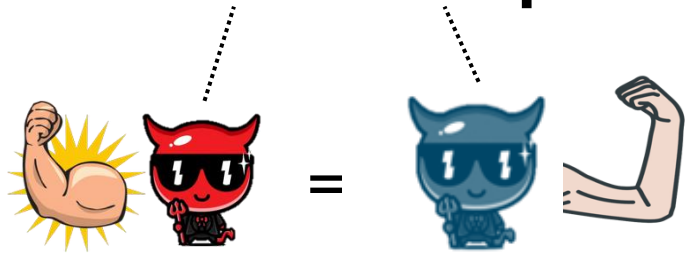
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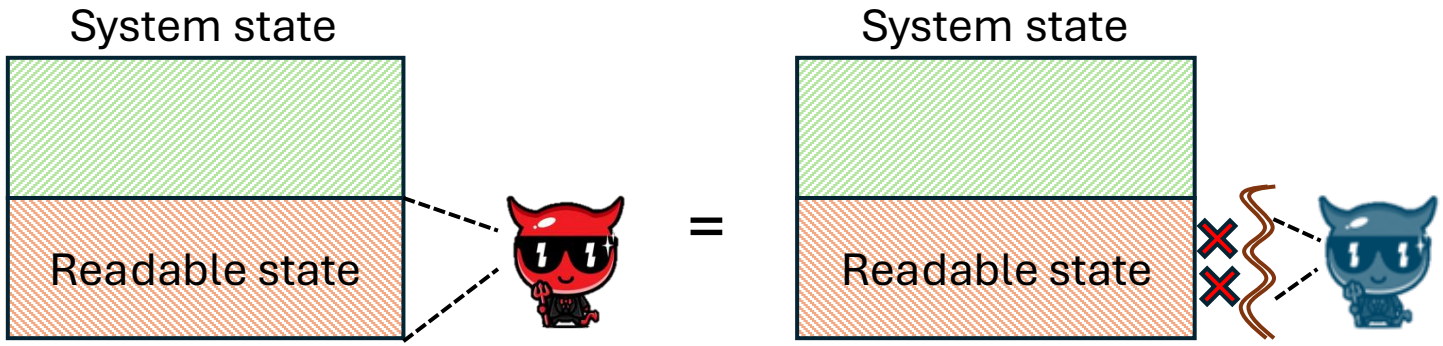
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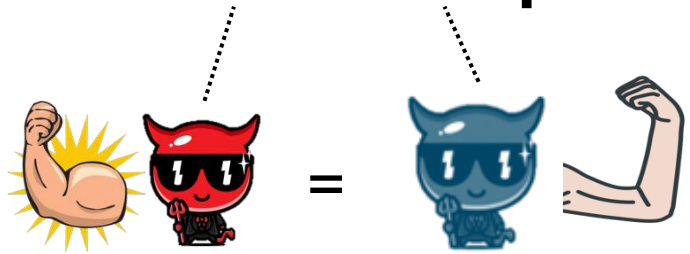
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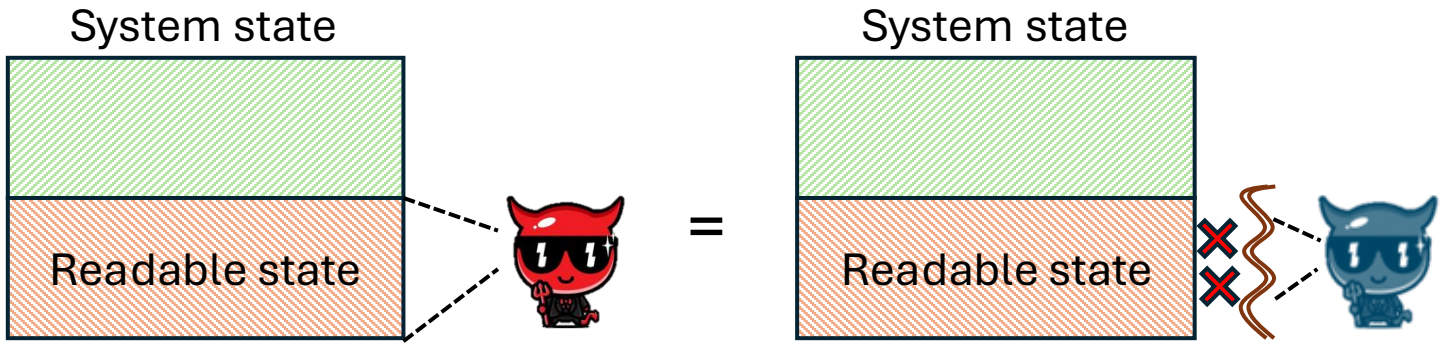


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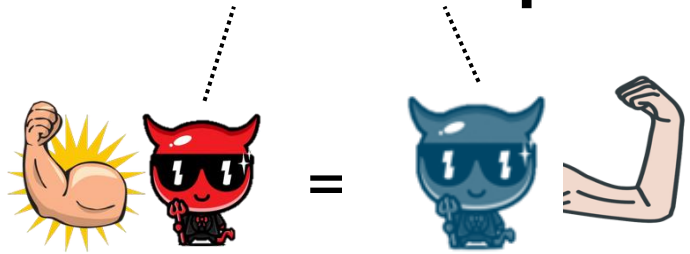
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"Adversaries that can use their abilities to read are no more powerful that those who don't"

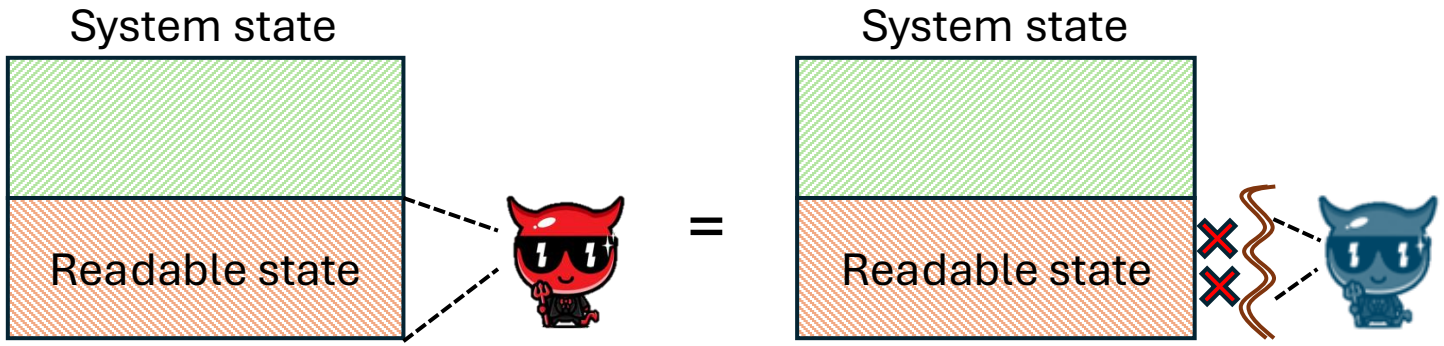
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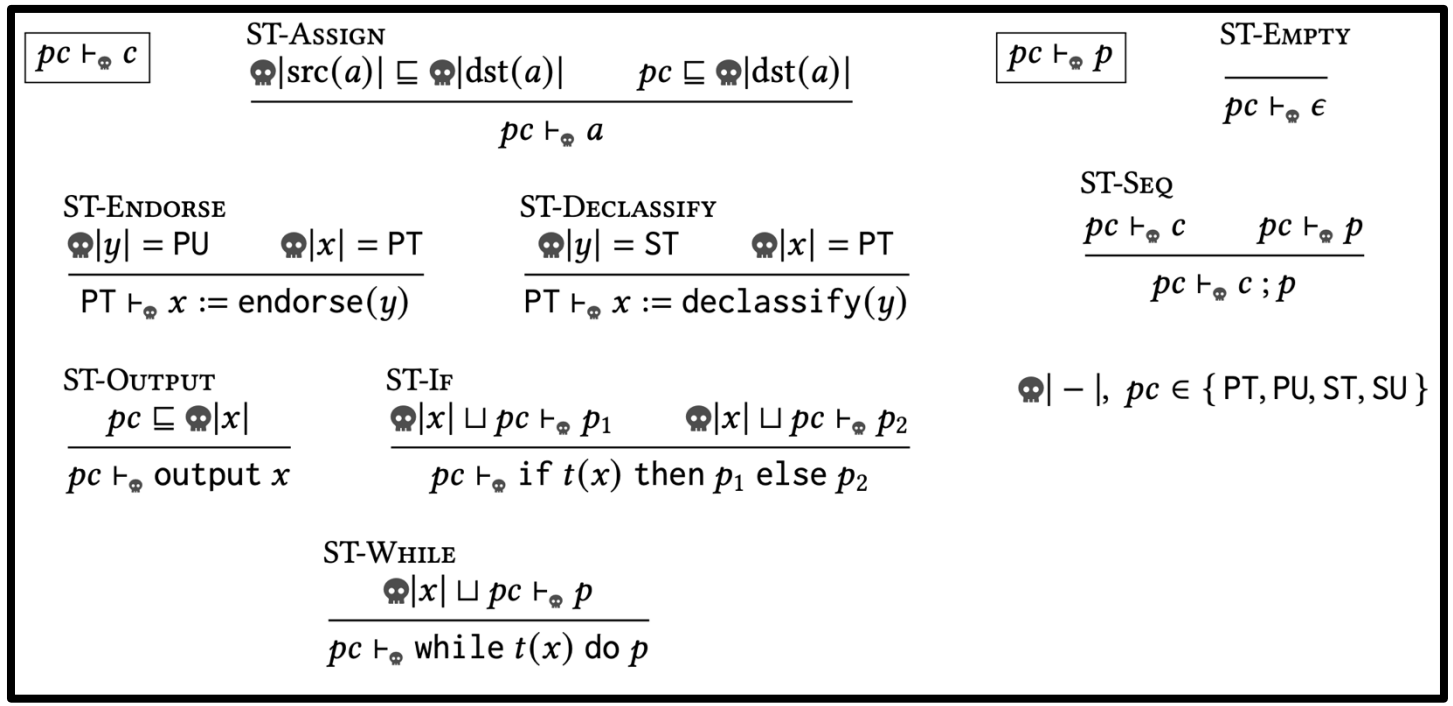
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Several more technical results

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Several more technical results

$pc \vdash_{☠} c$

ST-Assign

$$\frac{☠|\mathrm{src}(a)| \sqsubseteq ☠|\mathrm{dst}(a)|}{pc \vdash_{☠} a}$$

ST-Endorse

$$\frac{☠|y| = \mathsf{PU} \qquad ☠|x| = \mathsf{PT}}{\mathsf{PT} \vdash_{☠} x := \mathsf{endorse}(y)}$$

ST-Decla

$$\frac{☠|y| = \mathsf{S}}{\mathsf{PT} \vdash_{☠} x :=}$$

ST-Output

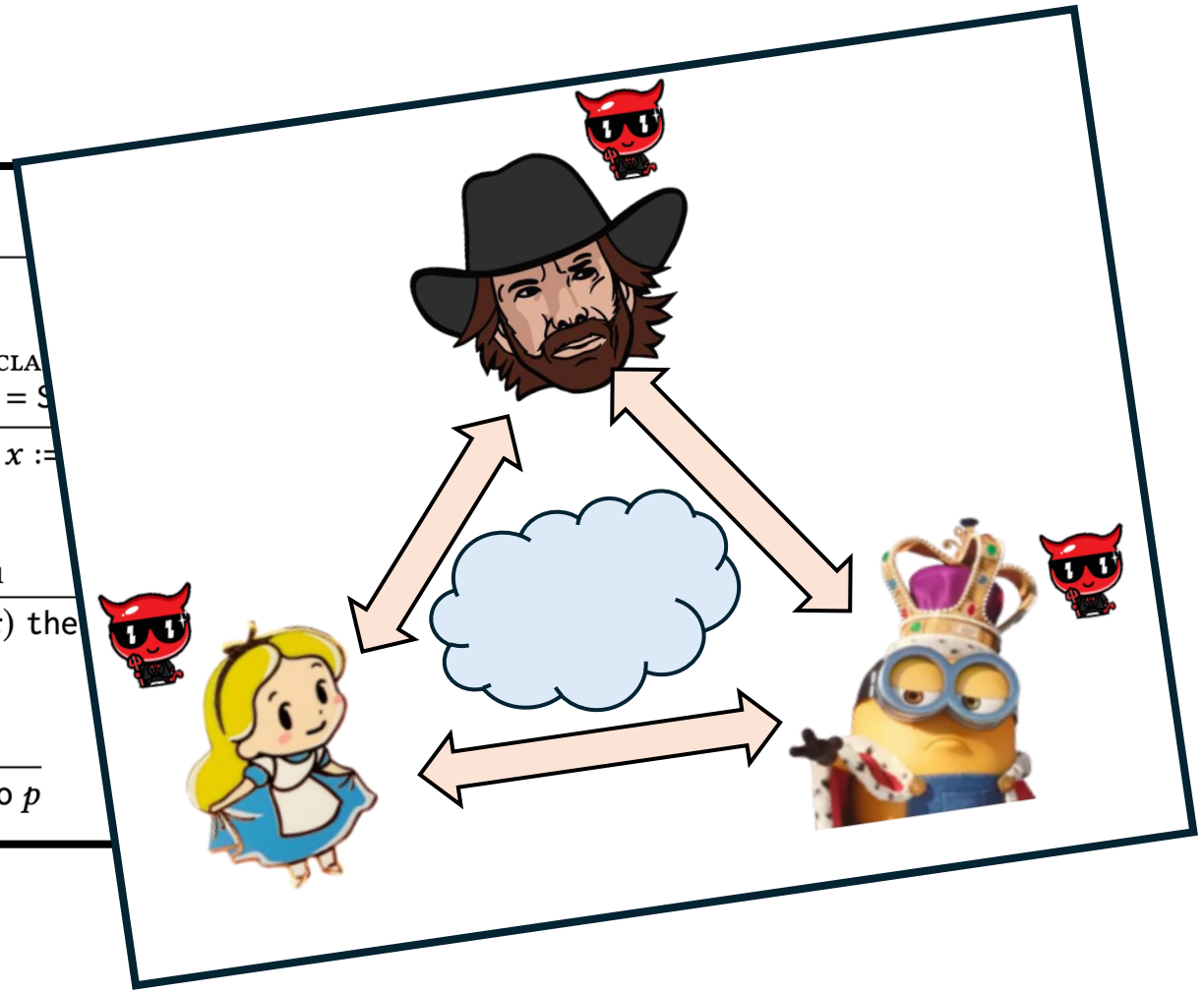
$$\frac{pc \sqsubseteq ☠|x|}{pc \vdash_{☠} \mathsf{output}\ x}$$

ST-If

$$\frac{☠|x| \sqcup pc \vdash_{☠} p_1}{pc \vdash_{☠} \mathsf{if}\ t(x)\ \mathsf{the}}$$

ST-While

$$\frac{☠|x| \sqcup pc \vdash_{☠} p}{pc \vdash_{☠} \mathsf{while}\ t(x)\ \mathsf{do}\ p}$$



Several more technical results

$pc \vdash_{\text{skull}} c$

ST-Assign
$$\frac{\text{skull}|\text{src}(a)| \sqsubseteq \text{skull}|\text{dst}(a)|}{pc \vdash_{\text{skull}} a}$$

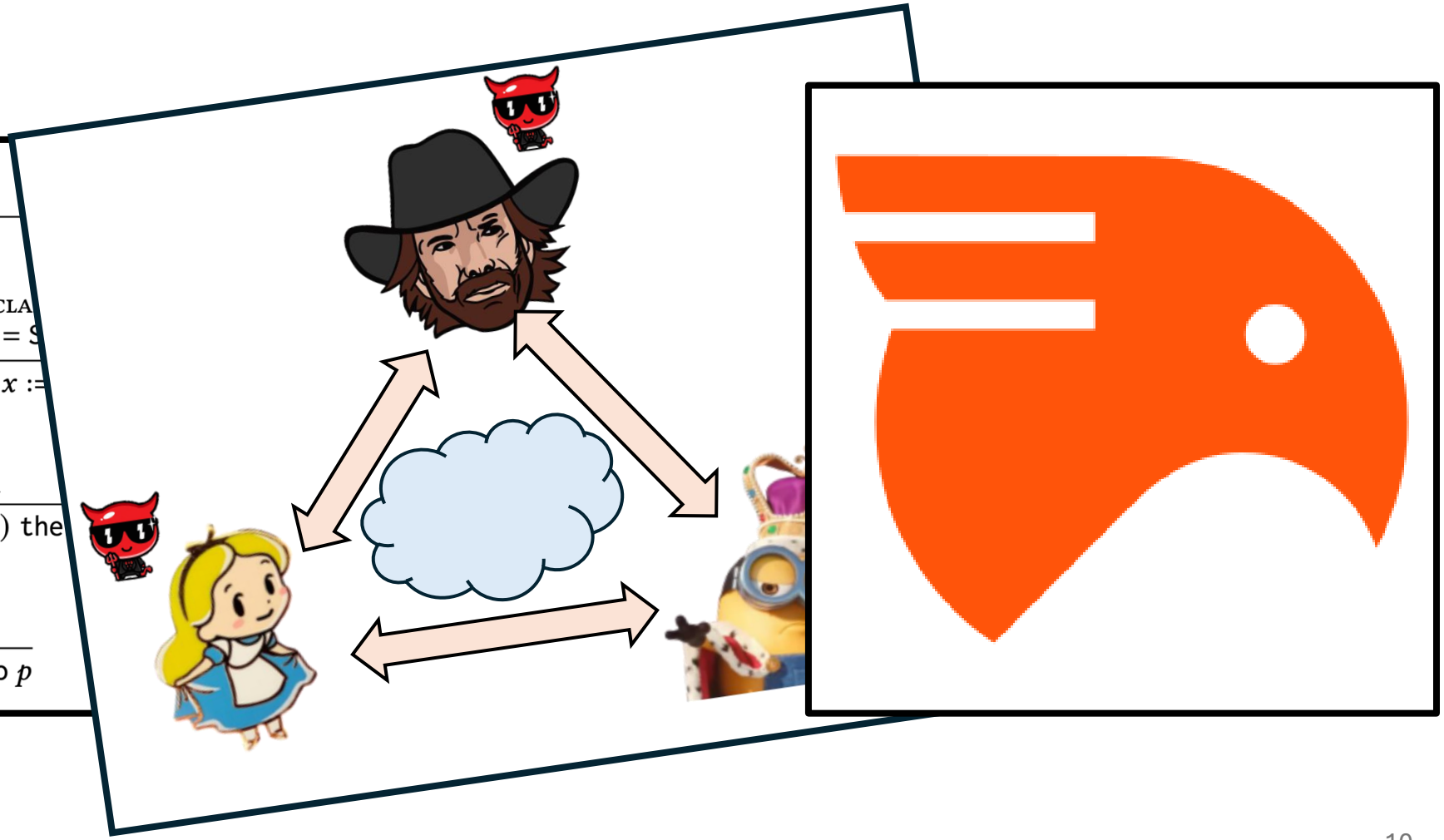
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$$\frac{pc \sqsubseteq \text{skull}|x|}{pc \vdash_{\text{skull}} \text{output } x}$$

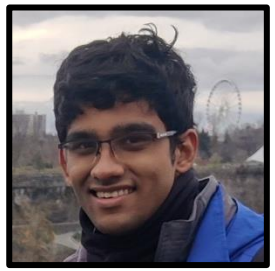
ST-If
$$\frac{\text{skull}|x| \sqcup pc \vdash_{\text{skull}} p_1}{pc \vdash_{\text{skull}} \text{if } t(x) \text{ the}}$$

ST-While
$$\frac{\text{skull}|x| \sqcup pc \vdash_{\text{skull}} p}{pc \vdash_{\text{skull}} \text{while } t(x) \text{ do } p}$$

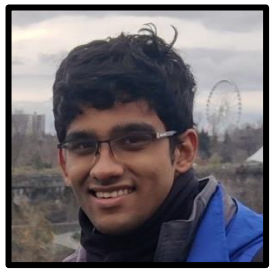


Current research

A theoretical basis for **information flow downgrading**




Auditable, refinable, and enforceable security for **AI prompts**

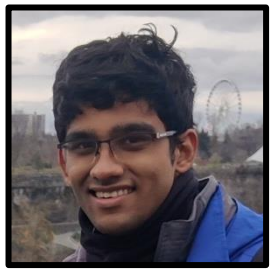





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This is a civilizational change

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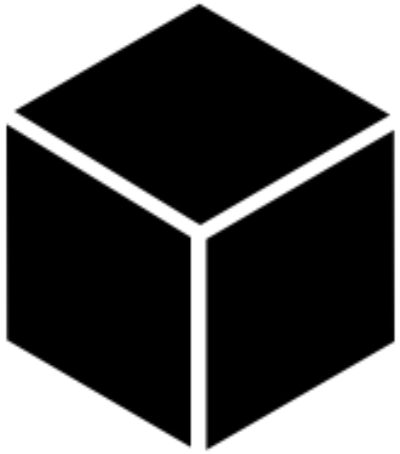
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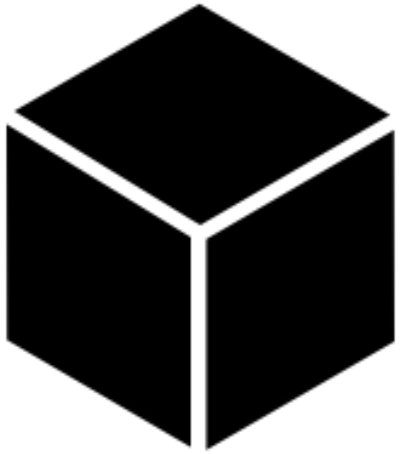




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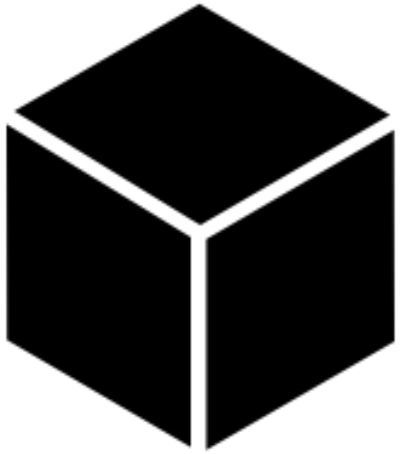




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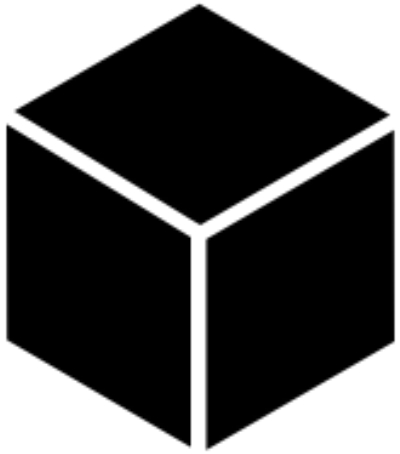


“We gotta lock in”
“Are we cooked?”



This is a civilizational change









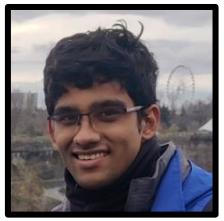
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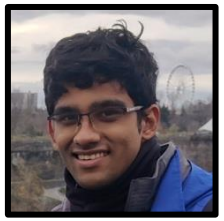
Getting guarantees is almost impossible!

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I'd like to write a script that does X

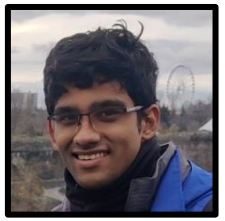
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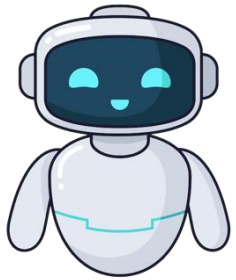
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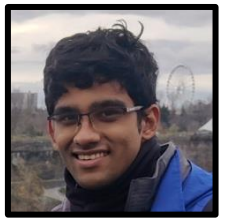
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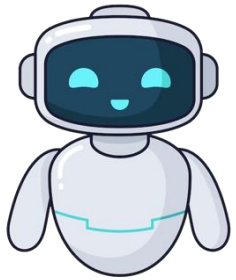
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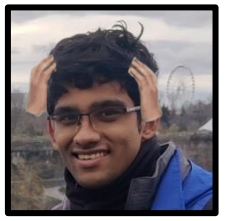


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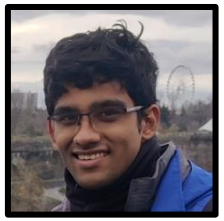
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Panic

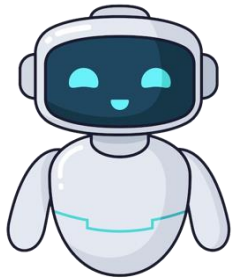
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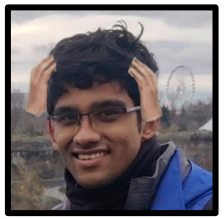


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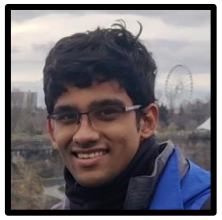
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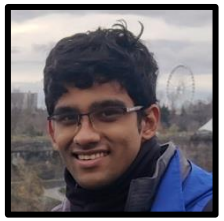


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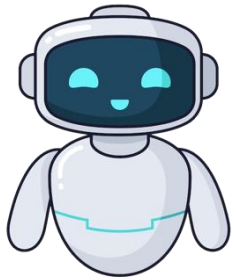
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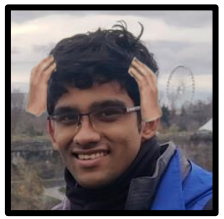


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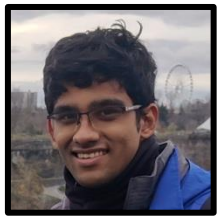
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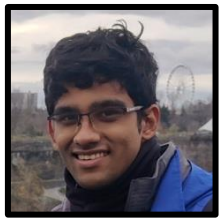
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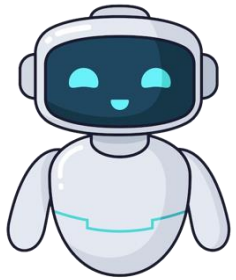
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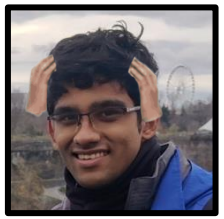


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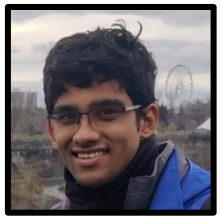
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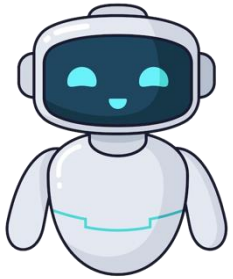
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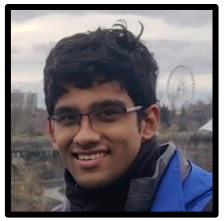
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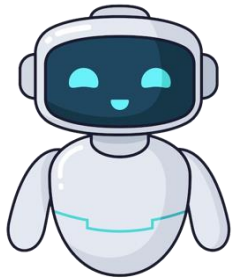
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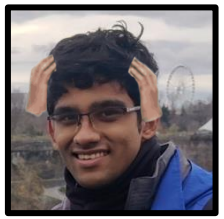


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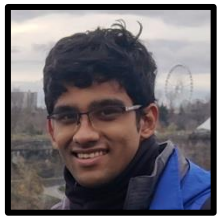
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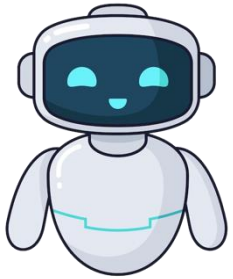
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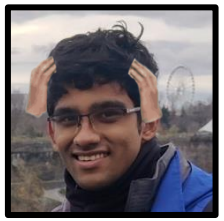


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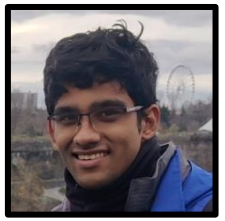




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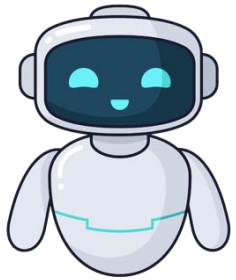
Based on true stories

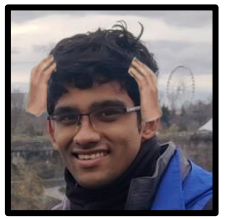


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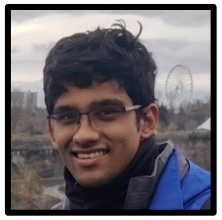
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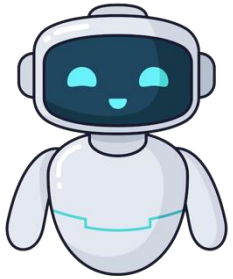
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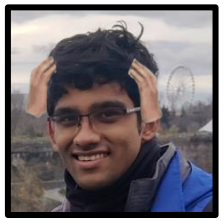


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We need stronger assurances for prompts!

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Large language models



Programming languages

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Get auditable, enforceable, and formal specs for every prompt!

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Aren’t specs hard to understand?

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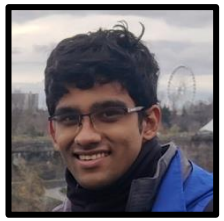


Aren’t specs hard to understand?

Use **specification refinement** to view specs are various levels of abstraction!

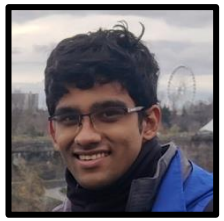
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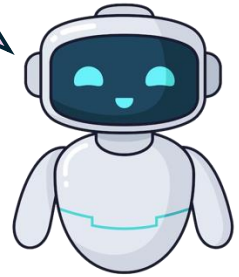
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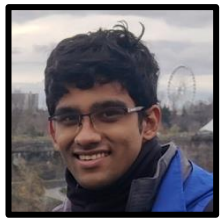


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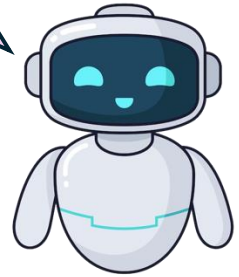


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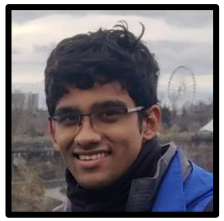
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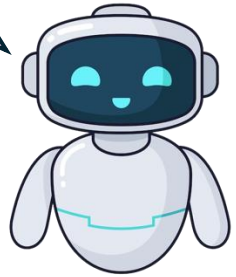
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Emails
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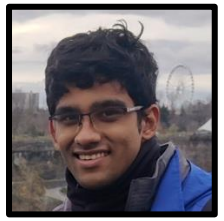
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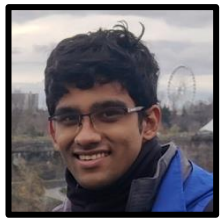
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Yep, that's the one

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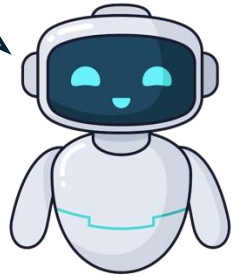


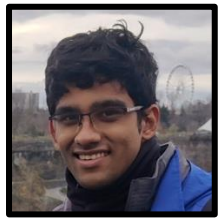
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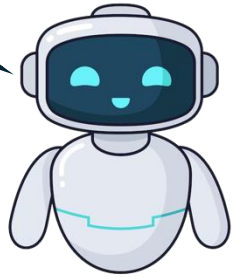
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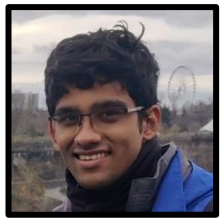


Yep, that's the one

Sure, sounds good. I've refined the spec to reflect that.



I have a dream...

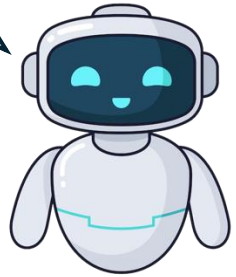


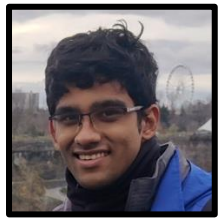
I'd like to send an email to Andrew telling him that I'm giving a talk at Cornell tech

Sure, this is Andrew Myers, your advisor, right?

Generated spec

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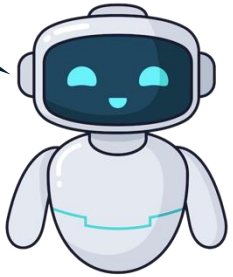
Generated spec

`Emails`

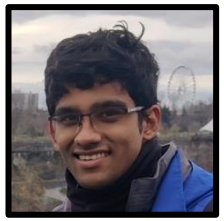
`(andru@cs.cornell.edu)`

refines

`Emails`



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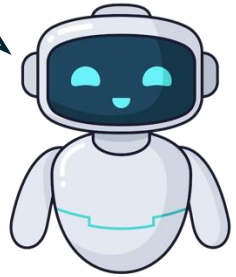


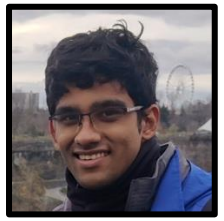
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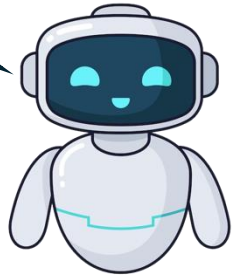
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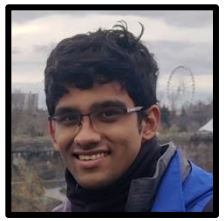
Generated spec

`Emails`

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refines

`Emails`



Execute

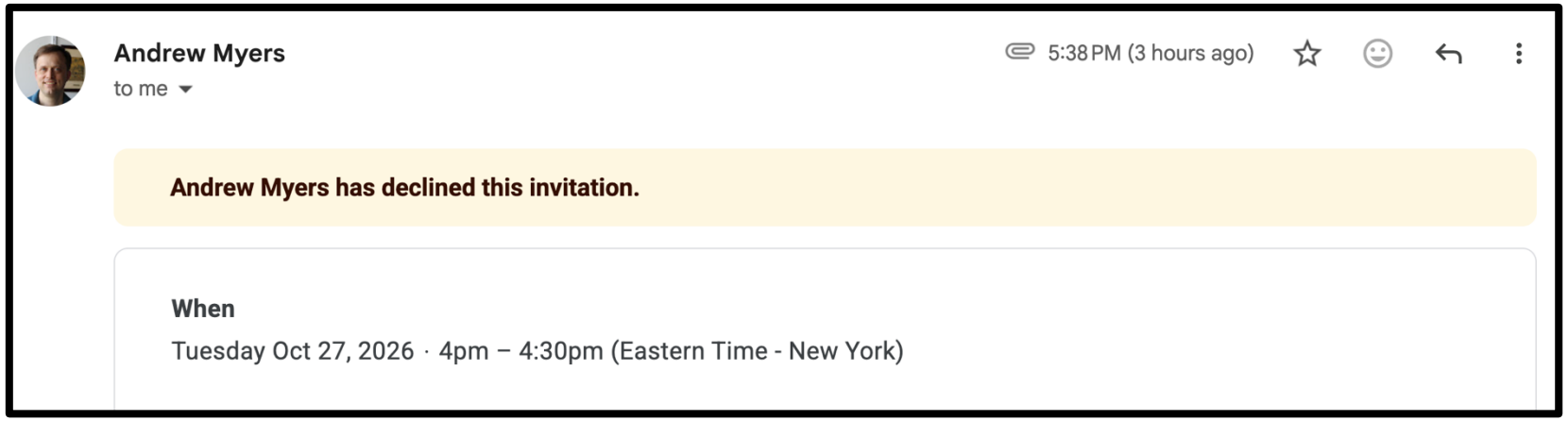
Dreams are cheap

Dreams are cheap

Let me just show you ☺

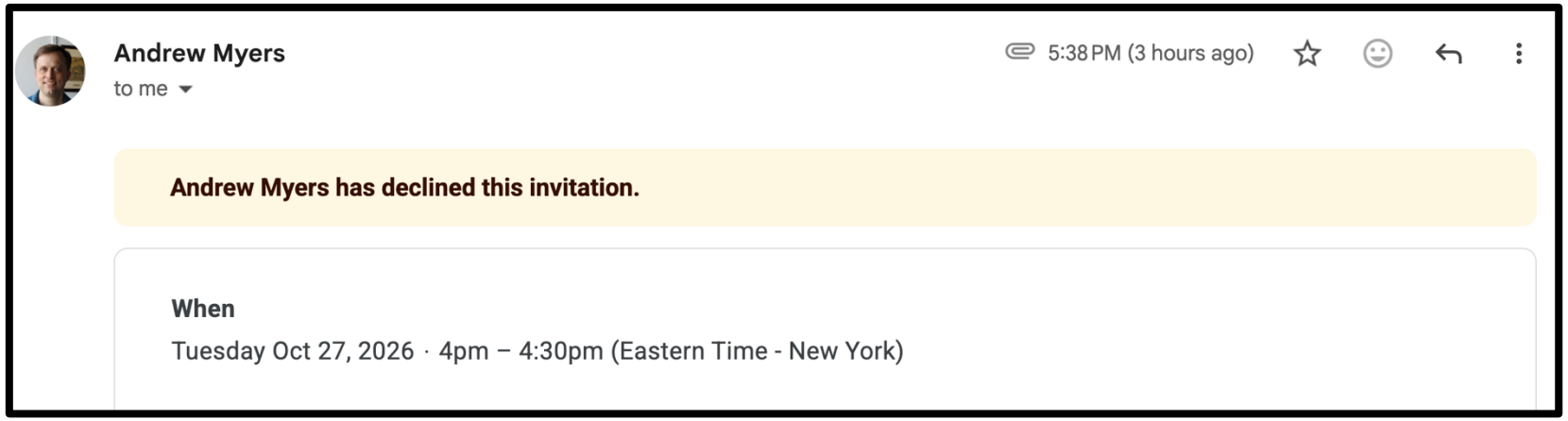
Dreams are cheap

Let me just show you ☺



Dreams are cheap

Let me just show you ☺



There is no escape.

Lots to do!!

Lots to do!!



Lots to do!!



curl, slack, git, cat, …

Lots to do!!



curl, slack, git, cat, …

```
Command ('git status')
        |
        v  refines
Filesystem
```

Lots to do!!



curl, slack, git, cat, …

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Command ('git status')
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        v
Filesystem
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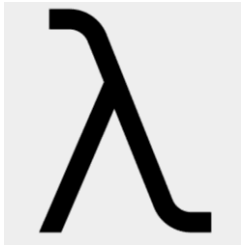
λ

Lots to do!!



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Command ('git status')
        |
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$c_1; c_2$

Lots to do!!

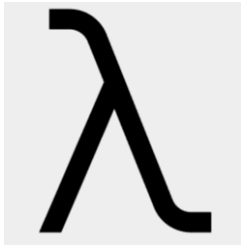


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```
Filesystem
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$c_1; c_2$

if b then c_1 else c_2

Lots to do!!

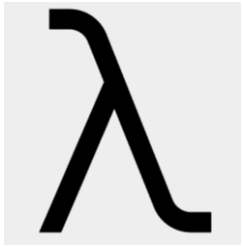


curl, slack, git, cat, …

`Command ('git status')`

refines

`Filesystem`



$c_1; c_2$

if b then c_1 else c_2

$v \leftarrow e$

Lots to do!!



curl, slack, git, cat, …

`Command ('git status')`

refines

`Filesystem`

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if b then c_1 else c_2

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$[\![\;]\!]$

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$[\![\ ]\!]$



"Generate a slide deck on …"

Lots to do!!

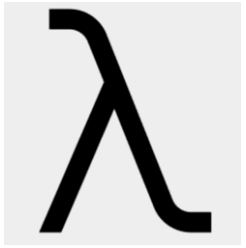


curl, slack, git, cat, …

`Command ('git status')`

refines

`Filesystem`



$c_1; c_2$

if b then c_1 else c_2

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$[\![\ ]\!]$



“Generate a slide deck on …”





Summing it up

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- With AI writing most of our code and even proofs, getting the right system specifications is crucial.
- Our work on information flow downgrading shows how the cryptographic real–ideal paradigm offers a simple and unified approach to language-based security.
- This talk also proposes a formally enforceable workflow for AI interaction that enriches AI prompting with programming language techniques—a direct step towards a future where we use our AI superpowers responsibly

Why security? What security? How security?

Suraaj Kanniwadi

The AI4AI retreat @ Cornell Tech

October 27 2026