# Universal Composability is Robust Compilation

Marco Patrignani[1] Robert Künneman[2] Riad S. Wahby[3] Ethan Cecchetti[4]




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# DISCLAIMER

This film has been modified as follows from its original version: it has been formatted to fit your screen.

# DISCLAIMER

pl != crypto

# A Magic Trick

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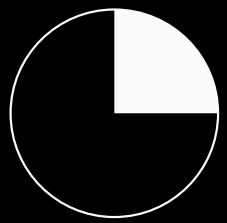

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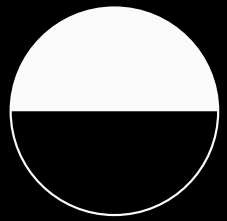

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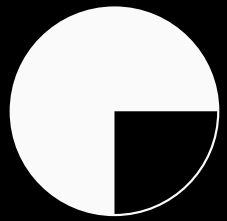

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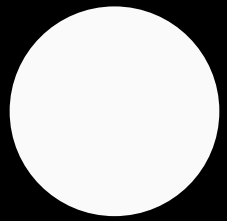

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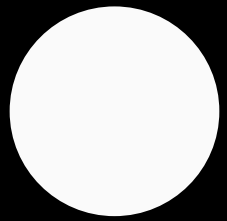

Spoiler: there are $0 + \epsilon$ hands raised

# Motivation and the Journey

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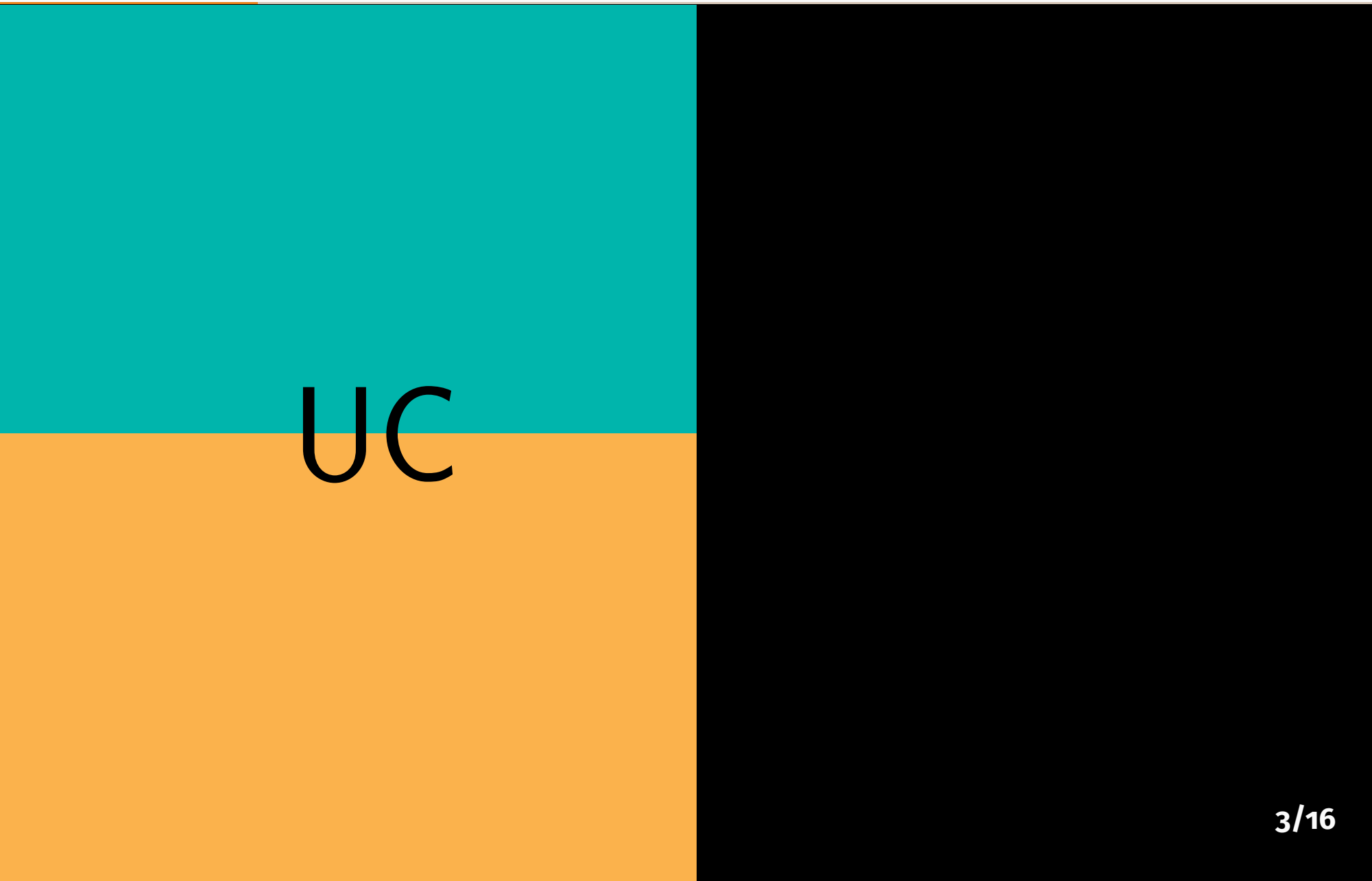
UC

$RC$

# **Fields:** UC



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This work: axiomatic formalisation, geared towards the newer theories SaUCy and iUC

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# UC **Base Notions: ITMs** [4]

- protocols Π (using concrete crypto)

*commitment for* $b \in \{0,1\}$ *with SID* $sid$*:*

compute $G_{pk_b}(r)$ for random $r \in \{0,1\}^n$
set $y = G_{pk_b}(r)$ for $b = 0$, or $y = G_{pk_b}(r) \oplus \sigma$ for $b = 1$
send $(\texttt{Com}, sid, y)$ to the receiver

Upon receiving $(\texttt{Com}, sid, y)$ from $P_i$, $P_j$ outputs $(\texttt{Receipt}, sid, cid, P_i, P_j)$

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- attackers A & S (corrupting parties etc.)
- environments Z (objective witness)

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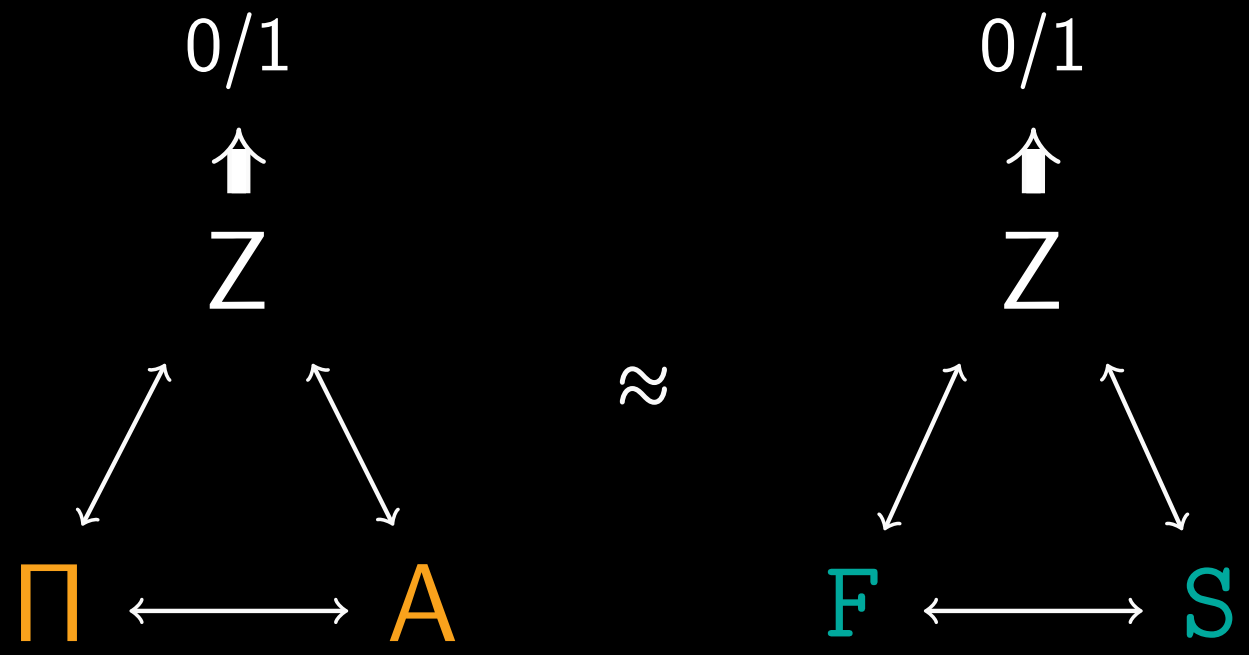


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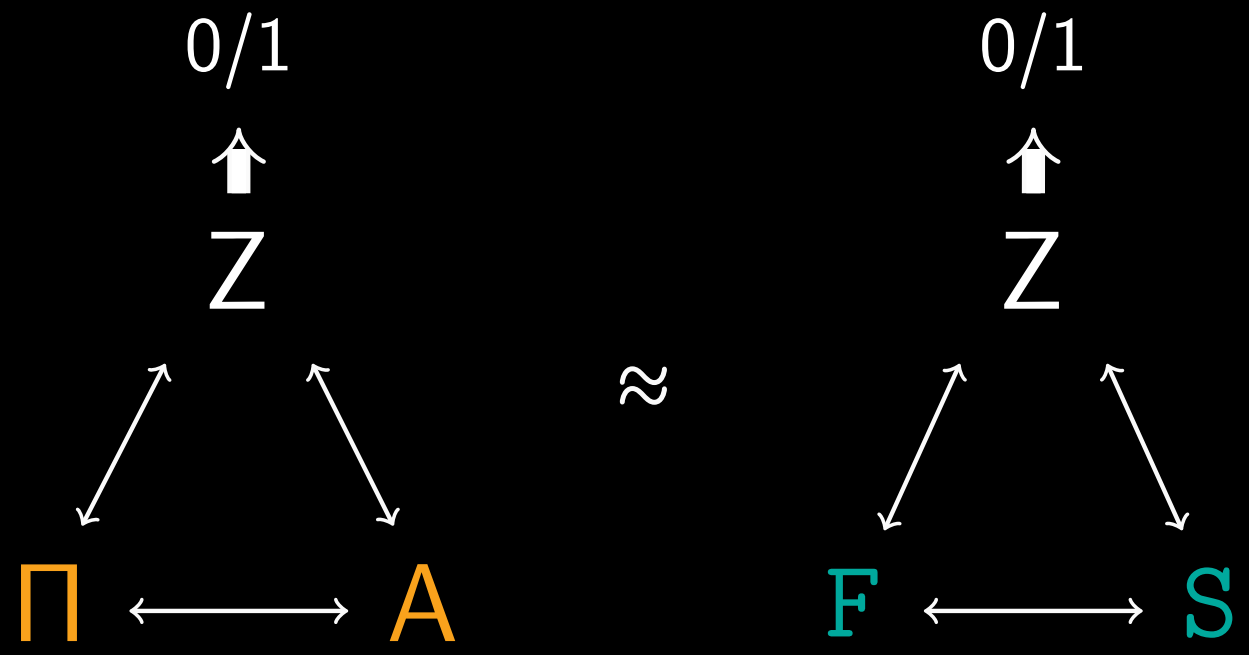
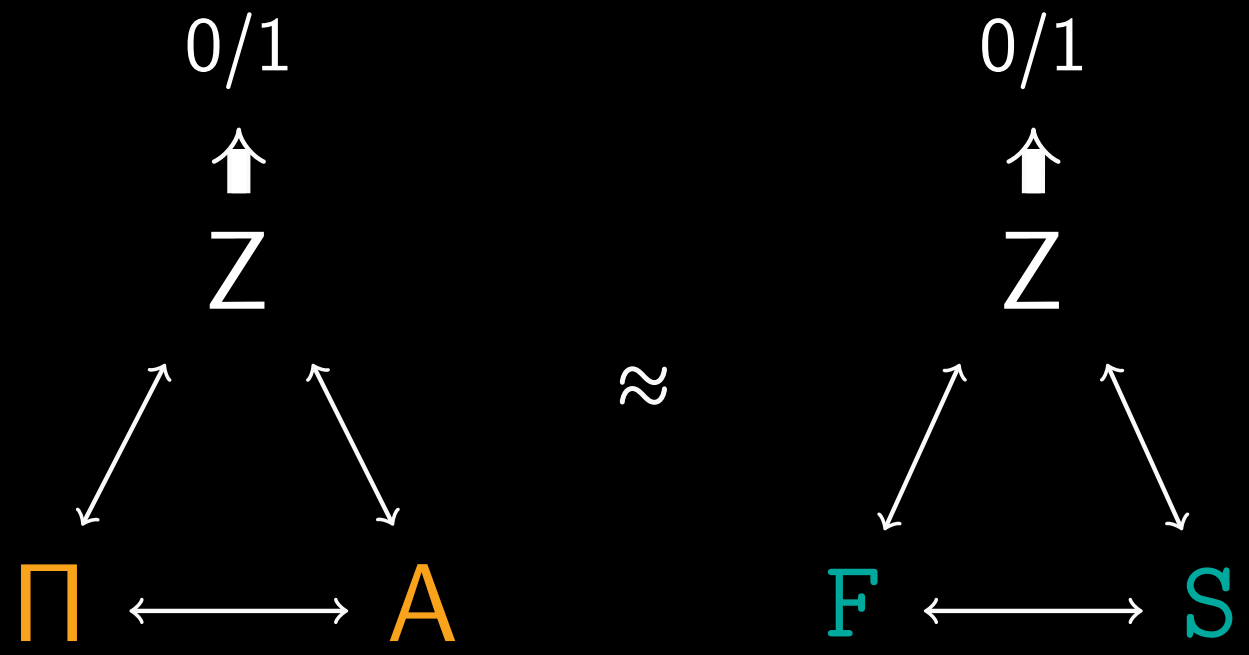



$\leftrightarrow$ represent communication channels

$$\Pi \vdash_{\mathrm{UC}} \mathtt{F} \stackrel{\text{def}}{=} \forall \mathsf{A}, \exists \mathtt{S}, \forall \mathsf{Z}.$$

$$\textsc{Exec}[\mathsf{Z}, \mathsf{A}, \Pi] \approx \textsc{Exec}[\mathsf{Z}, \mathtt{S}, \mathtt{F}]$$

# Perfect (!!) UC (computational UC in Künneman et al. CSF'24)

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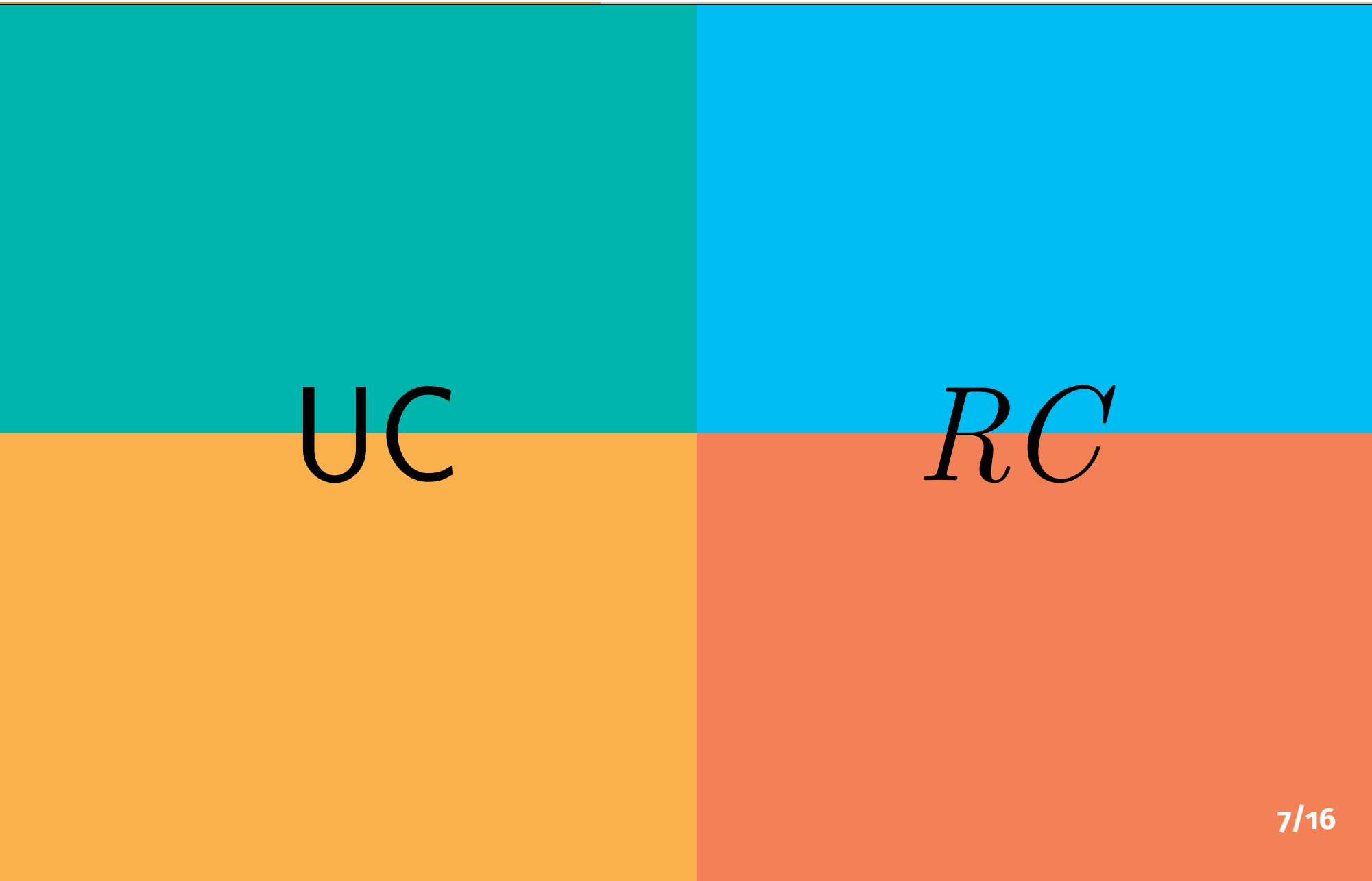
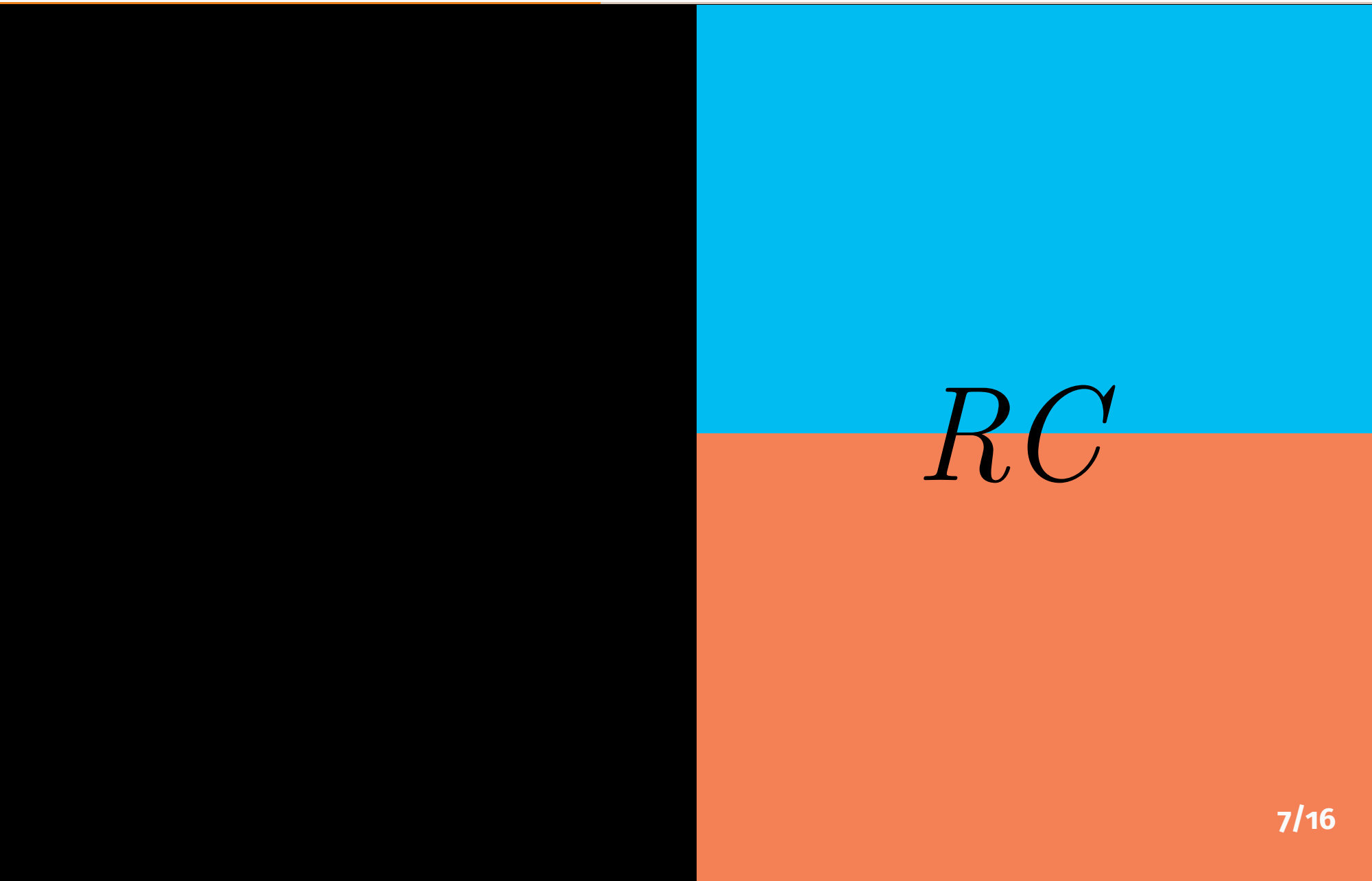


# Fields: $RC$



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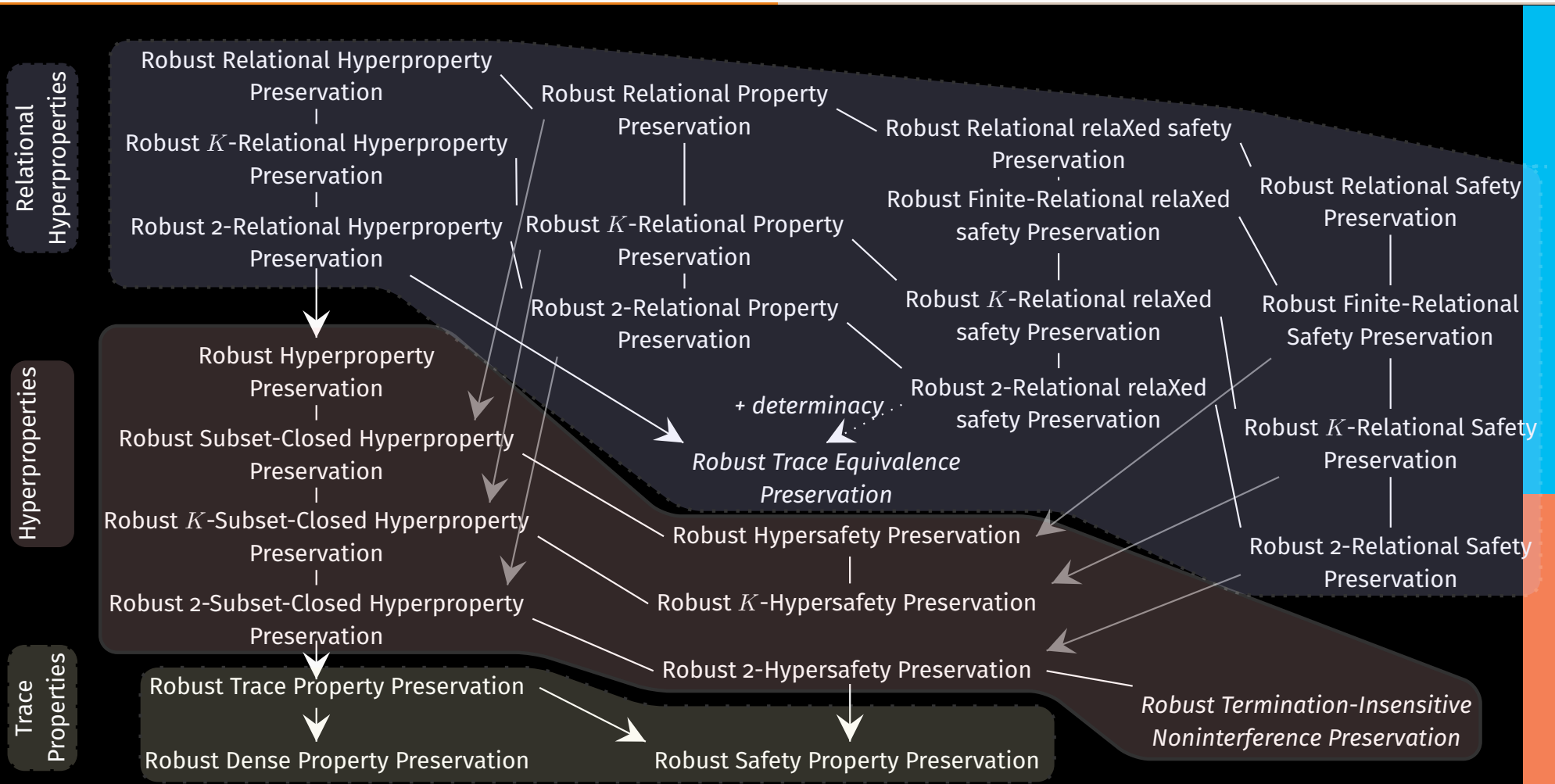


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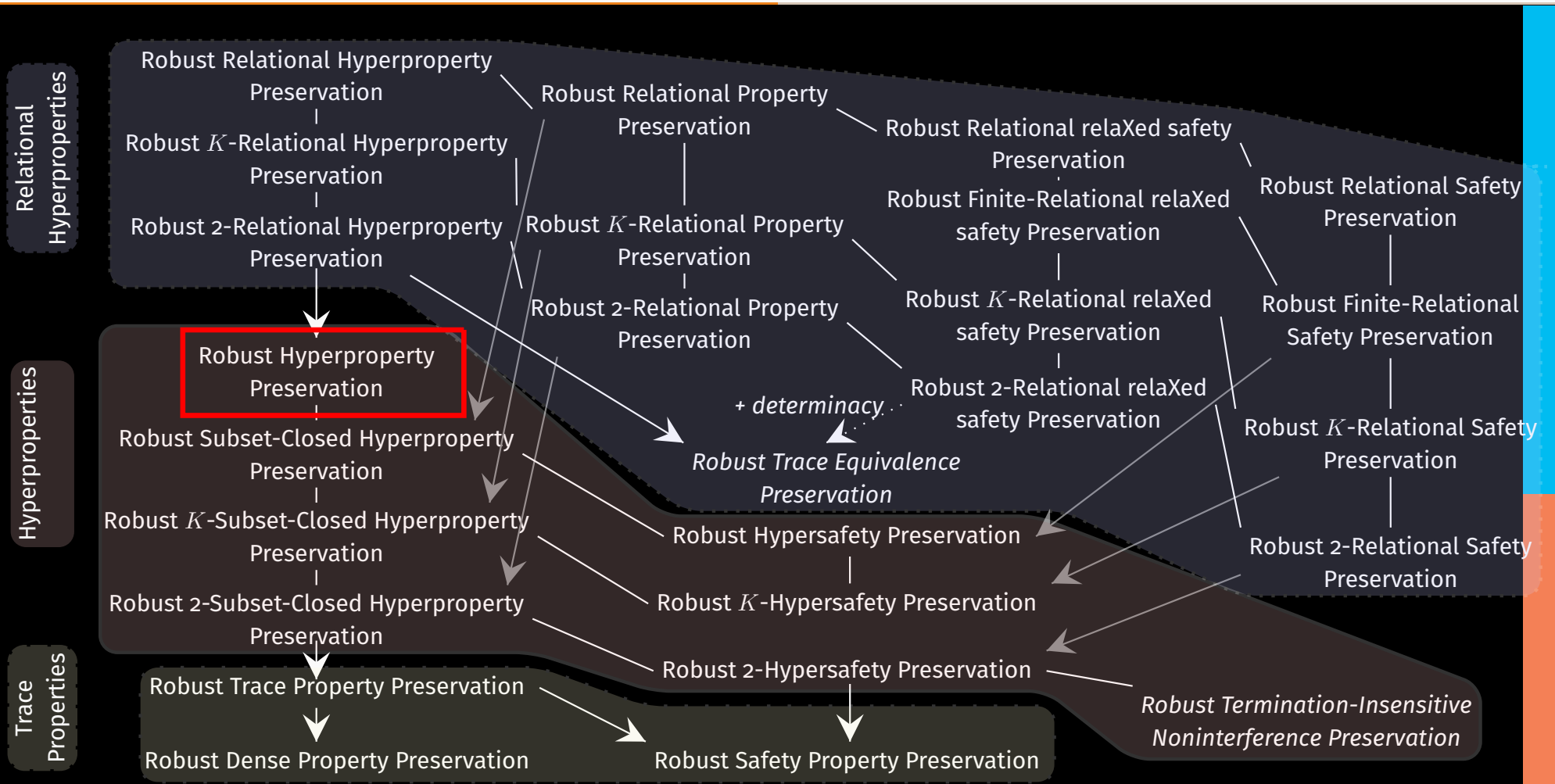


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# Robust Hyperproperty Preservation: $RHC$

For any language $S$ and $\mathbf{T}$

$$\begin{array}{ccccc} & \overline{t} & & \overline{t} & \\ & \rightsquigarrow & & \rightsquigarrow & \\ [\![P]\!] & \bowtie & \mathbf{A} \iff P & \bowtie & A \end{array}$$

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$$[\![\cdot]\!] \vdash RHC \stackrel{\text{def}}{=} \forall P, \mathbf{A}. \exists A. \forall \overline{t}.$$
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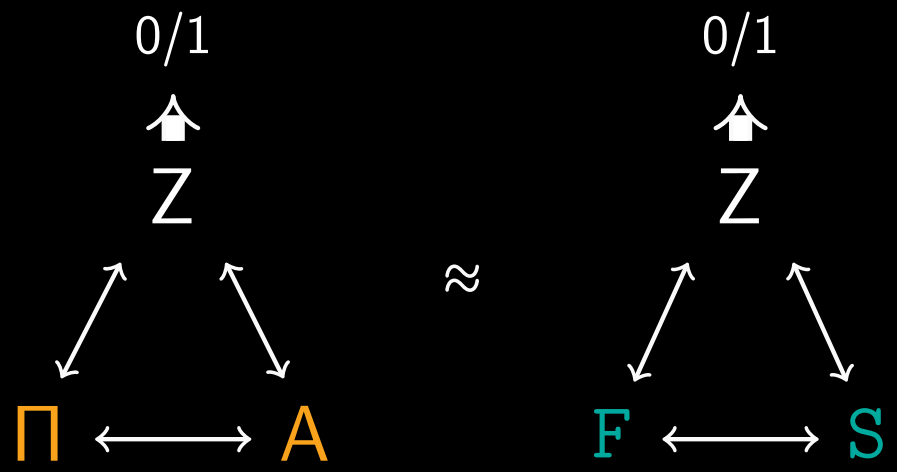
# A Closer Look

$$\Pi \vdash_{\mathsf{UC}} \mathrm{F} \stackrel{\text{def}}{=} \forall \mathrm{A}, \exists \mathrm{S}, \forall \mathrm{Z}.$$

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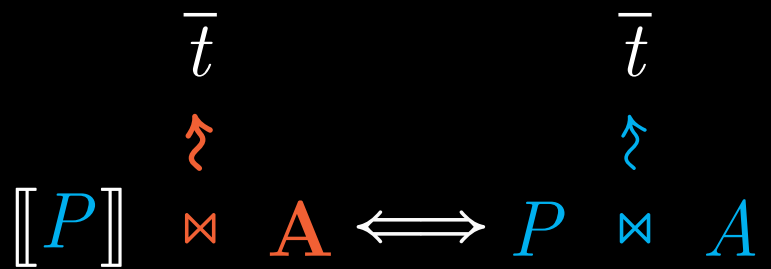

# Our (Isabelle'd) Connection

| UC | | $RC$ | |
|---|---|---|---|
| protocol | $\Pi$ | $[\![P]\!]$ | compiled program |
| concrete attacker | $\mathsf{A}$ | $\mathbf{A}$ | target context |
| ideal functionality | $\mathtt{F}$ | $P$ | source program |
| simulator | $\mathtt{S}$ | $A$ | source context |
| environment, output | Z, 0/1 | $\overline{t}$, $\rightsquigarrow$ | trace, semantics |
| communication | $\leftrightarrow$ | $\bowtie$ | linking |
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| communication | $\leftrightarrow$ | $\bowtie$ | linking |
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| human translation $\Pi \to \mathtt{F}$ | | $[\![\cdot]\!]\colon P \to \mathbf{P}$ compiler | |

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Prove $RHC$ via UC

(e.g., Viaduct ...Acay et al PLDI'21)

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Admittedly, less explored,

(is there more?)

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- Wrap real and `ideal` processes with an environment proxy to regulate scheduling
- Add the missing `lines` for adaptive corruption (binding or hiding, not both)

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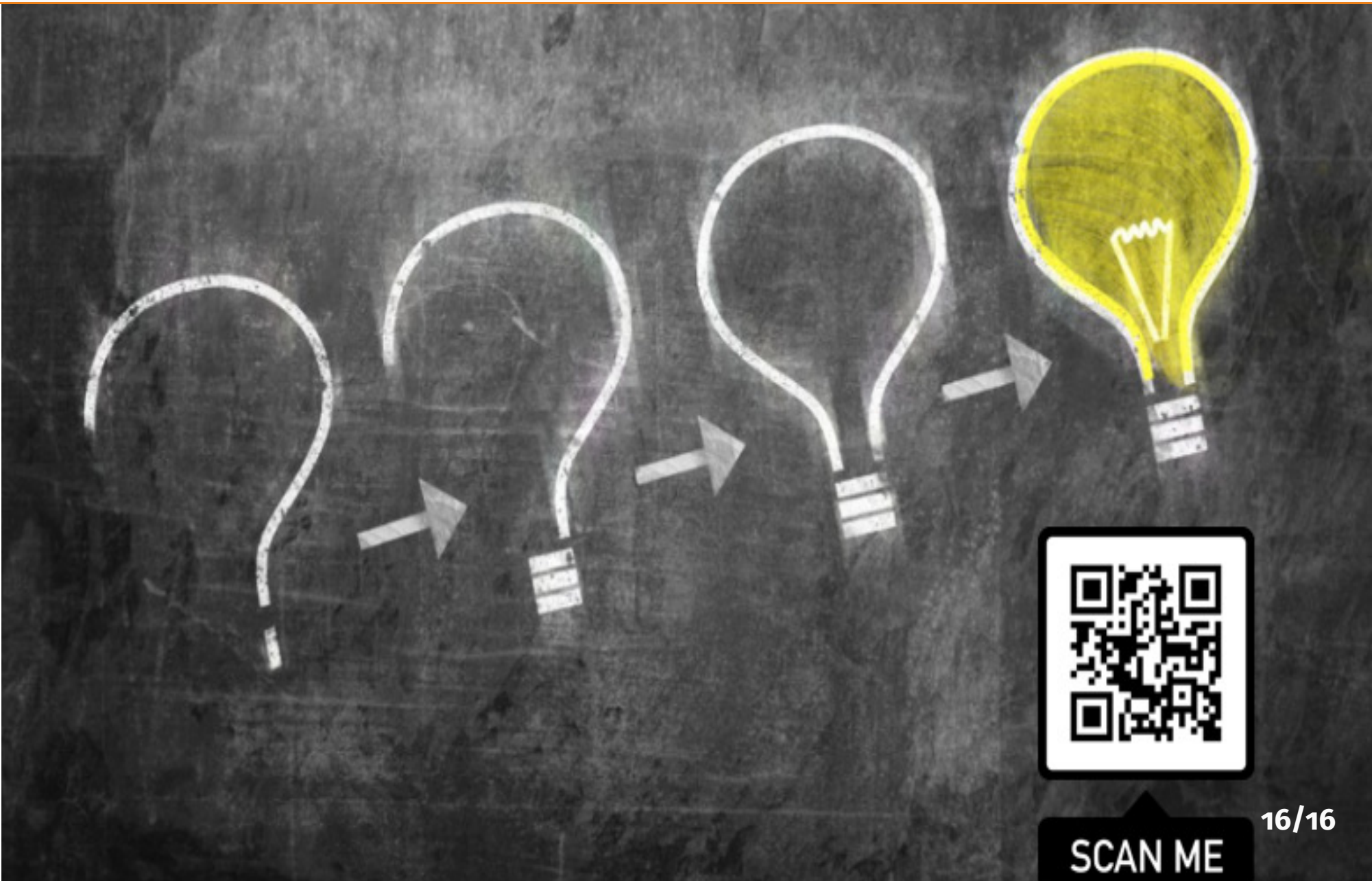
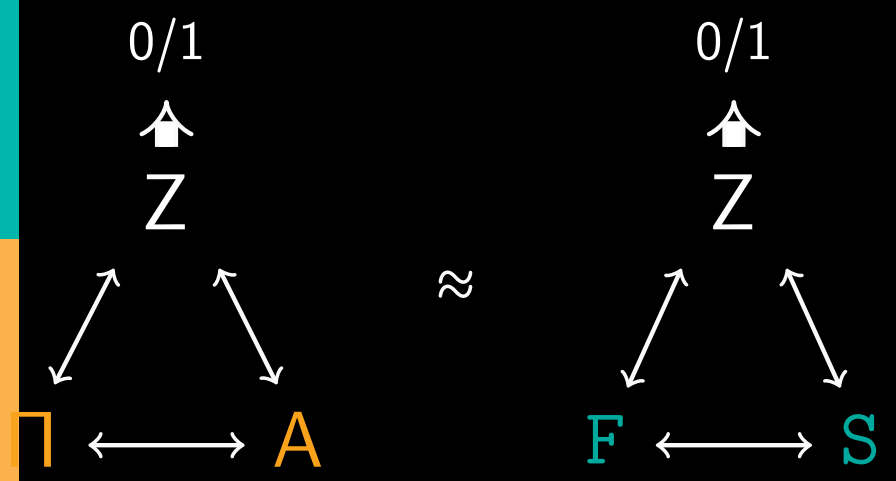
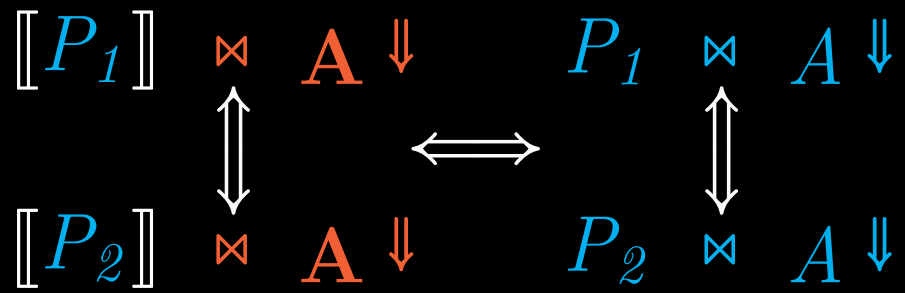
A security proof between ITMs is a UC proof,
a security proof between arbitrary languages is a RC one.

# Questions?



# The Full Abstraction (false) Conjecture




$FAC$ is relational, $RHC$ is propositional, like UC

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- if only there were a protocol definition language ...(future work)

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- Program FFI
- Attacker FFI
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- Must follow 3 (obvious) axioms

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  thus, no need to do induction, just reason about the $source + simulator$ and $\mathbf{target}$ programs (with tools)