CoCon

Andrei Popescu

Middlesex University London
Technical University Munich

Joint work with
Peter Lammich, Sergey Grebenshchikov,
Sudeep Kanav and Thomas Bauereiß

A Bit About My Whereabouts

Bucharest, Romania

Urbana-Champaign, US

Munich, Germany

Technische Universität München

Middlesex, UK

Interactive Theorem Proving

A Verified Conference System

Conference system (think EasyChair, HotCRP) =
web application for submitting and reviewing scientific papers

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WARNING: HotCRP version 2.47 (commit range 94ca5a0e43bd7dd0565c2c8dc7d8f710a206ab49 through 9c1b45475411ecb85d46bad1f76064881792b038) was subject to an information exposure where some authors could see PC comments. Users of affected versions should upgrade or set the following option in `Code/options.inc`: `$Opt["disableCapabilities"] = true;`

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Implemented and verified CoCon, a conference system with confidentiality guarantees

CoCon

CoCon = Feature-Rich Conference Management System (similar to EasyChair and HotCRP)

https://cocon.in.tum.de

Welcome to CoCon.

CoCon is a conference management system with verified document confidentiality. What makes CoCon special compared to other conference systems is the fact that **quite certainly it does not leak**.

Learn more »

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Email

Password

Forgot your password?

Sign in

New user? Sign up here

Email

Full name

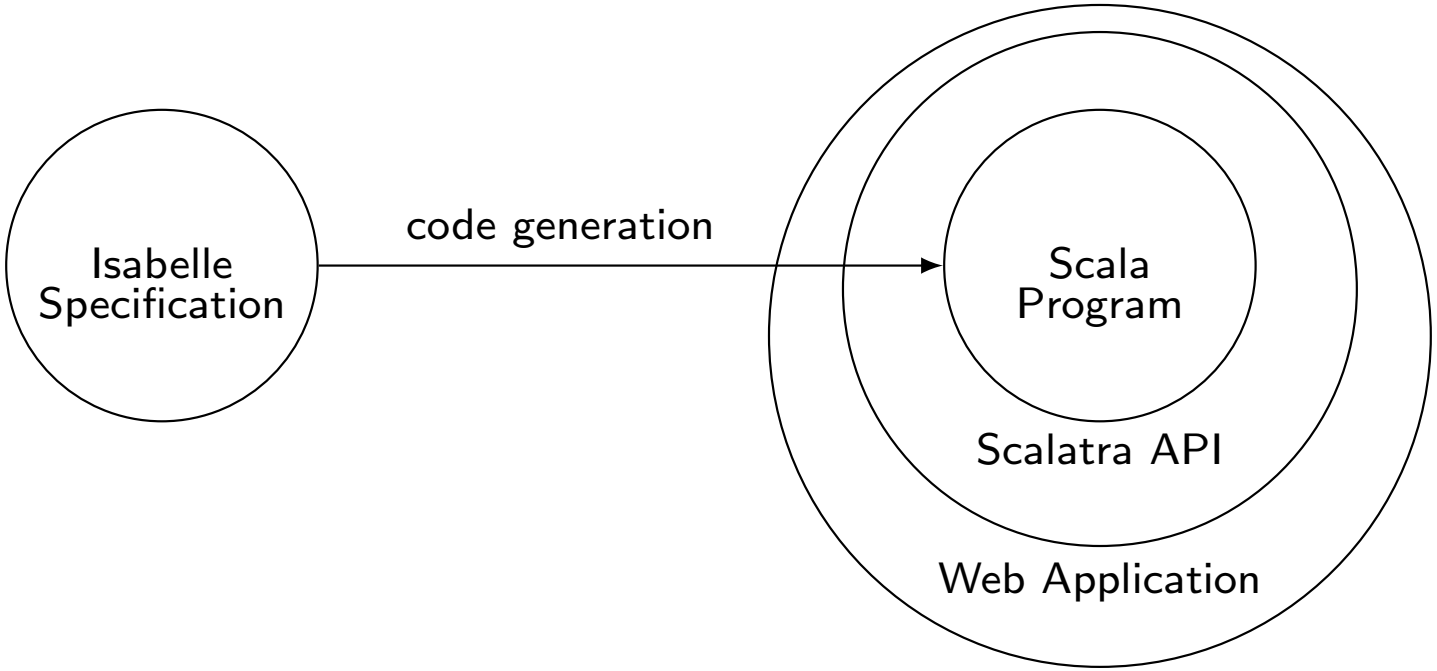
Affiliation

Password

Password (confirmation)

Sign up

CoCon's Architecture



CoCon's Formal Guarantees

- A user learns nothing about a paper's content beyond the last submitted version unless she becomes an author of the paper

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Source Sink

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Bounded-Deducibility (BD) Security

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Bounded-Deducibility (BD) Security
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Source Sink Trigger Bound

Bounded-Deducibility (BD) Security
- applicable to arbitrary I/O automata
- capable of expressing flexible declassification bounds and triggers

Bounded-Deducibility (BD) Security

$\mathsf{SystemTrace} \subseteq \mathsf{Event}^*$

$\mathsf{SystemTrace}$

Secret^*

Obs^*

Bounded-Deducibility (BD) Security

$\mathsf{SystemTrace} \subseteq \mathsf{Event}^*$

S = produce secrets from selected events

$$\mathsf{SystemTrace} \xrightarrow{\mathsf{S}} \mathsf{Secret}^*$$

Obs^*

Bounded-Deducibility (BD) Security

$\mathsf{SystemTrace} \subseteq \mathsf{Event}^*$

O = produce observations from selected events

$$\begin{tikzcd}
\mathsf{SystemTrace} \arrow[r, "\mathsf{S}"] \arrow[d, "\mathsf{O}"'] & \mathsf{Secret}^* \\
\mathsf{Obs}^* &
\end{tikzcd}$$

Bounded-Deducibility (BD) Security

$\mathsf{SystemTrace} \subseteq \mathsf{Event}^*$

$\mathsf{T} : \mathsf{Event} \rightarrow \mathsf{Bool}$

$$\begin{tikzcd}
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Bounded-Deducibility (BD) Security

$\mathsf{SystemTrace} \subseteq \mathsf{Event}^*$

$\mathsf{T} : \mathsf{Event} \to \mathsf{Bool} \qquad \mathsf{B}$ relation on Secret^*

$$\begin{tikzcd}
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$\mathsf{SystemTrace} \subseteq \mathsf{Event}^*$

Unless T occurs, O can learn nothing about S beyond B

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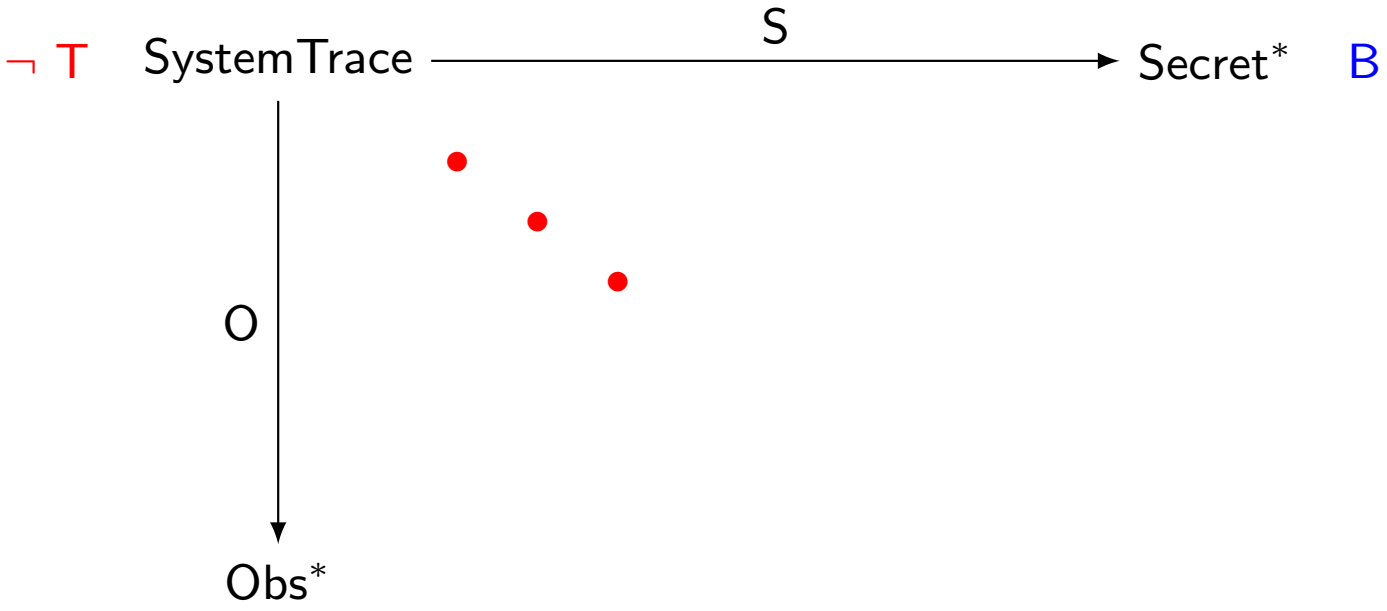

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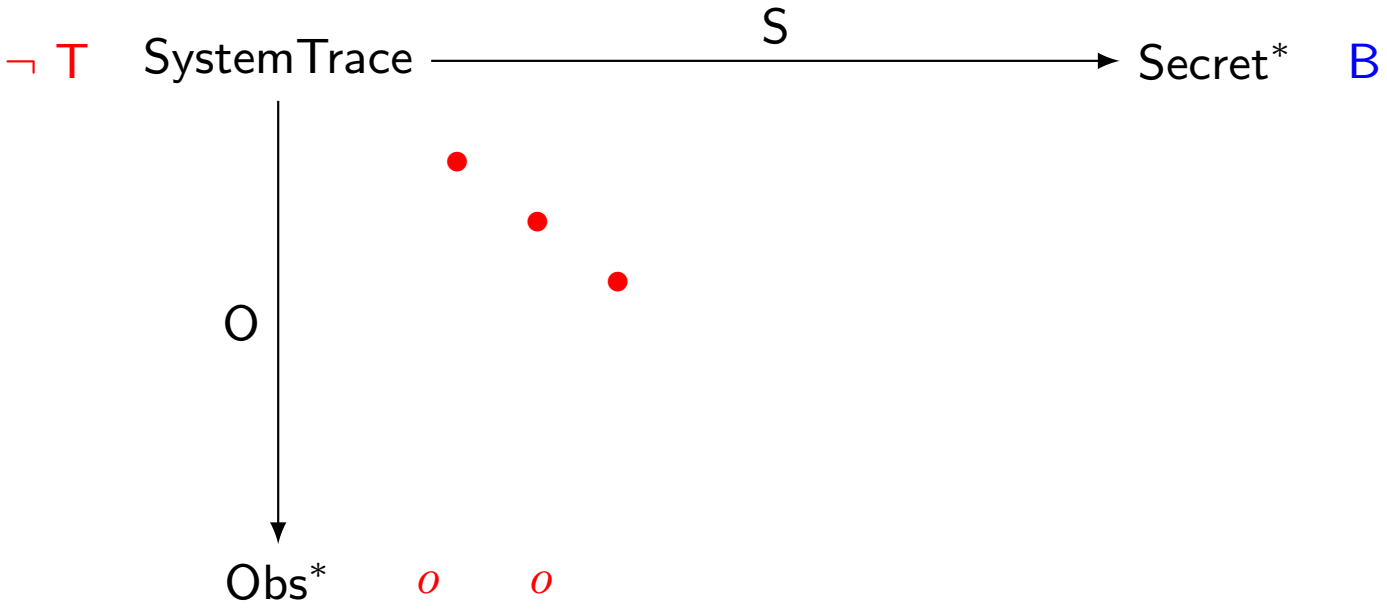

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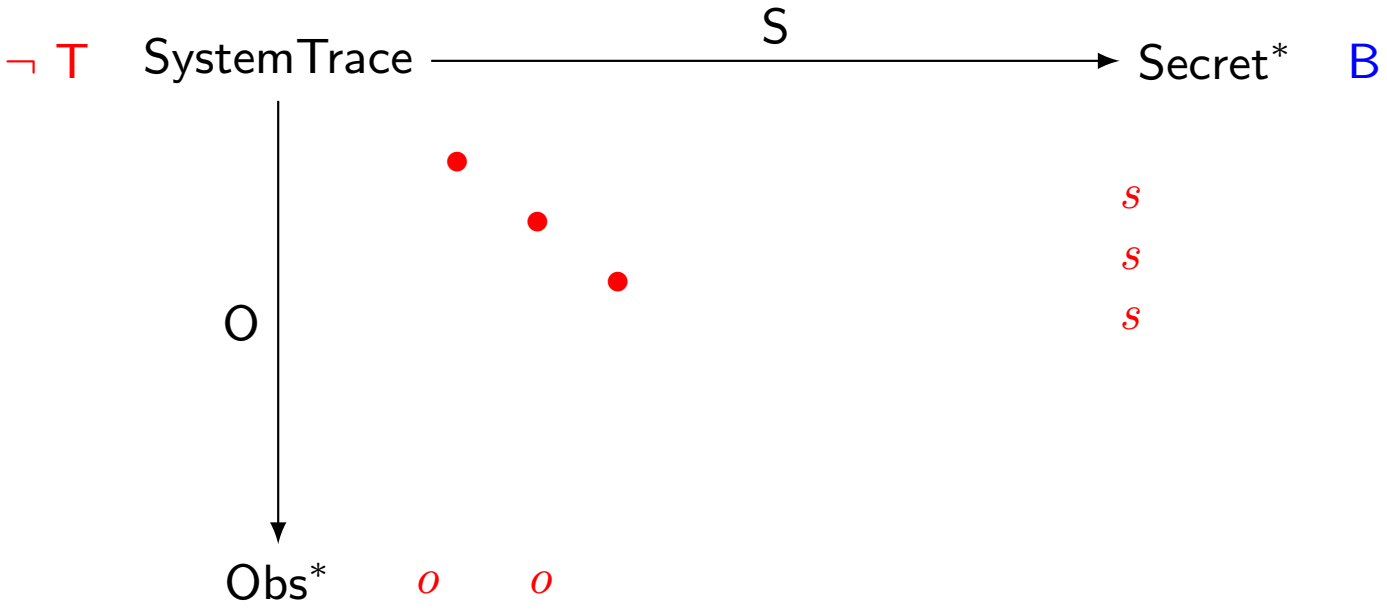

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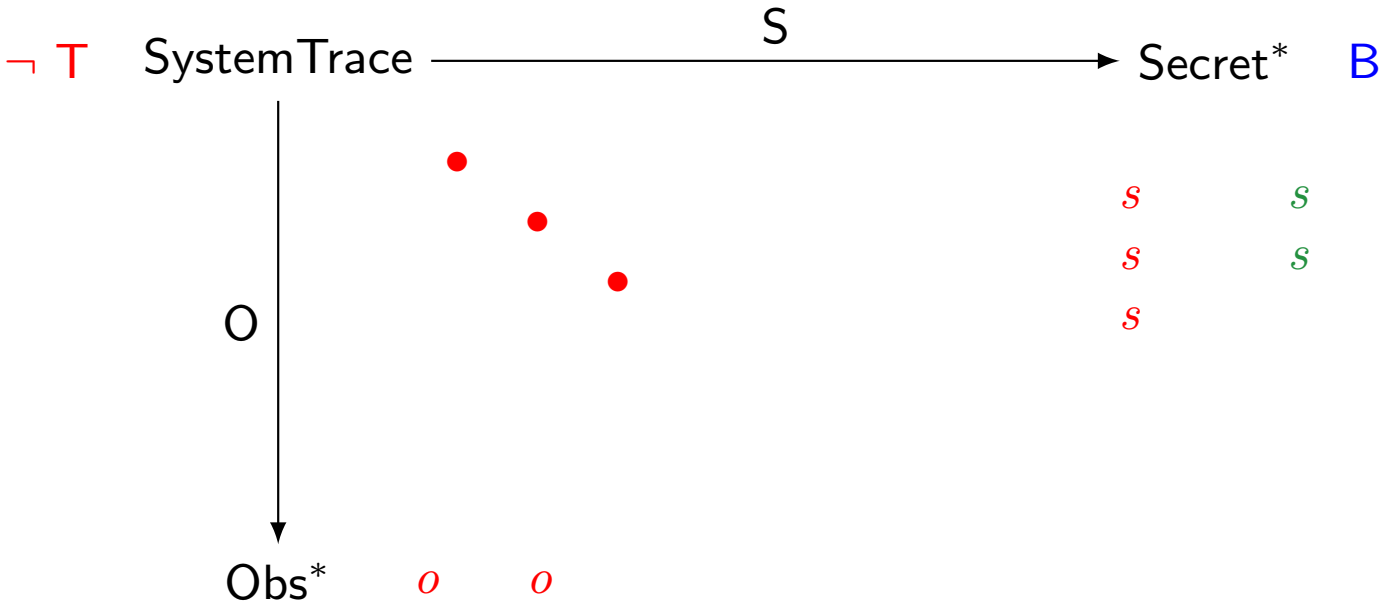

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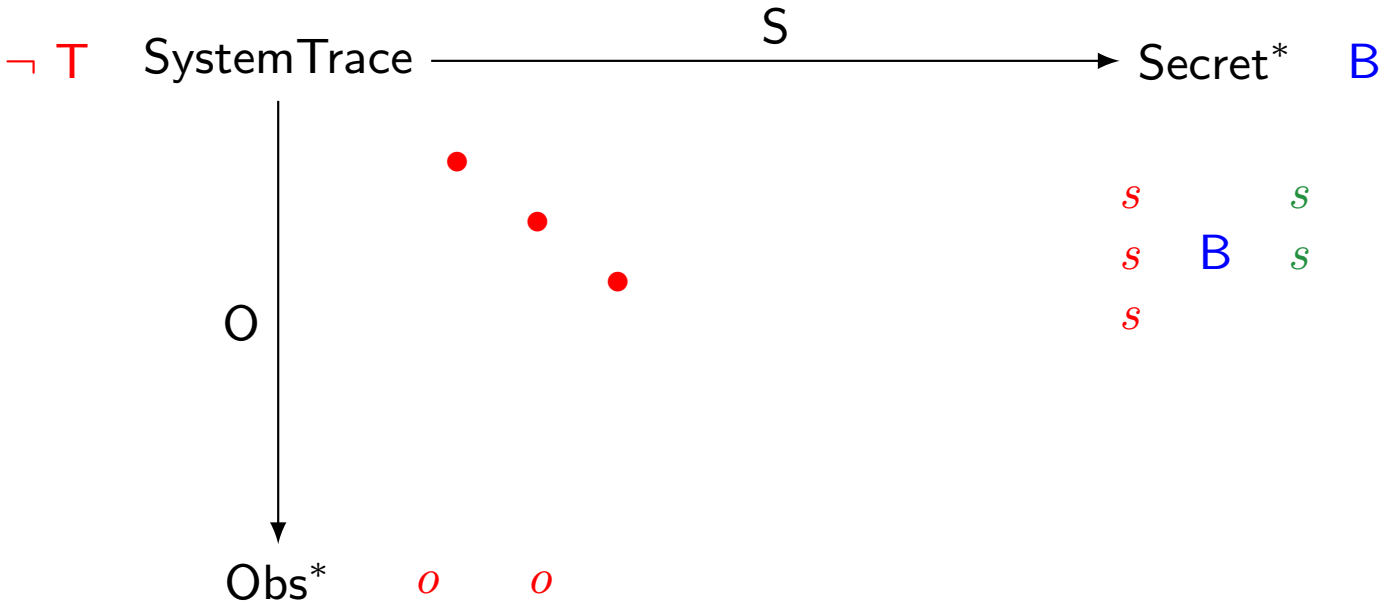

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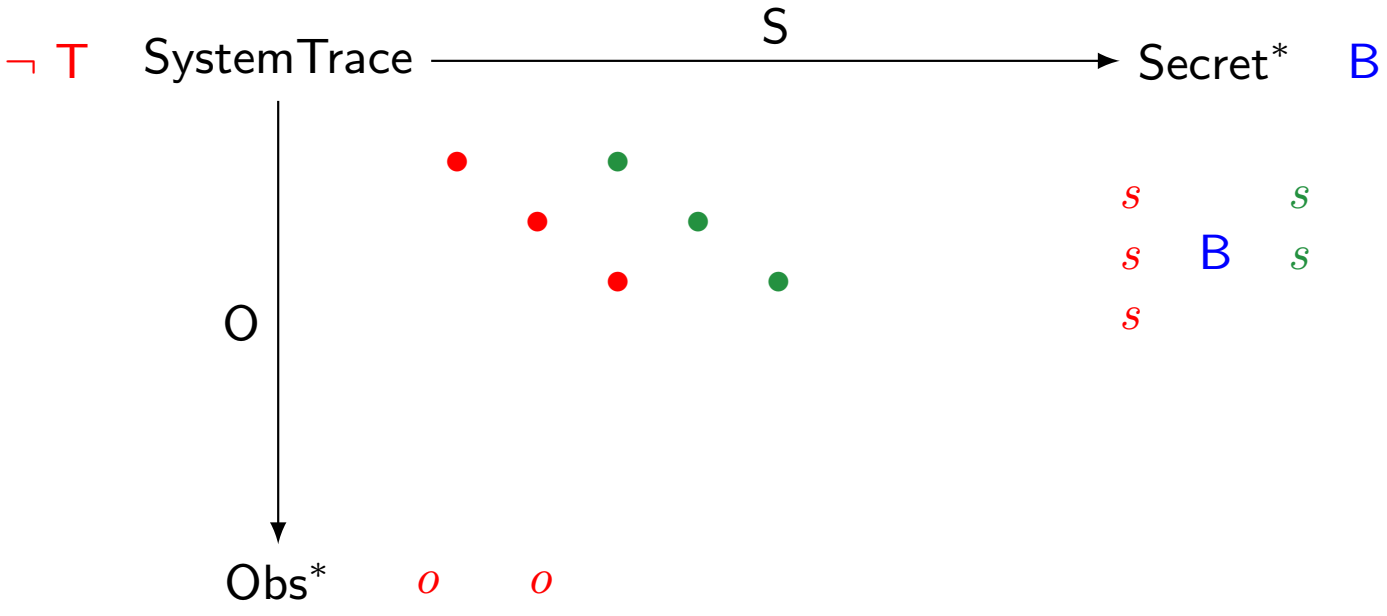

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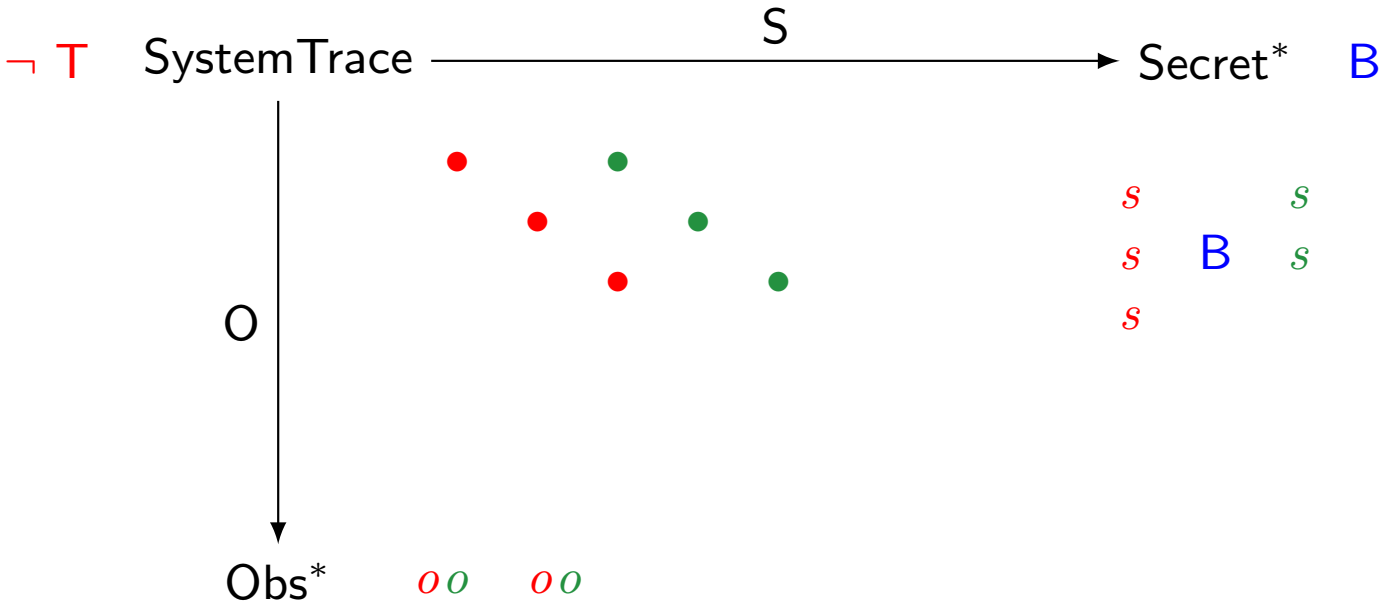
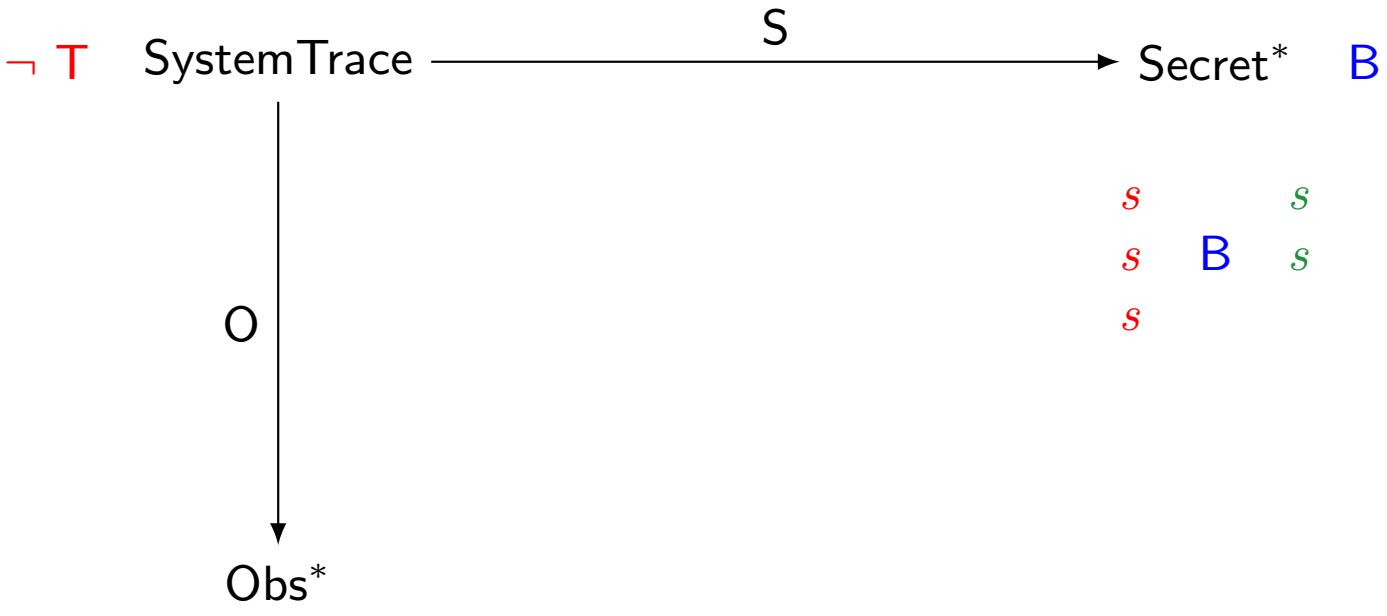


Bounded-Deducibility (BD) Security

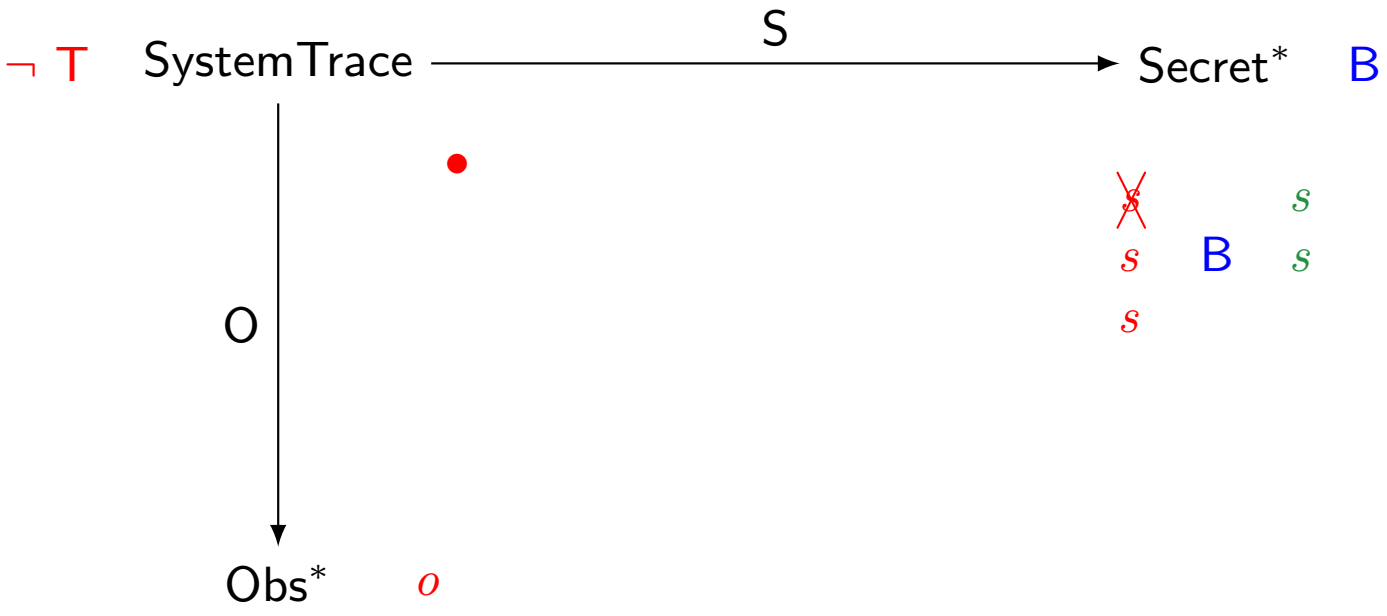
Proof by unwinding



Bounded-Deducibility (BD) Security

Proof by unwinding

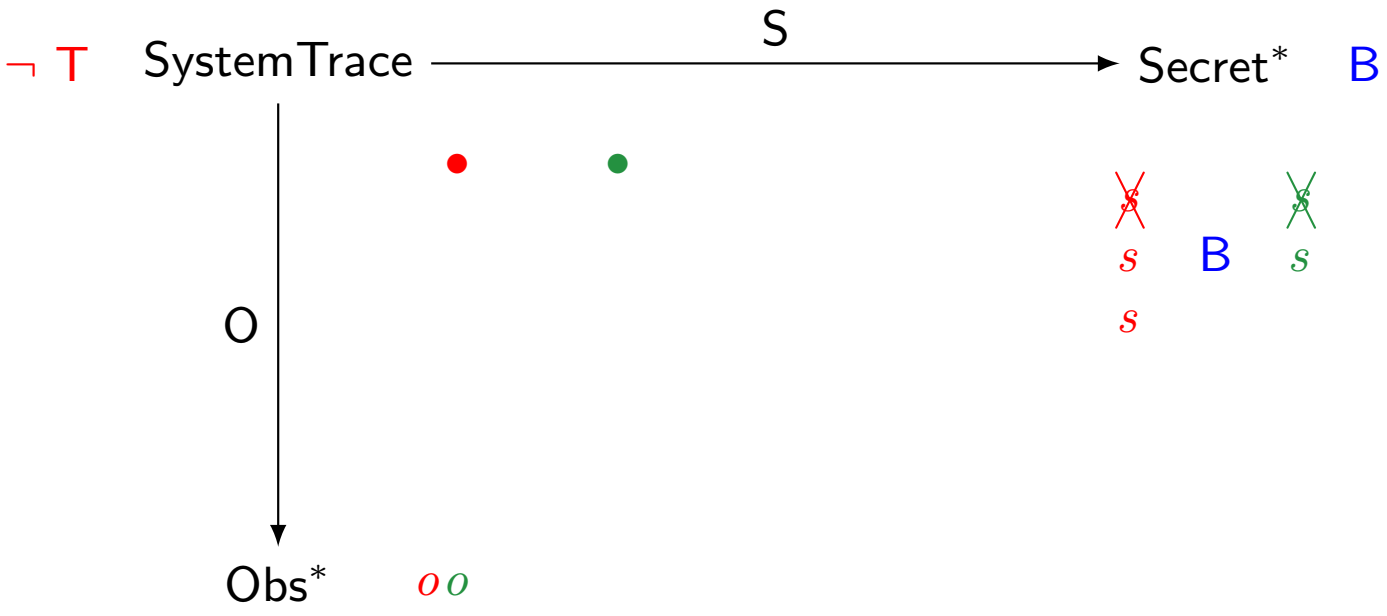
Action



Bounded-Deducibility (BD) Security

Proof by unwinding

Action / Reaction: Match



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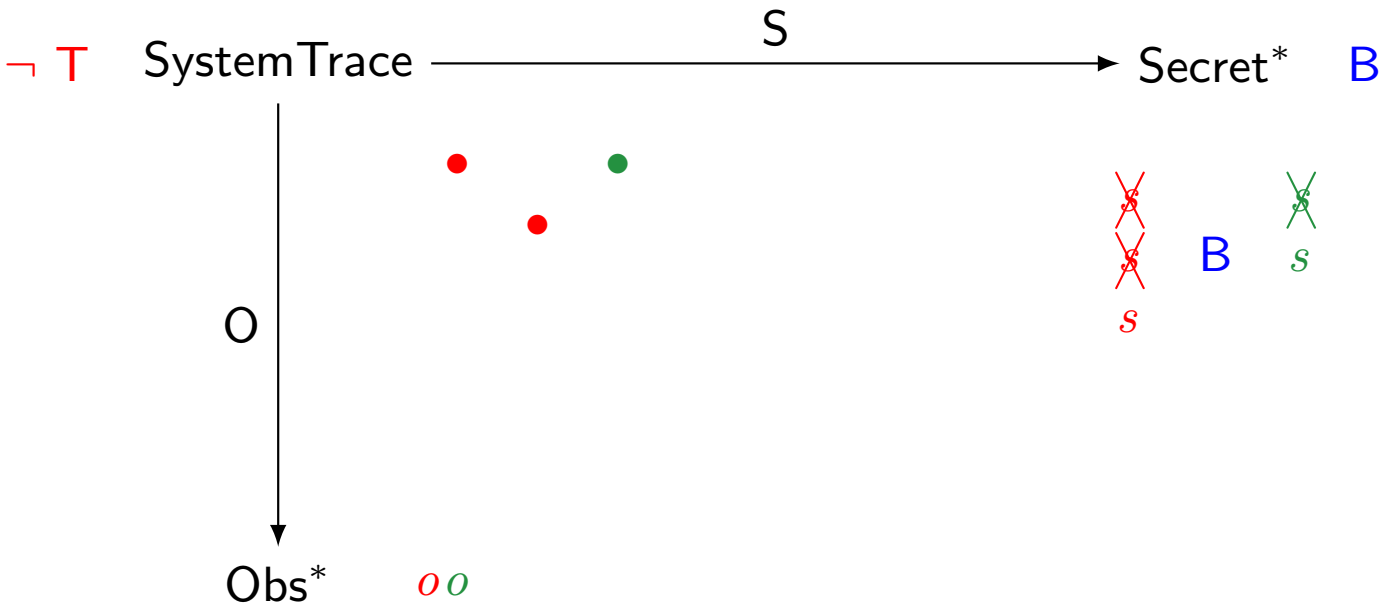
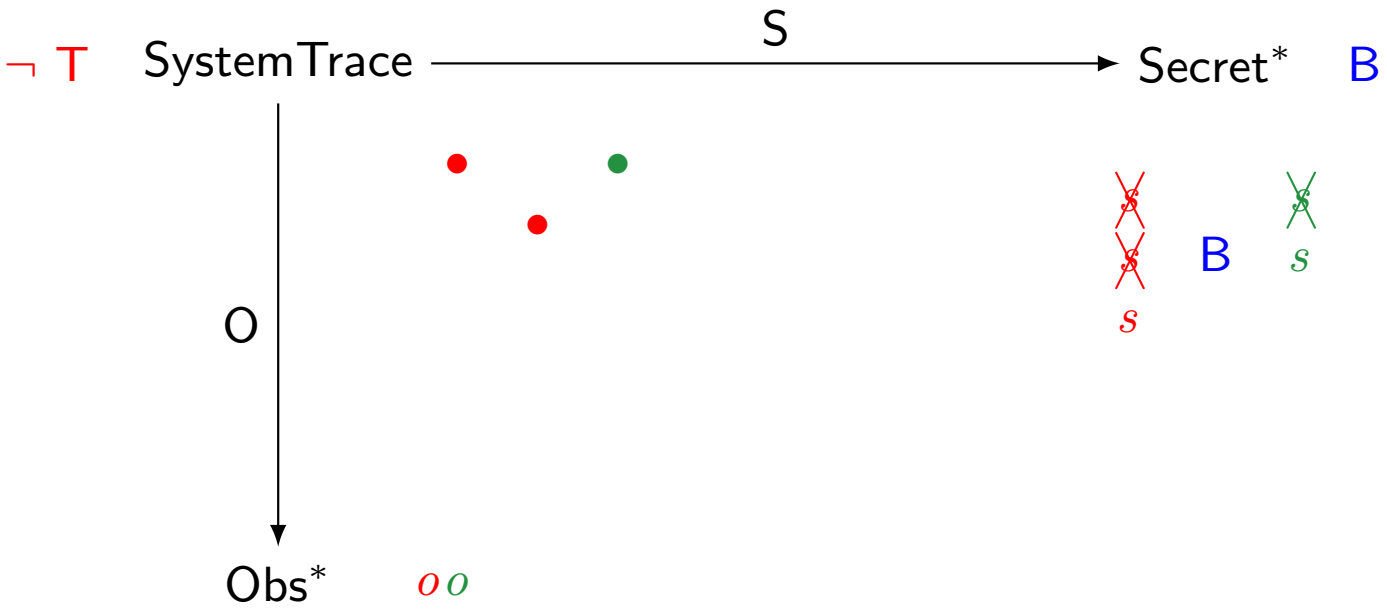


Bounded-Deducibility (BD) Security

Proof by unwinding

Action / Reaction: Ignore



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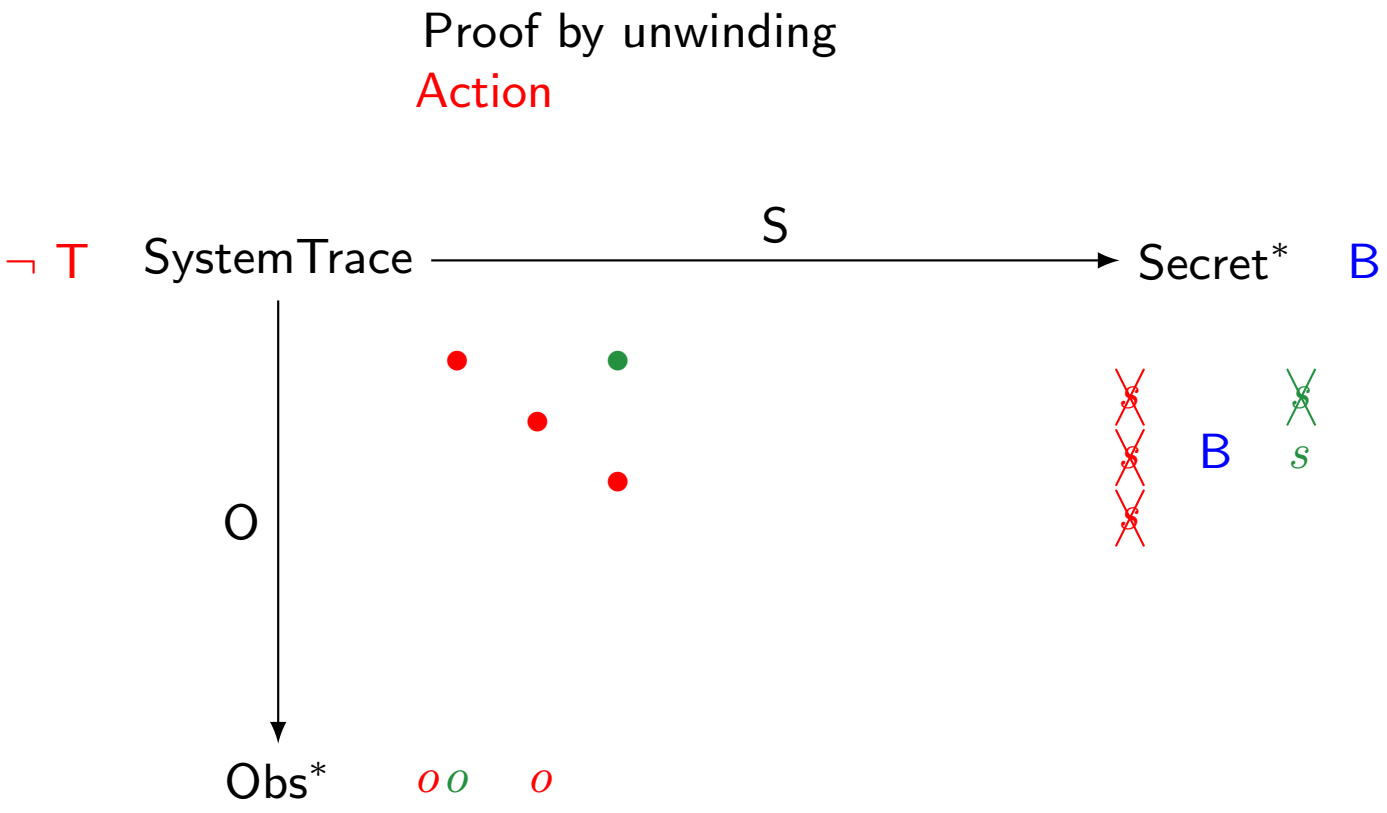

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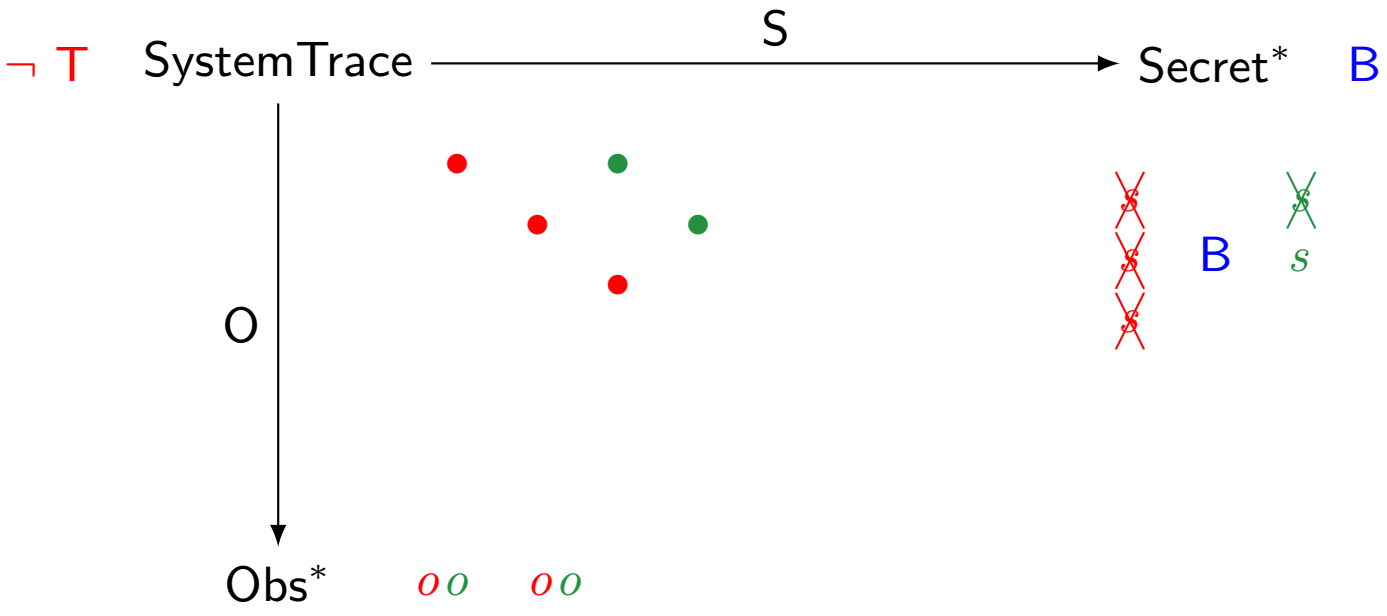
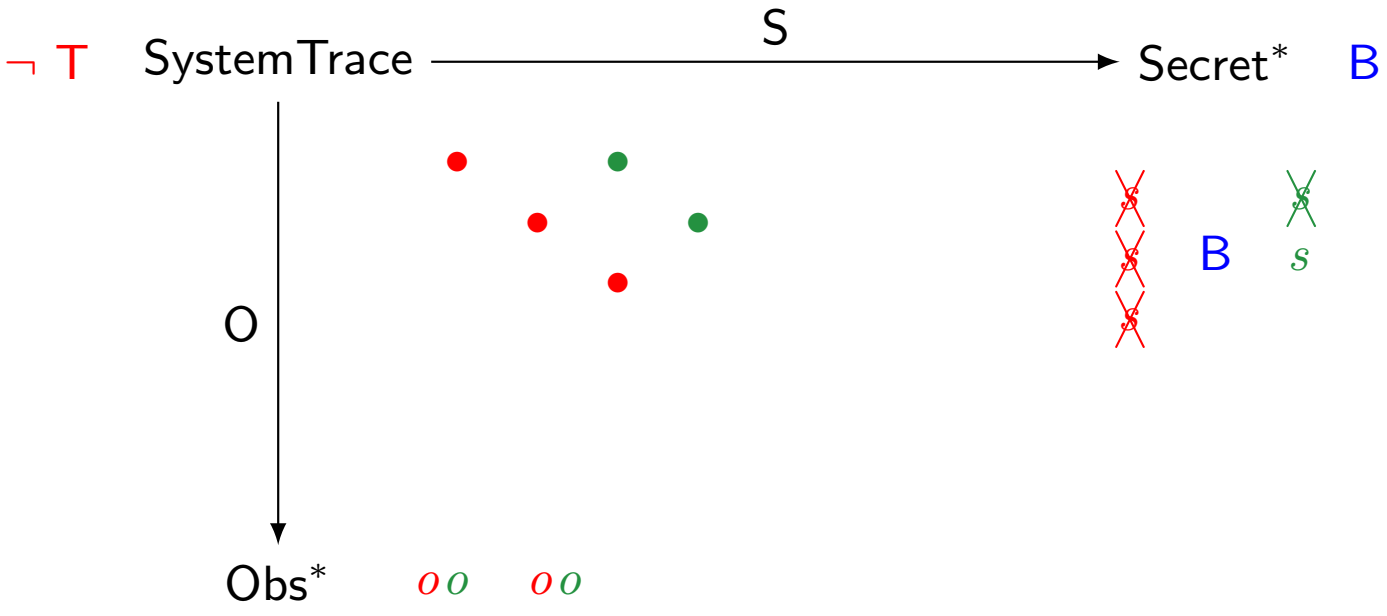
Action / Reaction: Match



Bounded-Deducibility (BD) Security

Proof by unwinding

Independent action ...



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Proof by unwinding

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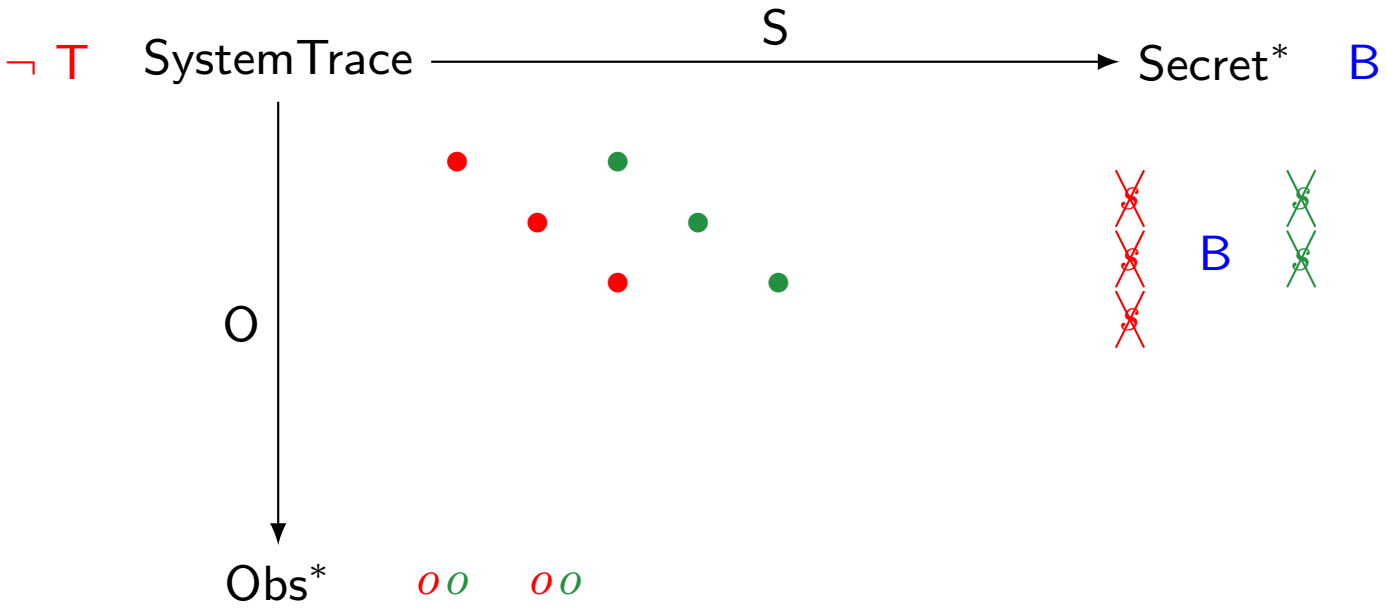
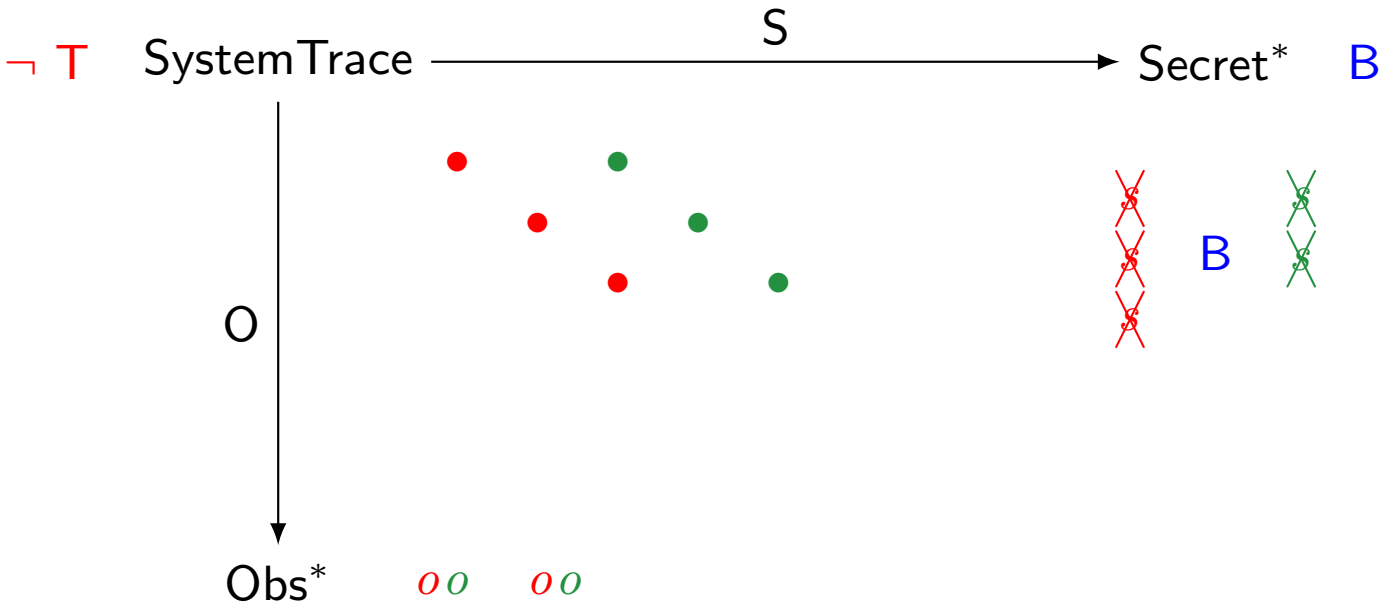


Bounded-Deducibility (BD) Security

Proof by unwinding ✓

Independent action



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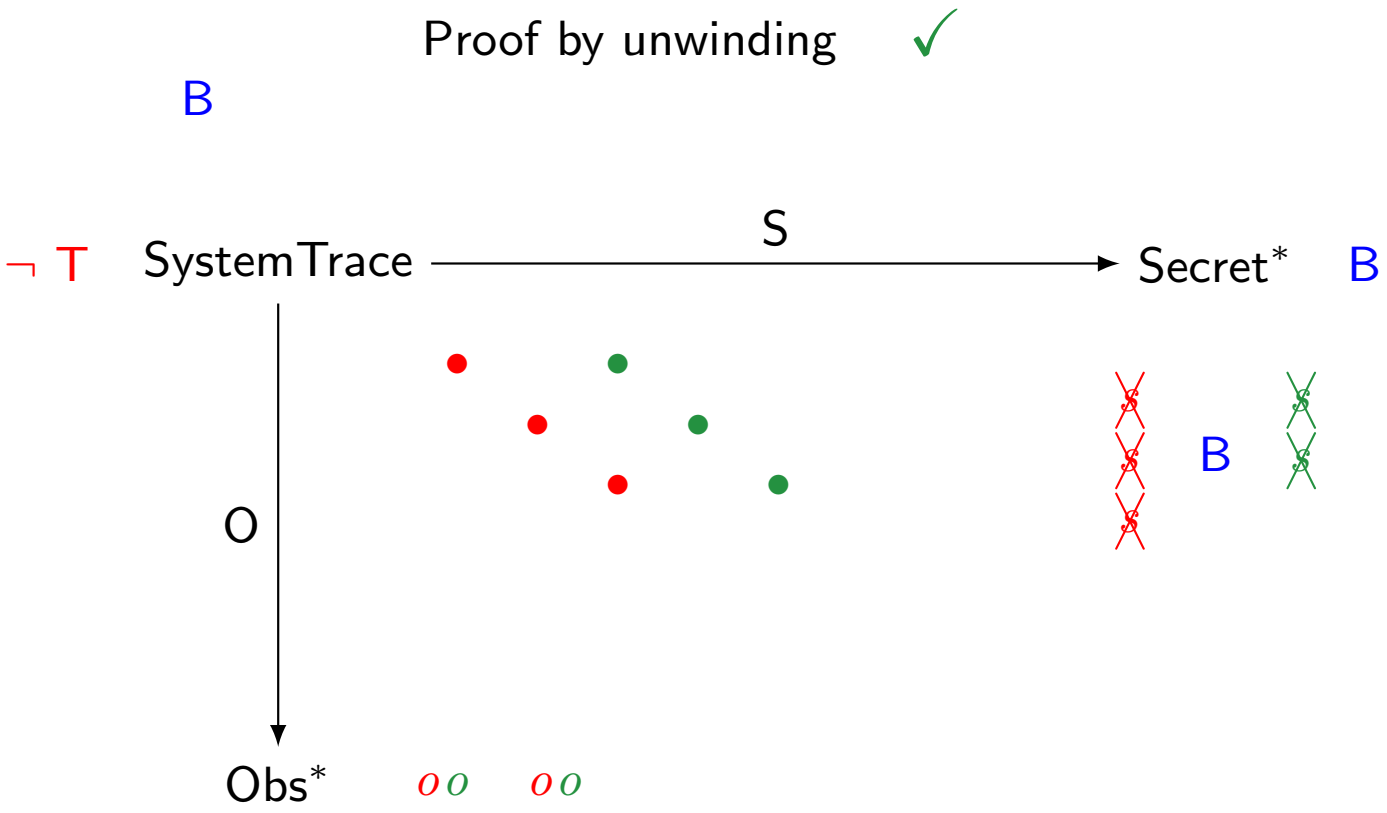

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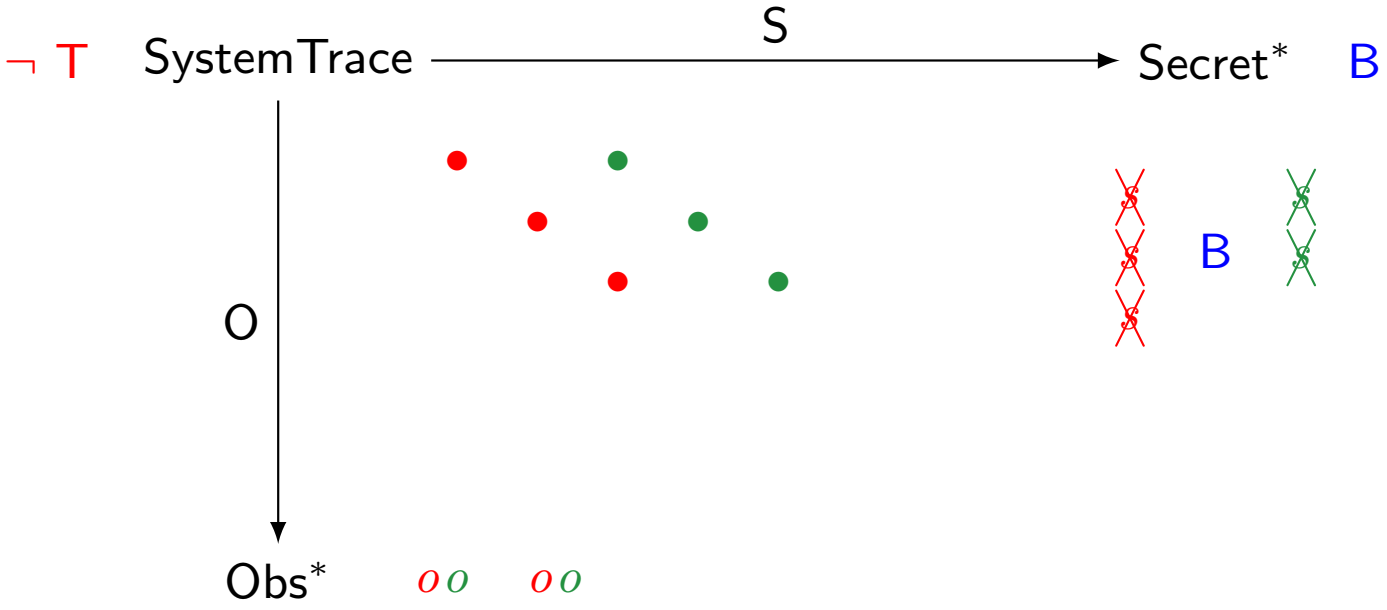
$$B \mapsto \Delta \subseteq \mathsf{State} \times \mathsf{Secret}^* \times \mathsf{State} \times \mathsf{Secret}^*$$



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$+$

Strategy for:

- when to act independently
- when to react
- if react: when to match and when to ignore

Source	Trigger	Bound
Paper Content	Paper Authorship	Last Uploaded Version
	Paper Authorship or PC Membership^{B}	Nothing
Review	Review Authorship	Last Edited Version Before Discussion and All the Later Versions
	Review Authorship or Non-Conflict PC Membership^{D}	Last Edited Version Before Notification
	Review Authorship or Non-Conflict PC Membership^{D} or PC Membership^{N} or Paper Authorship^{N}	Nothing
Discussion	Non-Conflict PC Membership	Nothing
Decision	Non-Conflict PC Membership	Last Edited Version
	Non-Conflict PC Membership or PC Membership^{N} or Paper Authorship^{N}	Nothing
Reviewer Assignment to Paper	Non-Conflict PC Membership^{R}	Non-Conflict PC Membership of Reviewers

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Overall Verification Effort

BD Security Framework: 1000 LOC

Confidentiality properties: 5000 LOC

Safety verification: 1000 LOC

Accountability: 700 LOC

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(1) + (2) $\longrightarrow$ Authors never learn such and such

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Confidentiality + Safety + Accountability $\Longrightarrow$ Relax

Summary of Verification

- Generic parameterized security notion
- Associated unwinding proof method
- Instantiated to reason about CoCon's confidentiality:

  What, when, by whom
  can be learned about
  the documents in the system
  (papers, reviews, discussions, reviewer assignment)

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Kanav, Lammich, Popescu. A conference management system with verified document confidentiality. CAV 2014

"The authors cunningly chose a topic that directly speaks to the reviewers of their paper."

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And practical considerations about CoCon keep bringing new theoretical challenges...

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Our answer: No, but we apologize for the confusing behavior.

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If PC member is also author, can see content but not score
Previous confusion caused by "unknown" treated as 0

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To avoid this: To gather data for a notification to a user, only employ sequences of actions permitted to that user.

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Given a confidentiality-verified system

Extend the system

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Summary: old action invocation + some output filtering

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System nondeterministically produces secret bit $i \in \{0, 1\}$.
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Then secret i is revealed.

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Why? And can we give the answer for a general class of systems?

Borrowing BD Security in an Ideal World

$$
\begin{tikzcd}
\mathsf{Obs}'^{*} \arrow[r, "\rho"] & \mathsf{Obs}^{*} \\
\mathsf{SystemTrace}' \arrow[u, "\mathsf{o}'"] \arrow[r, "\pi"] \arrow[dr, "\mathsf{s}'"'] & \mathsf{SystemTrace} \arrow[u, "\mathsf{o}"'] \arrow[d, "\mathsf{s}"] \\
& \mathsf{Secret}^{*}
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$$

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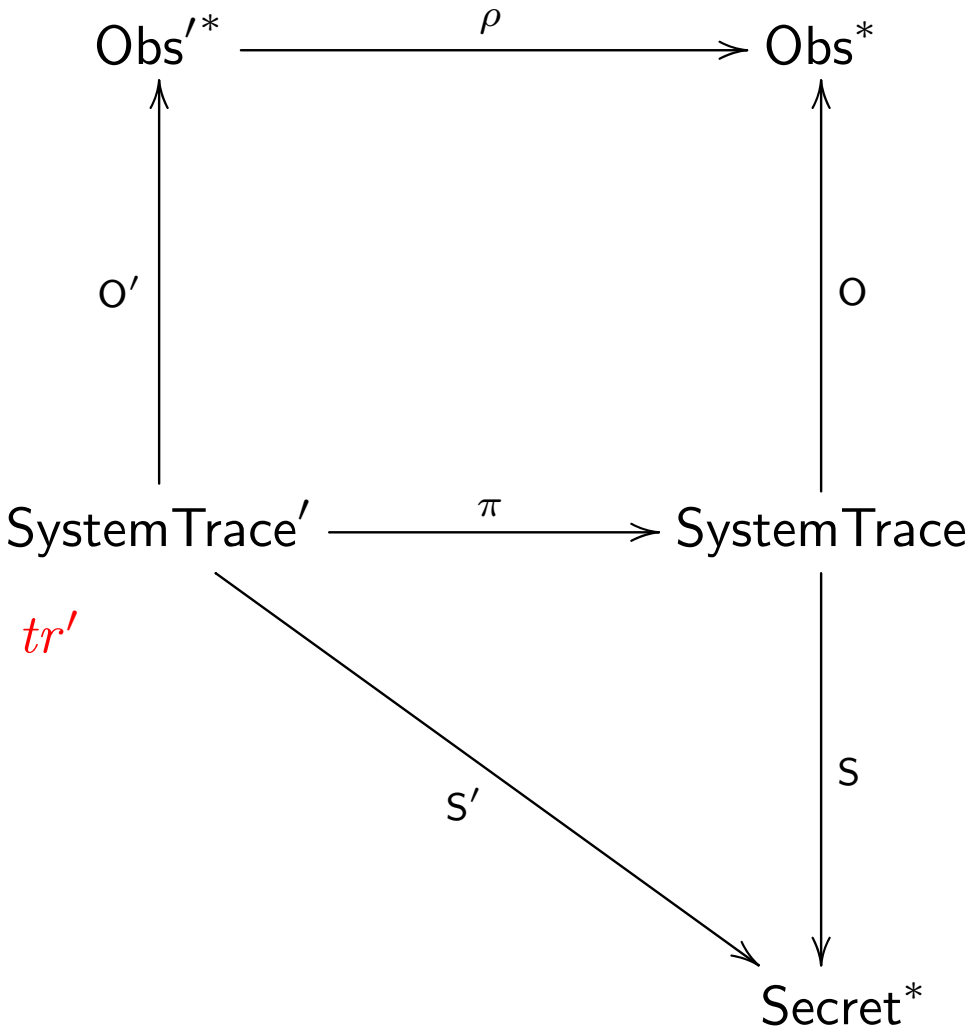

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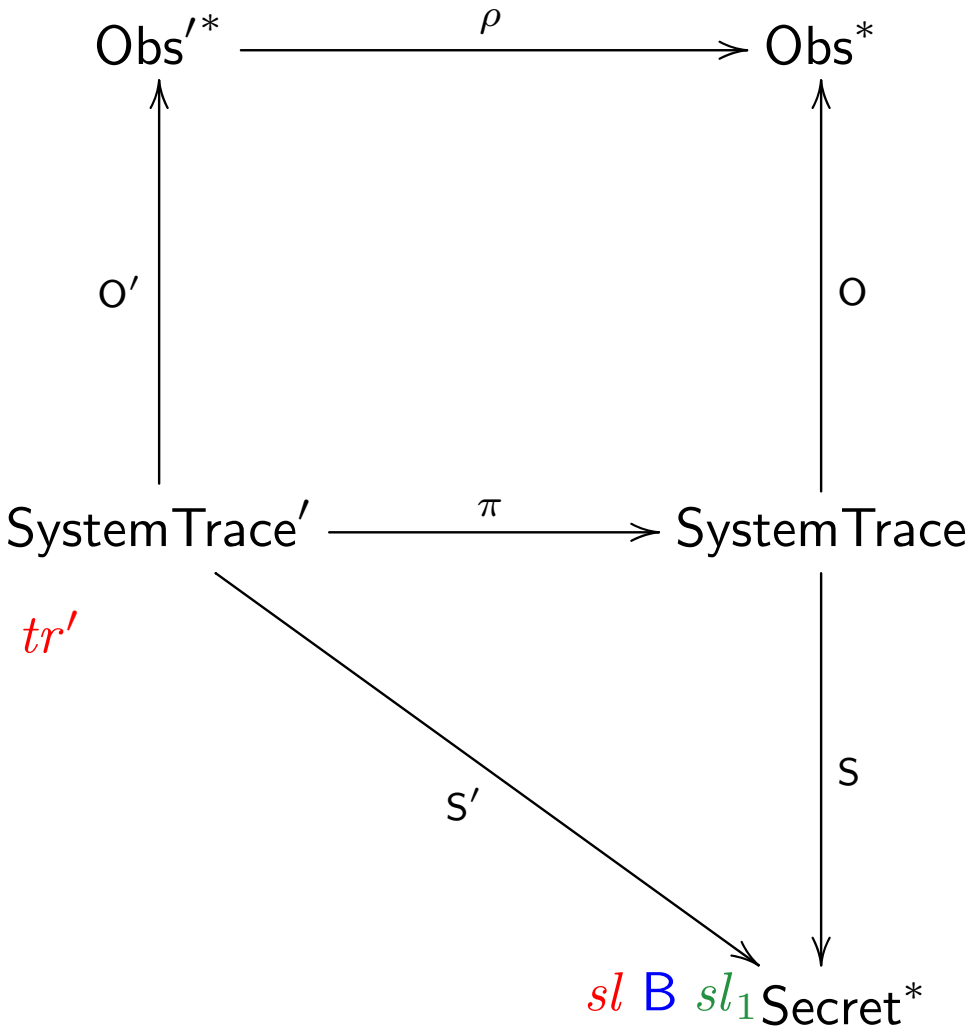

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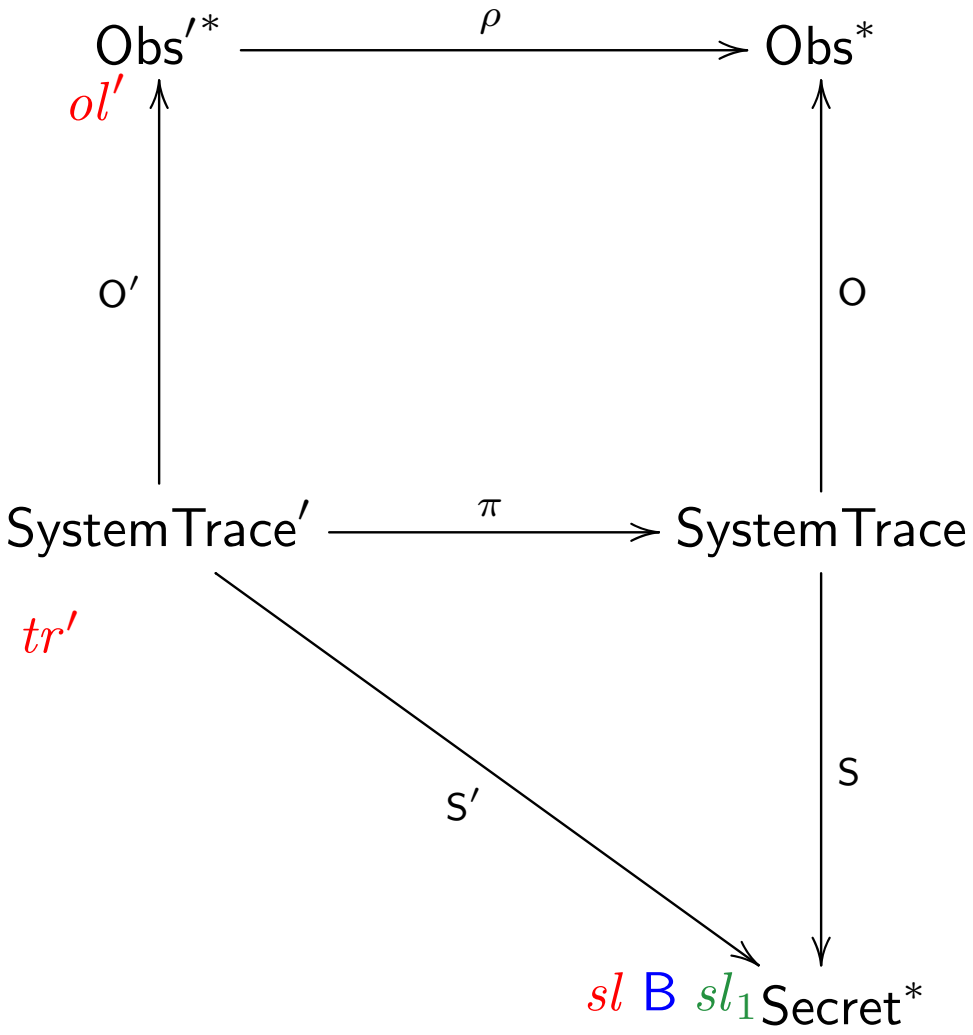

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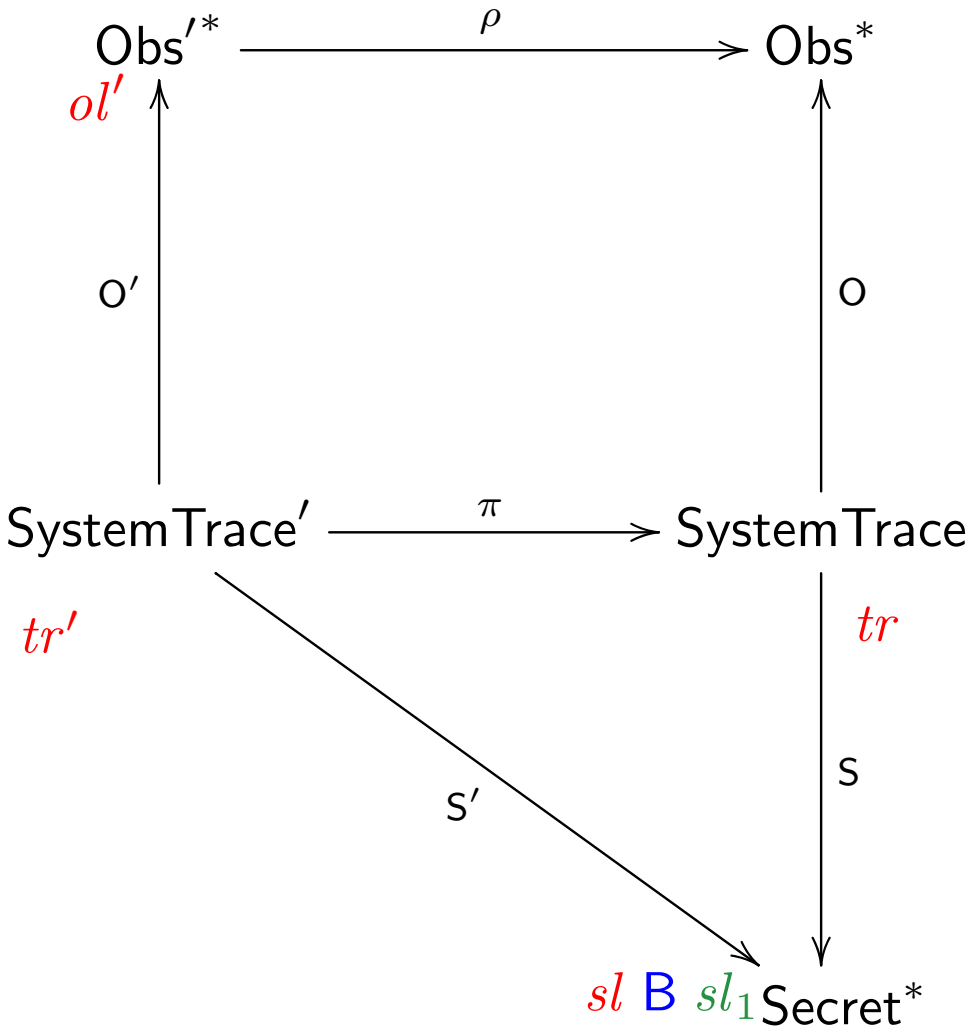

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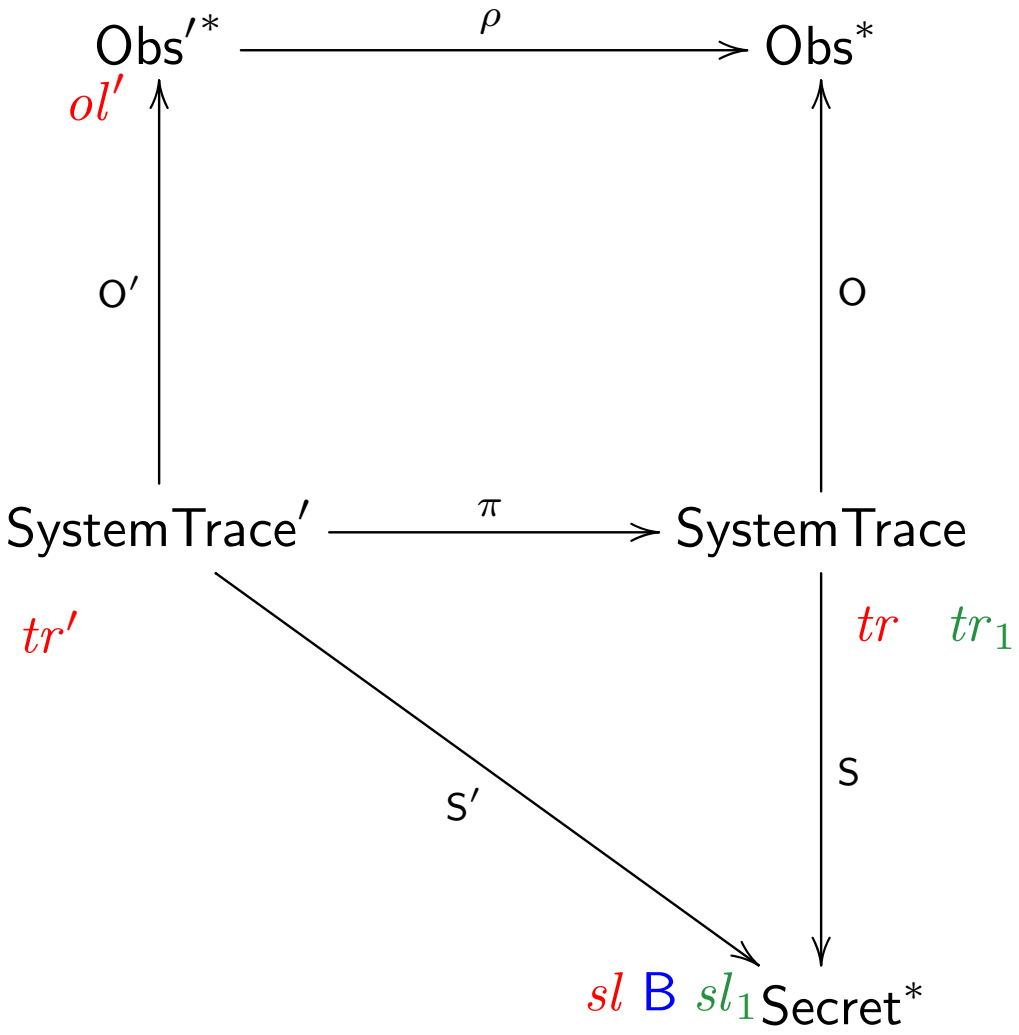

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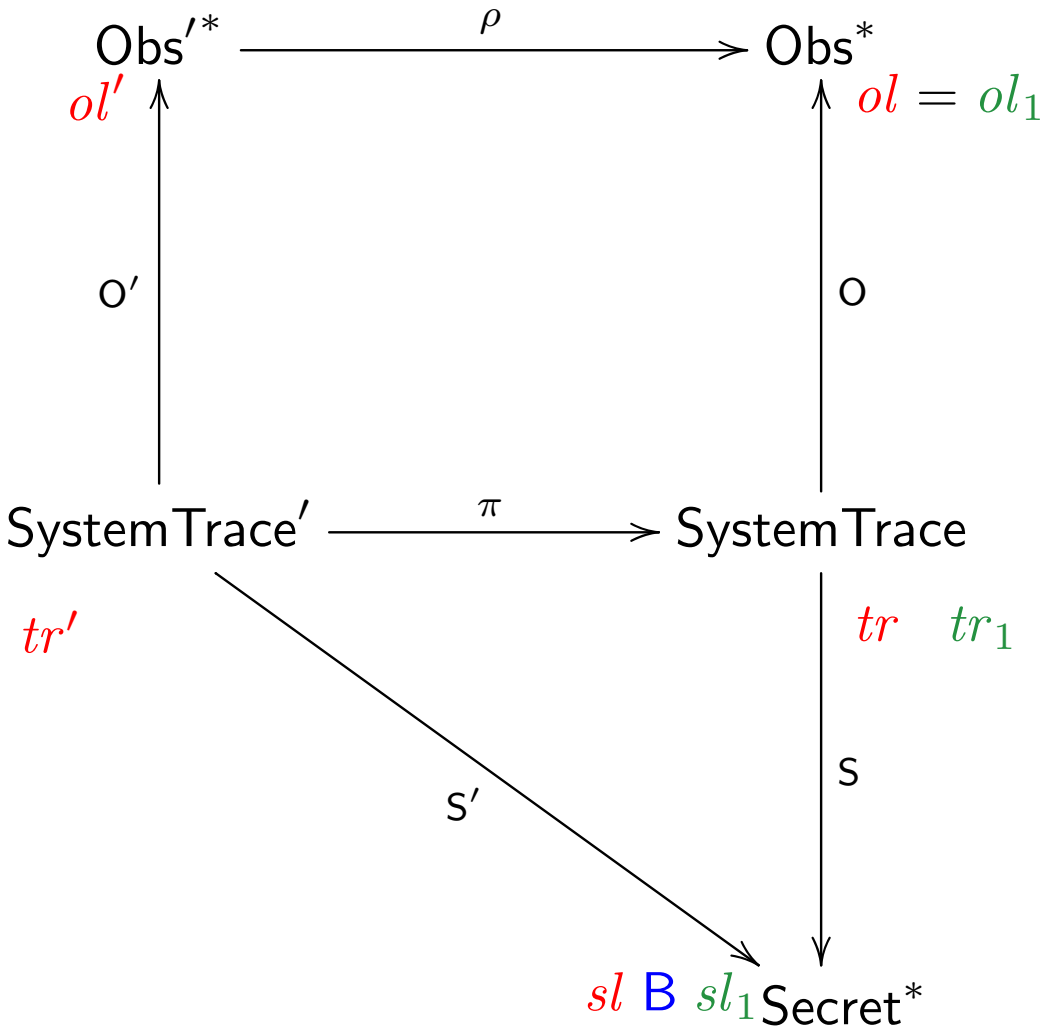

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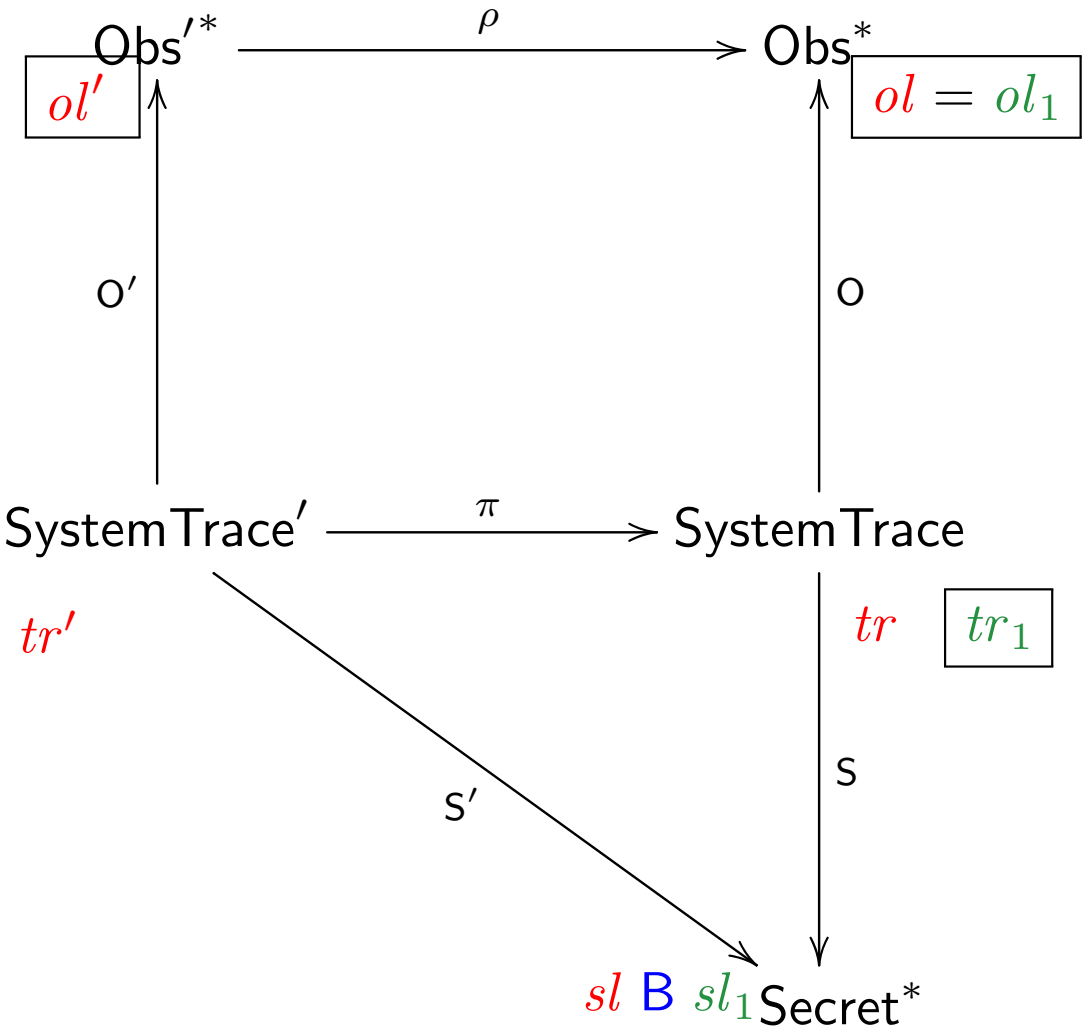

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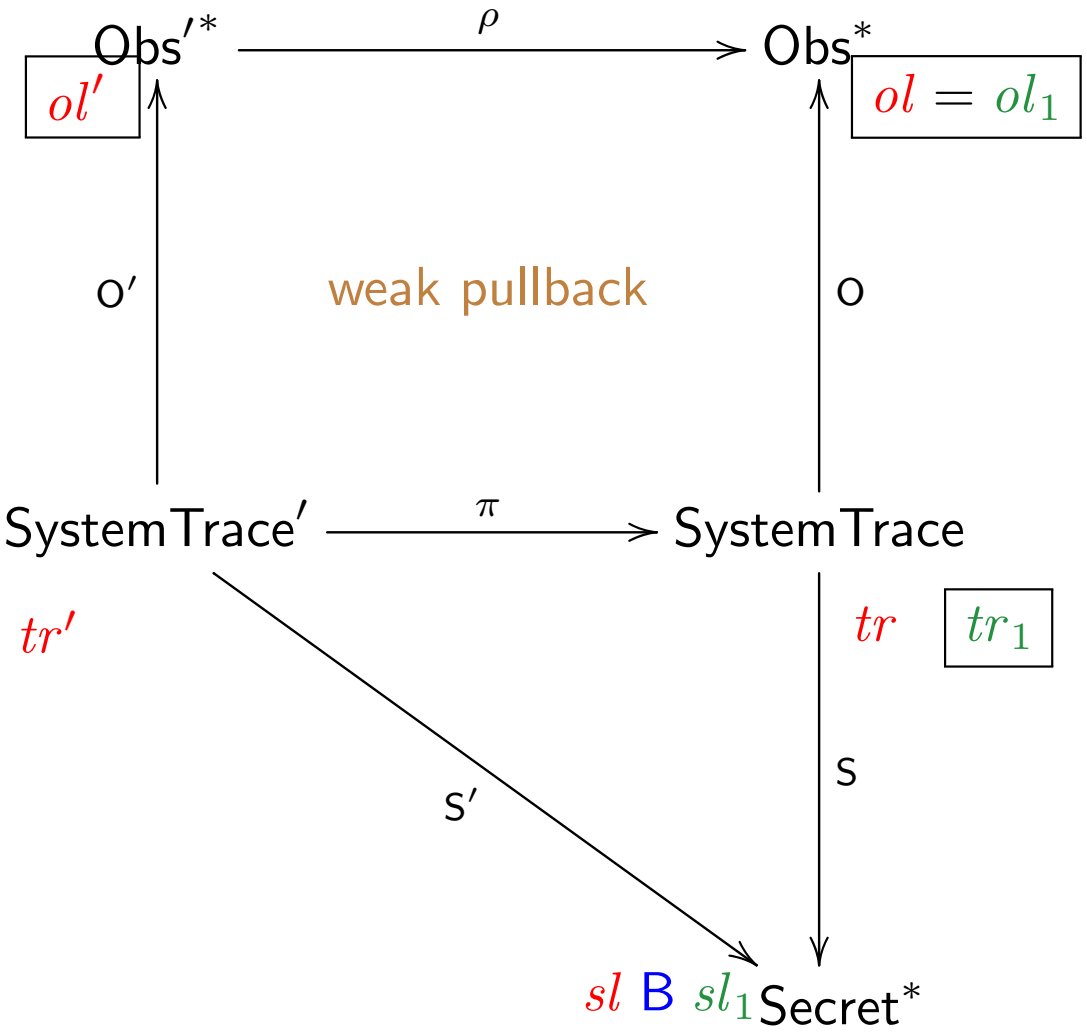

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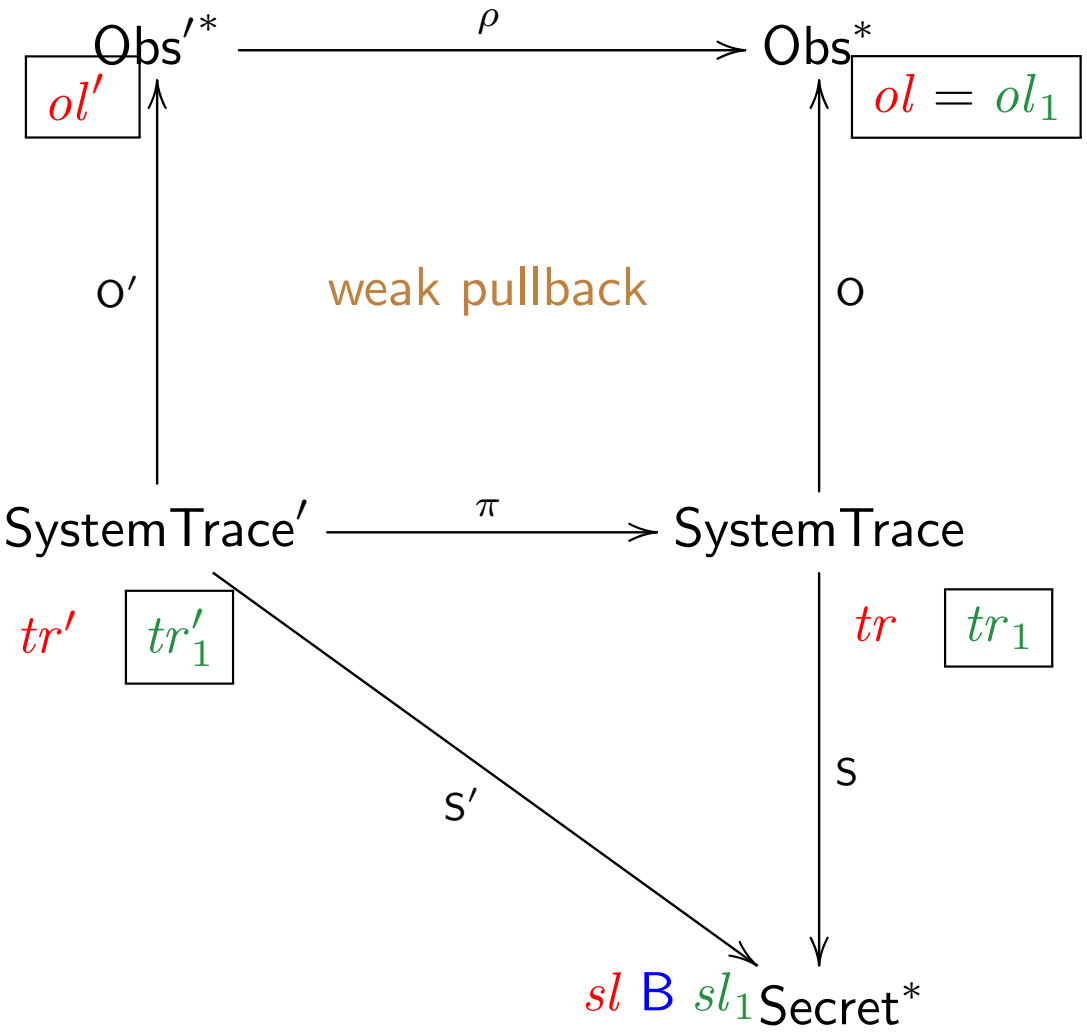

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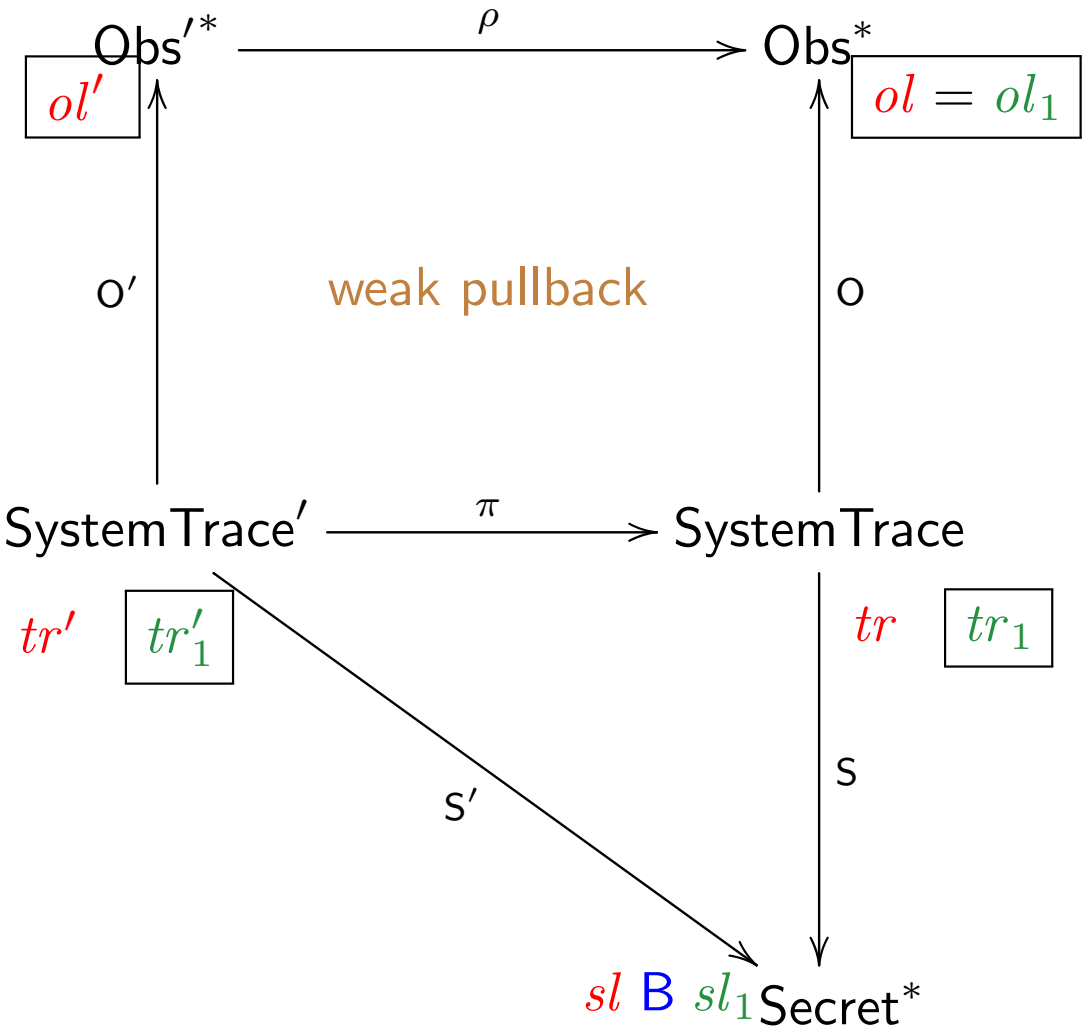

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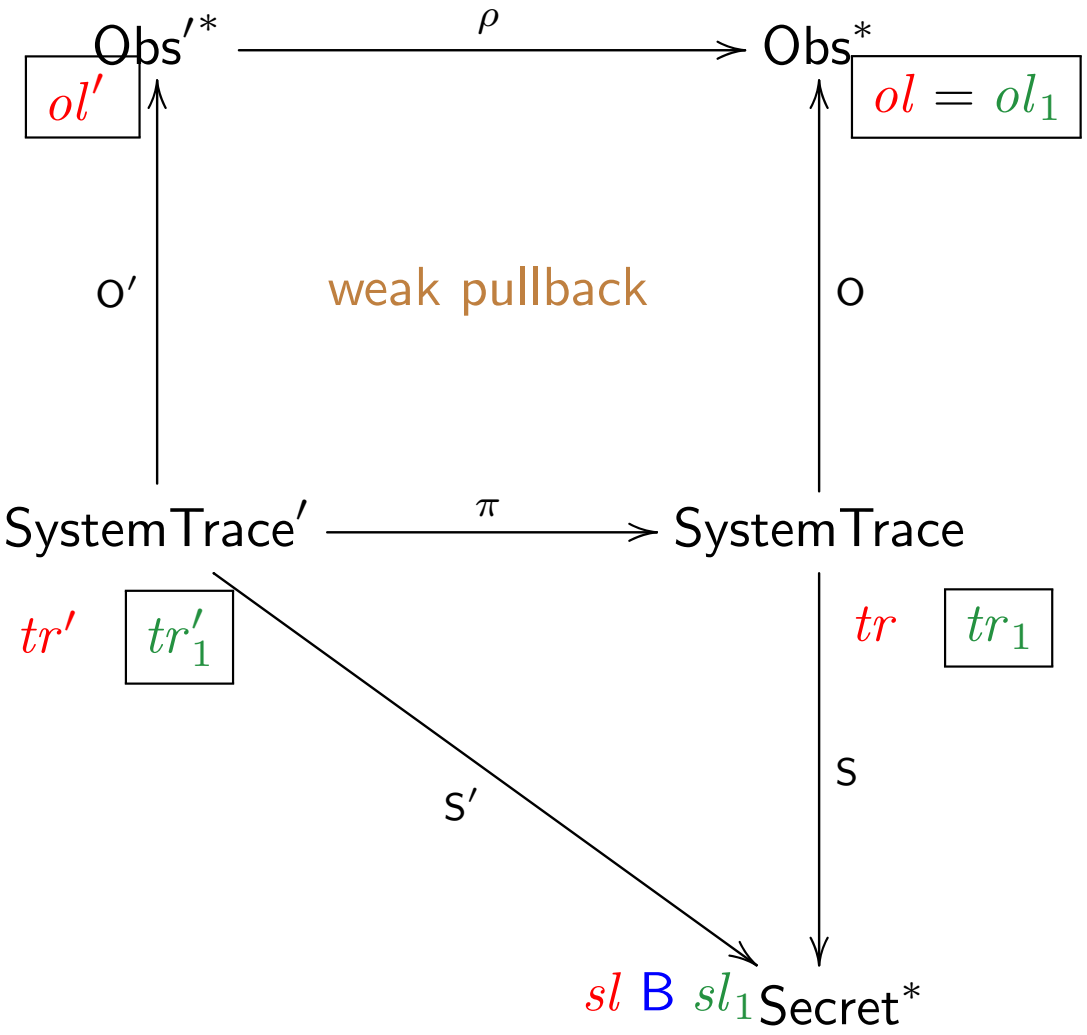

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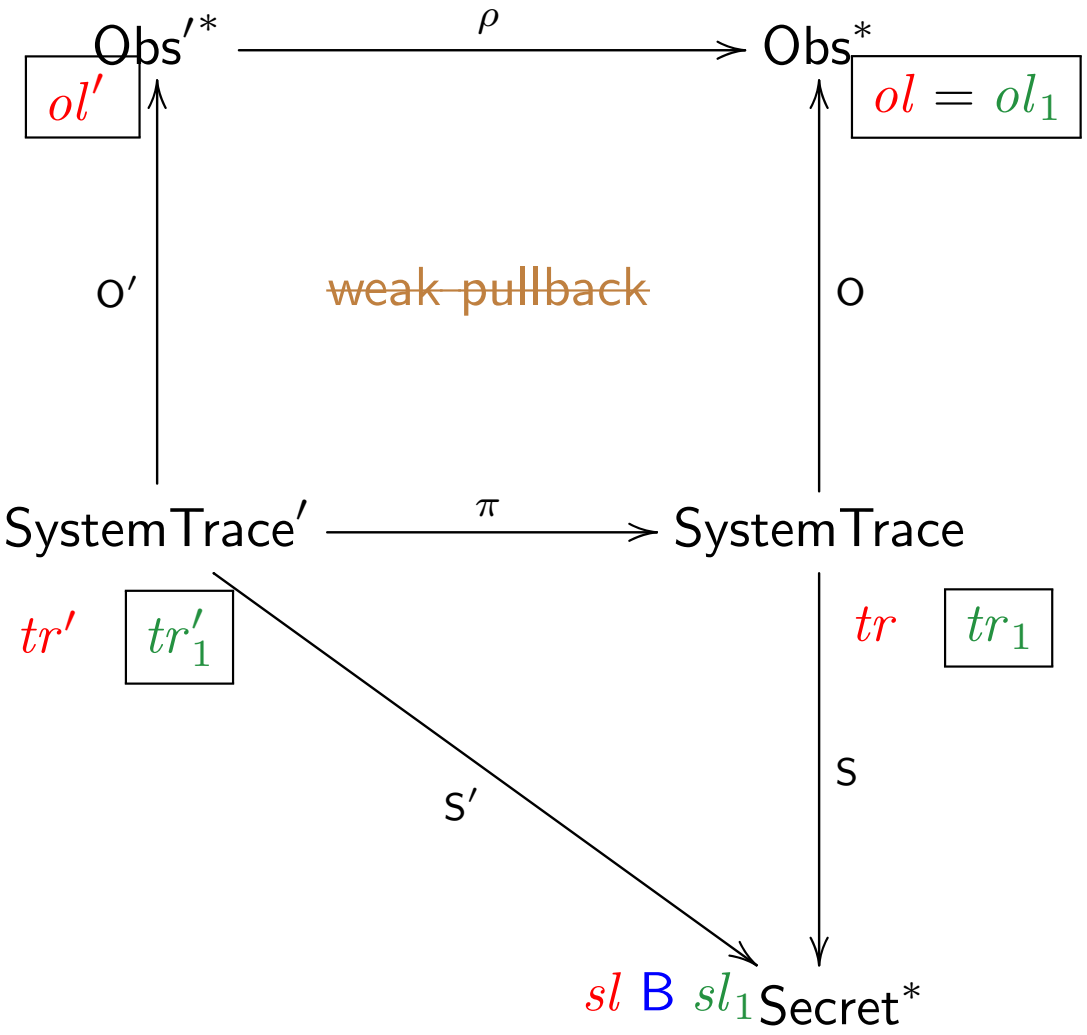

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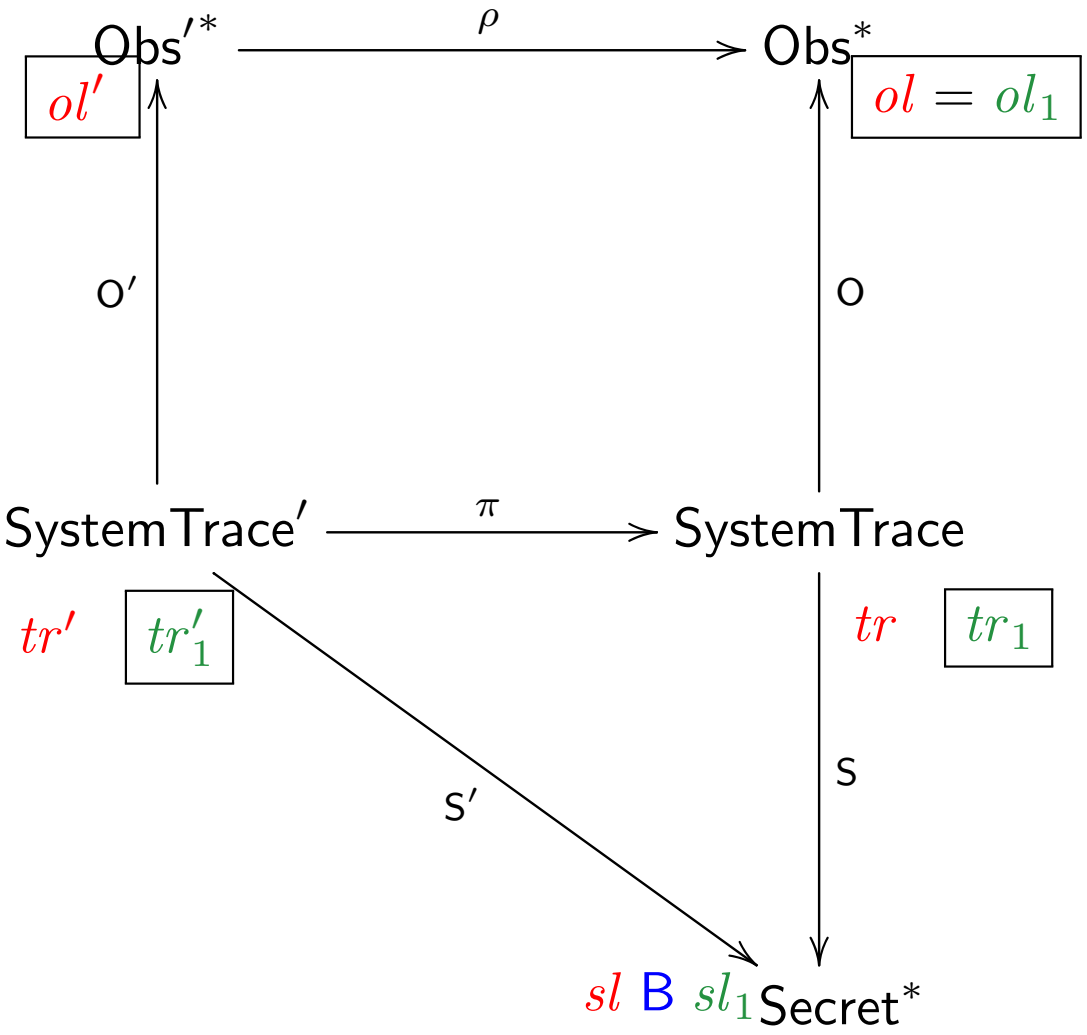

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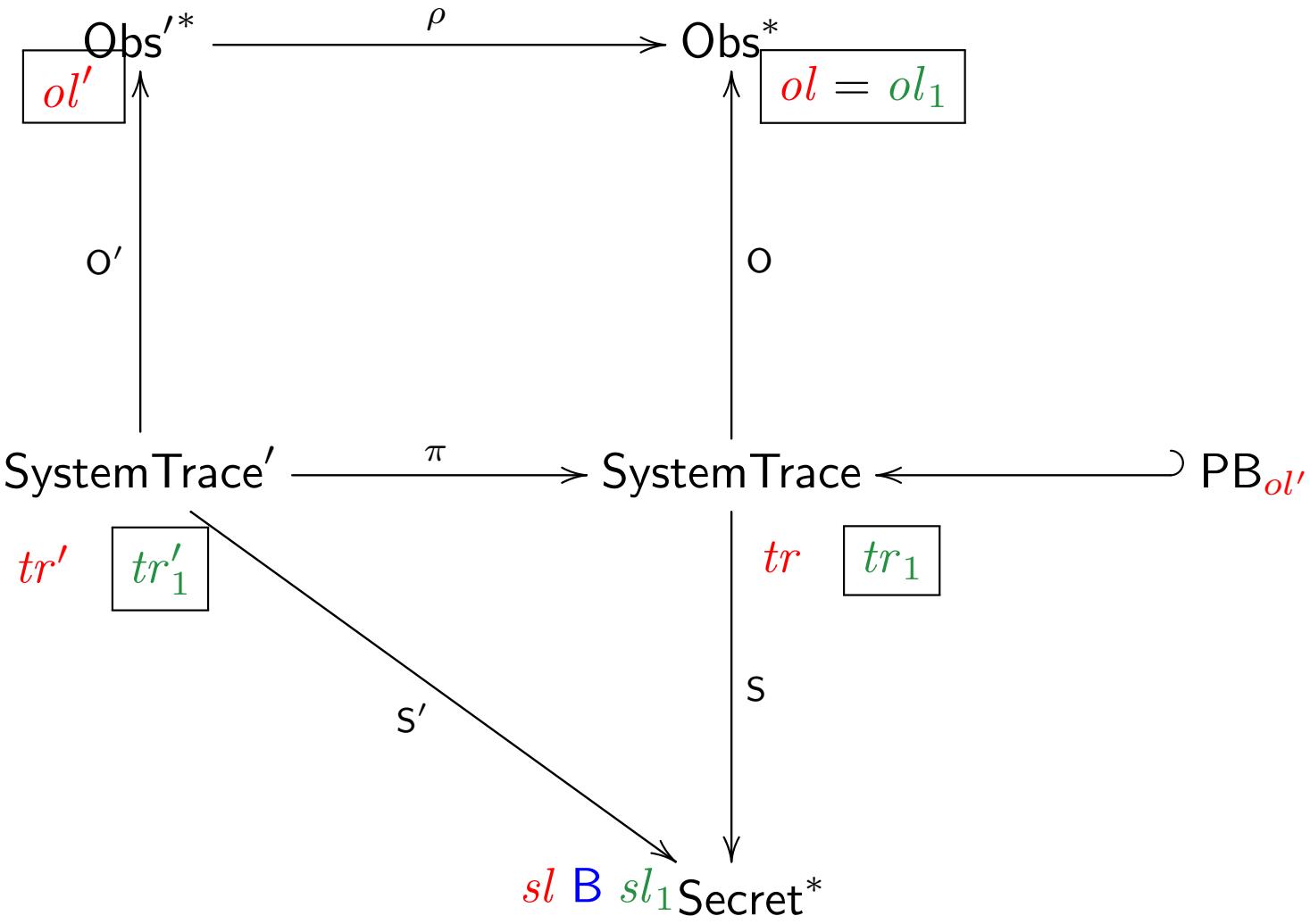

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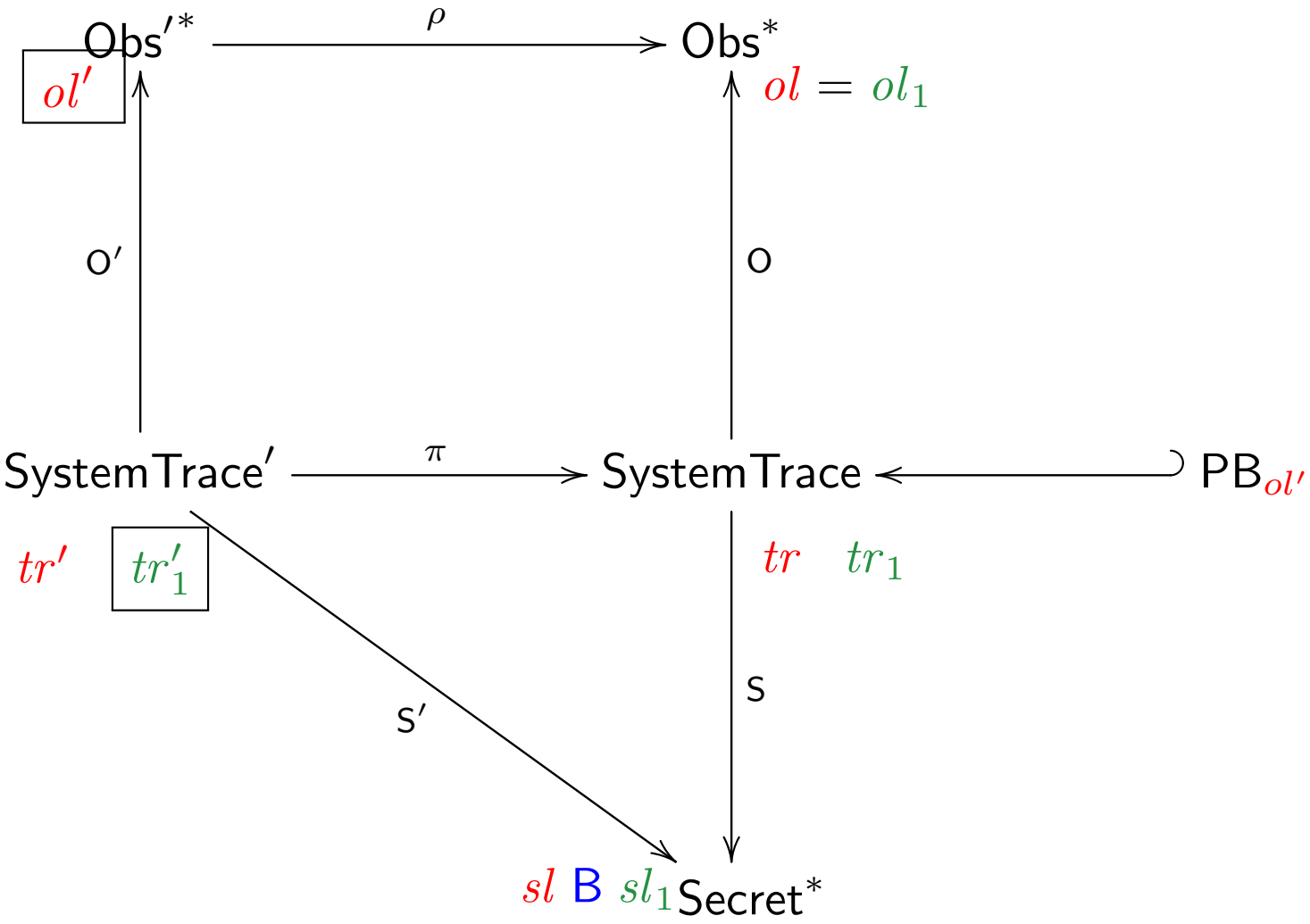

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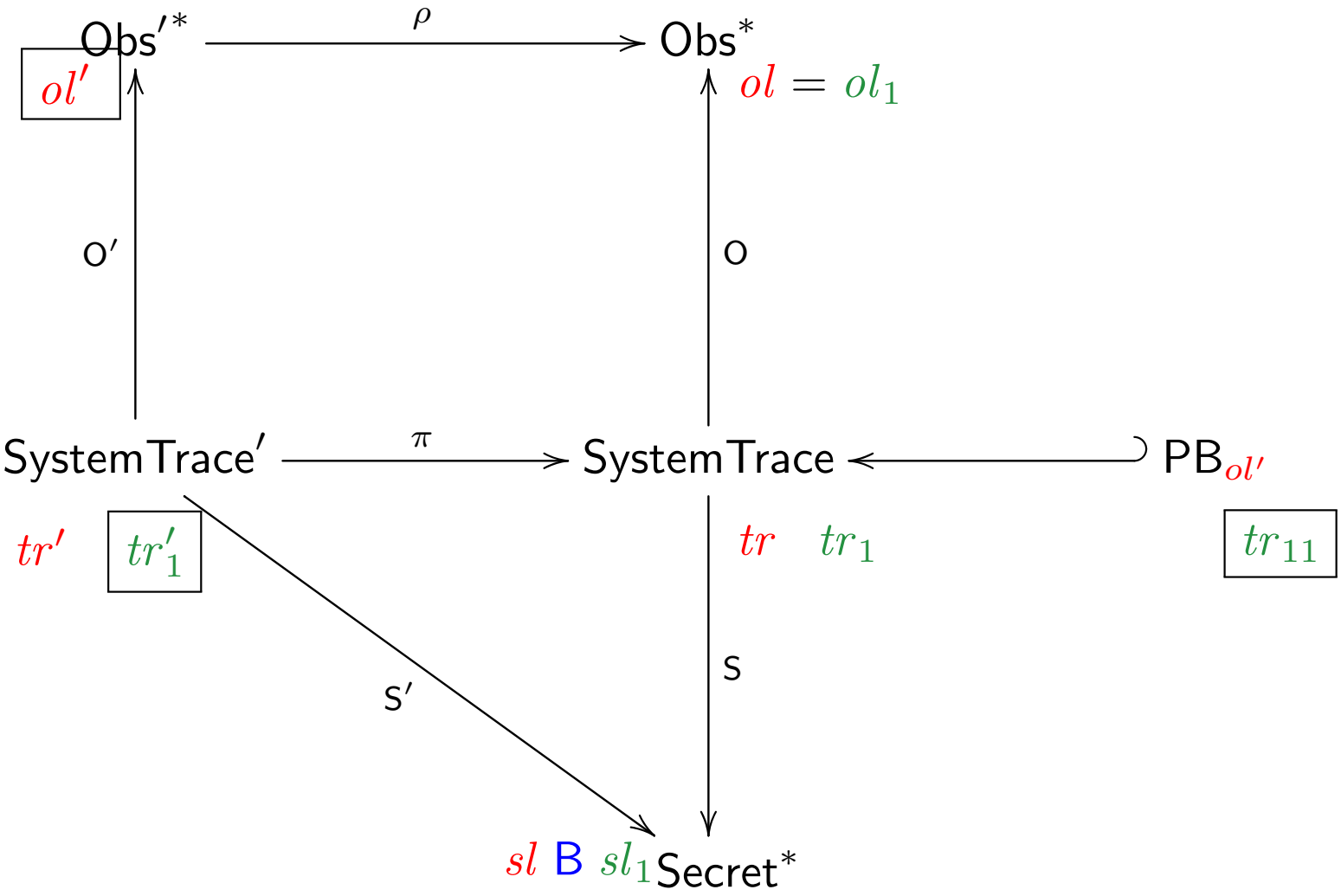

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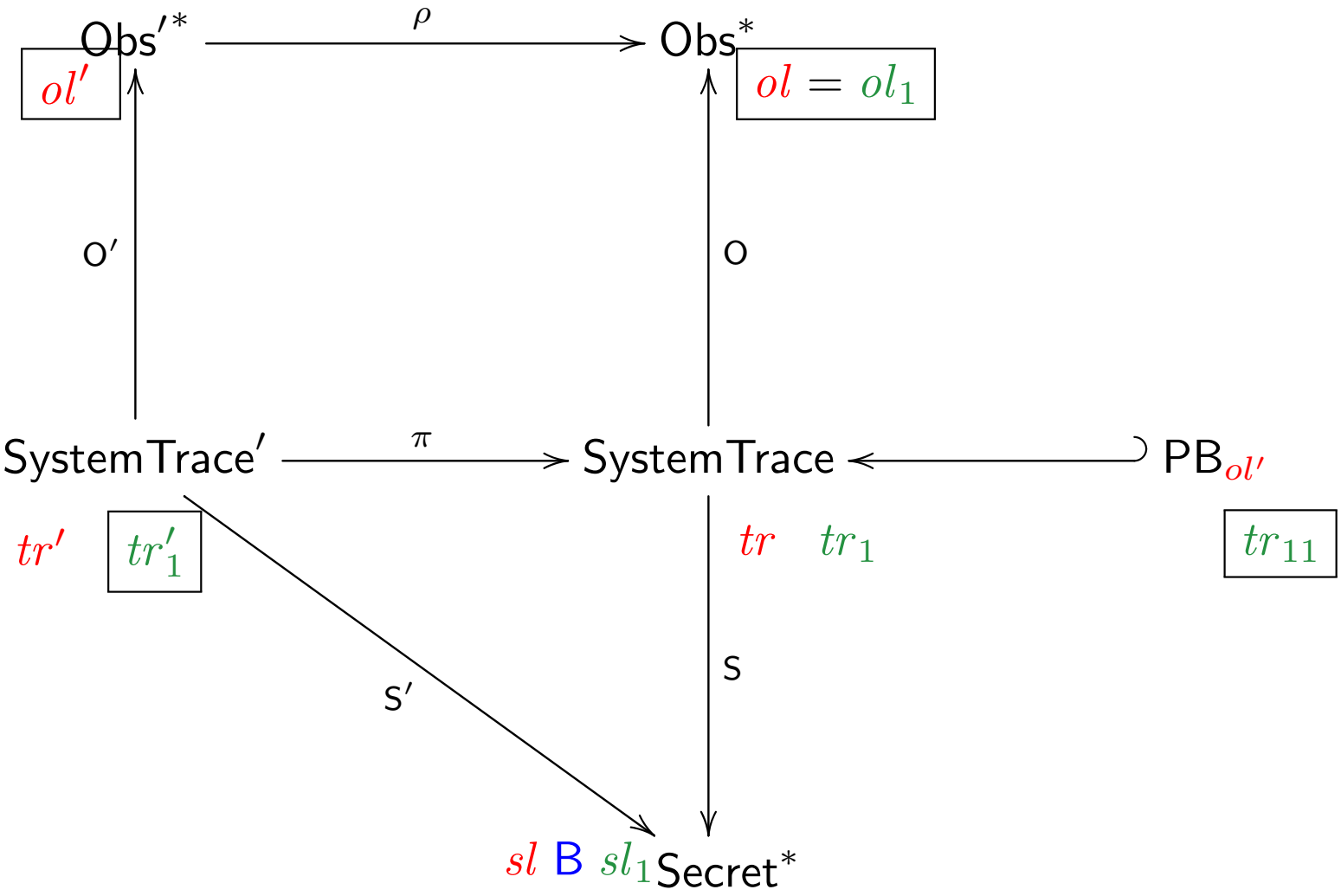

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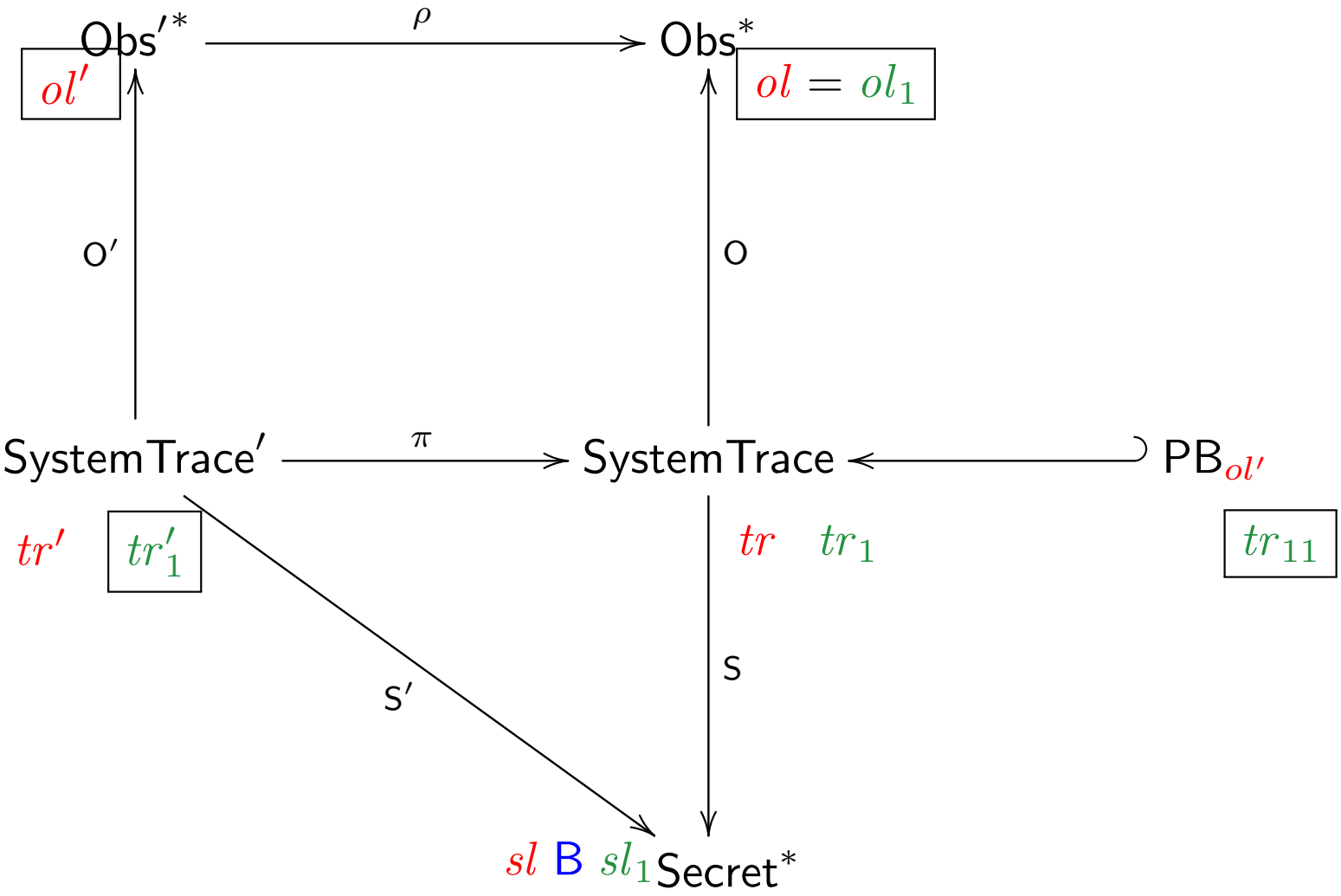

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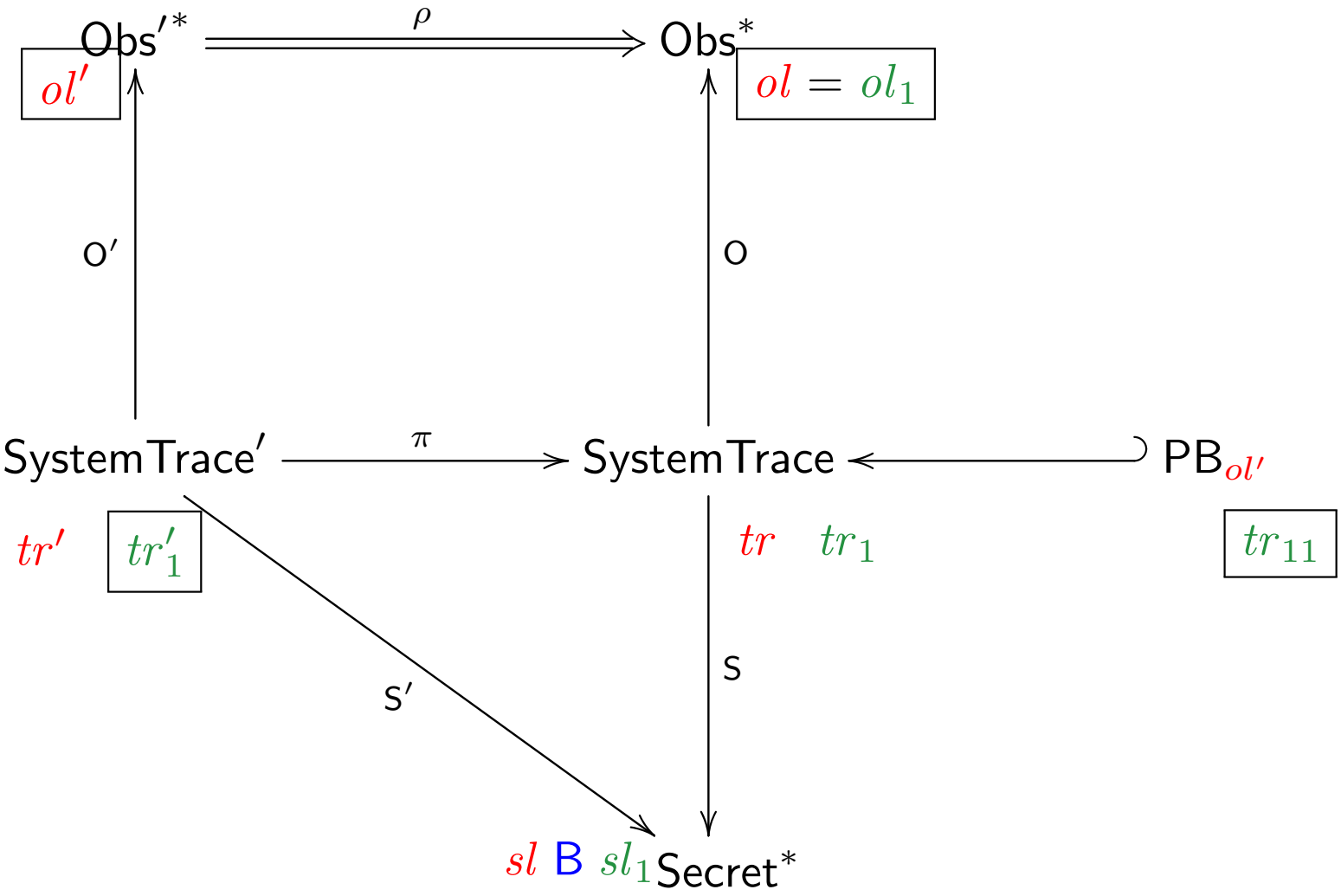

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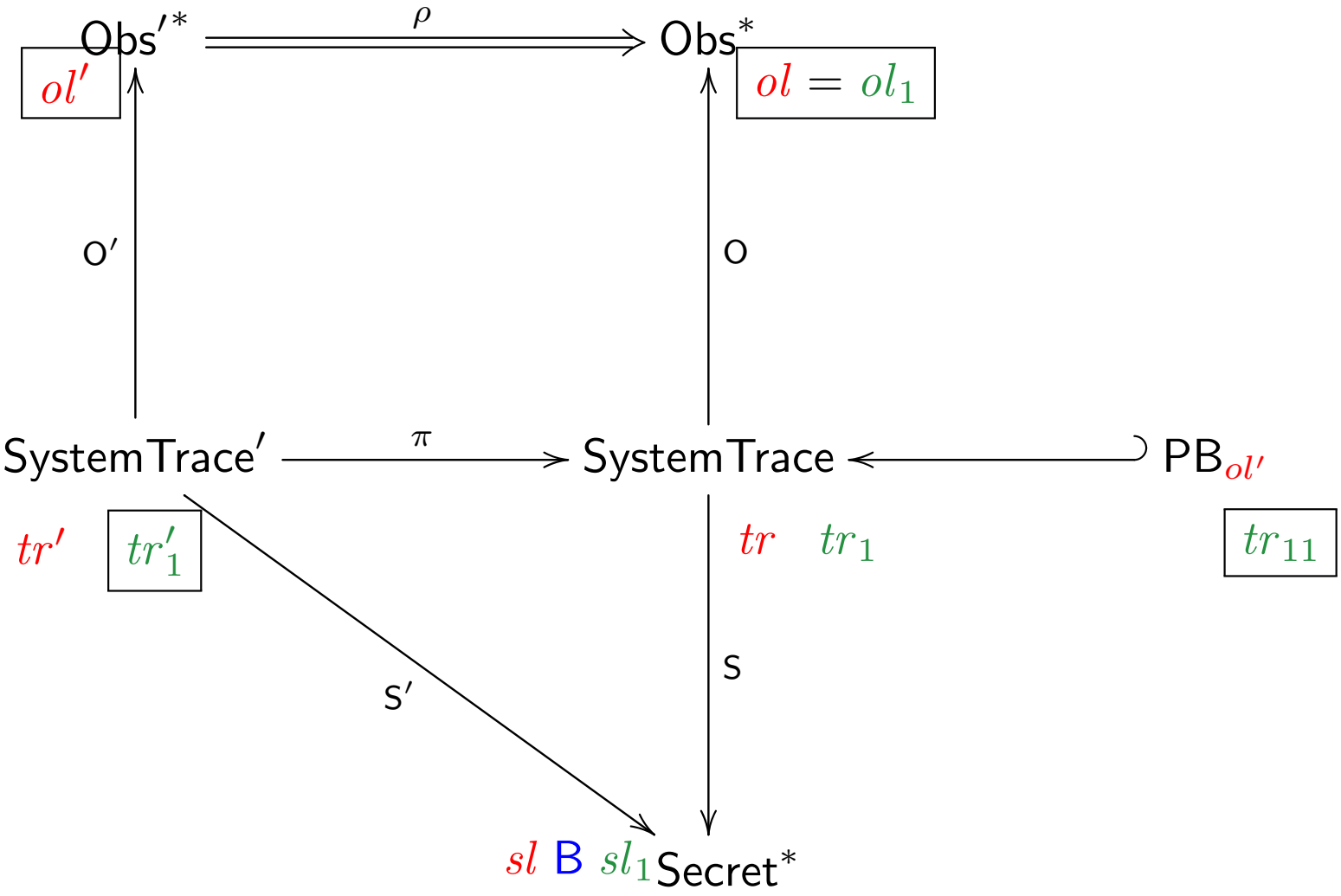

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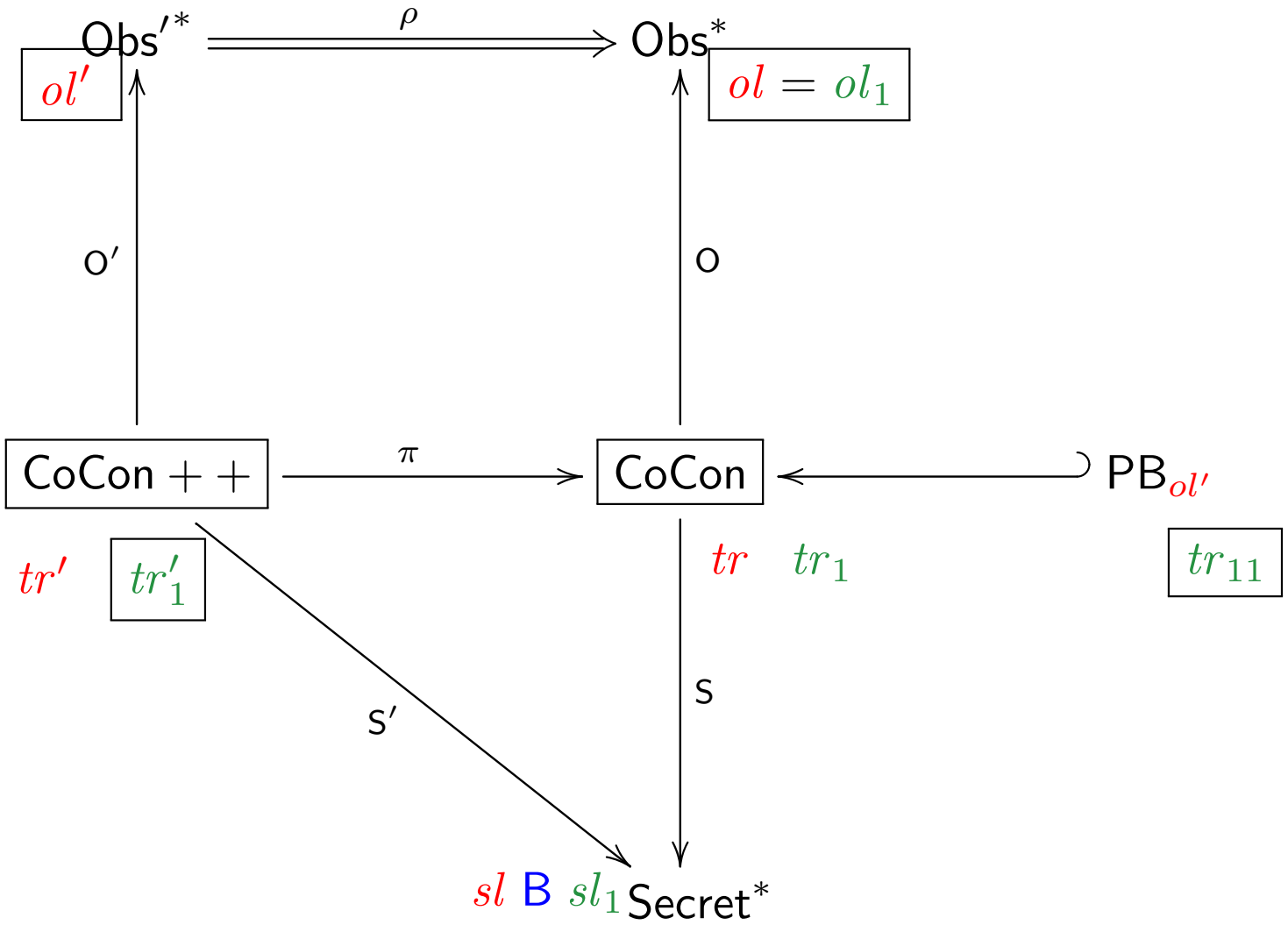

Adjustment property:

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What I Don't Like About CoCon

It's not as much fun as other systems...

Bugs with Happy End

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Email content: The 24th European Symposium on Programming (ESOP15) program committee is sorry to inform you that your paper #68 was rejected, and will not appear in the conference.

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Later email: Dear author, SORRY... we meant the paper is accepted! Apologies it was a long day.

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Experimenting with CoCon only we fail to explore BD security compositionality

Ongoing Work – CoSMed

EPSRC grant: Verification or Web-Based Systems (VOWS)

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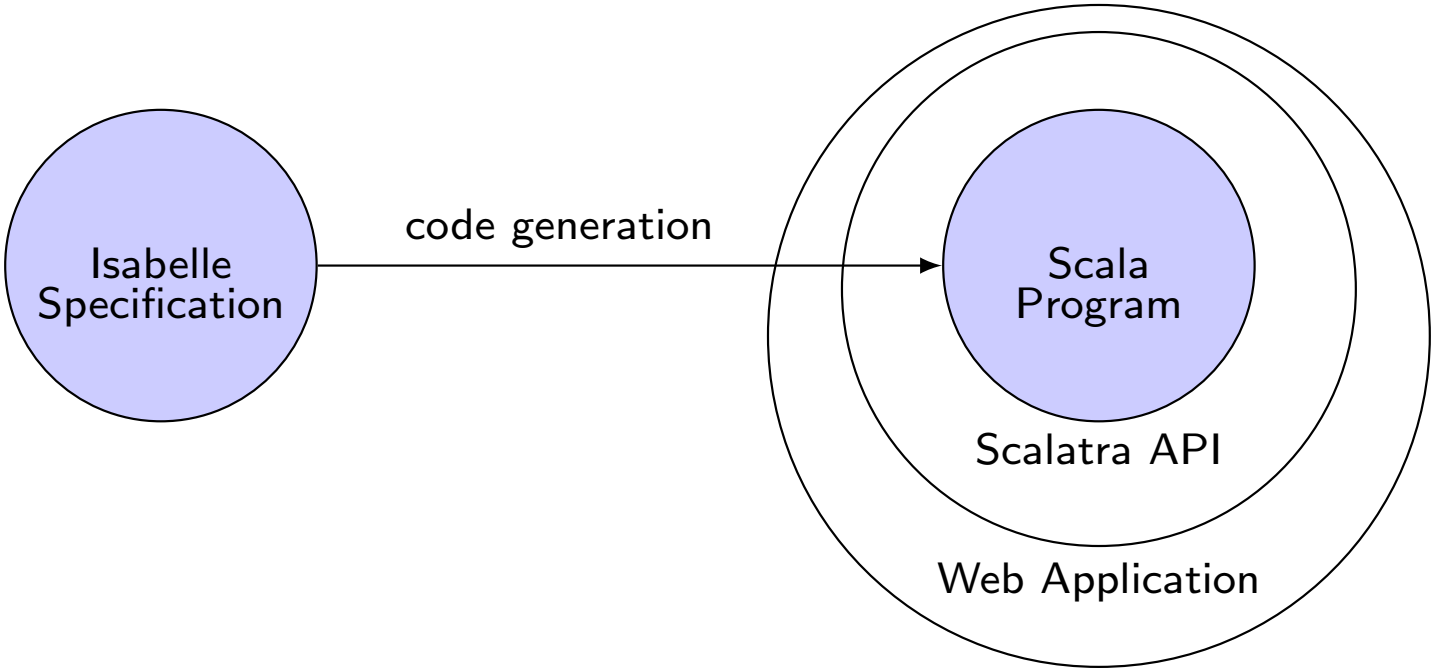
Example:
A non-friend user will learn nothing about the content of friend-restricted documents even if the document is shared with the client clones

Future Work: End to End Security



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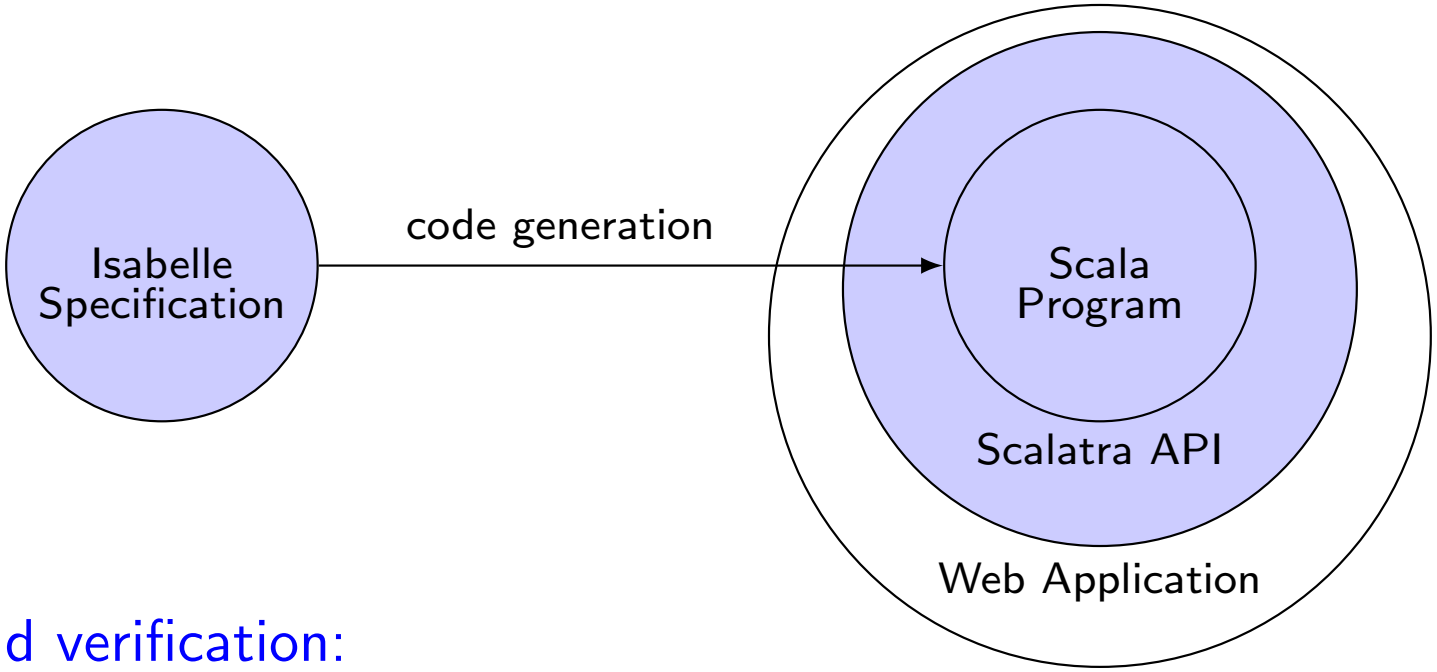
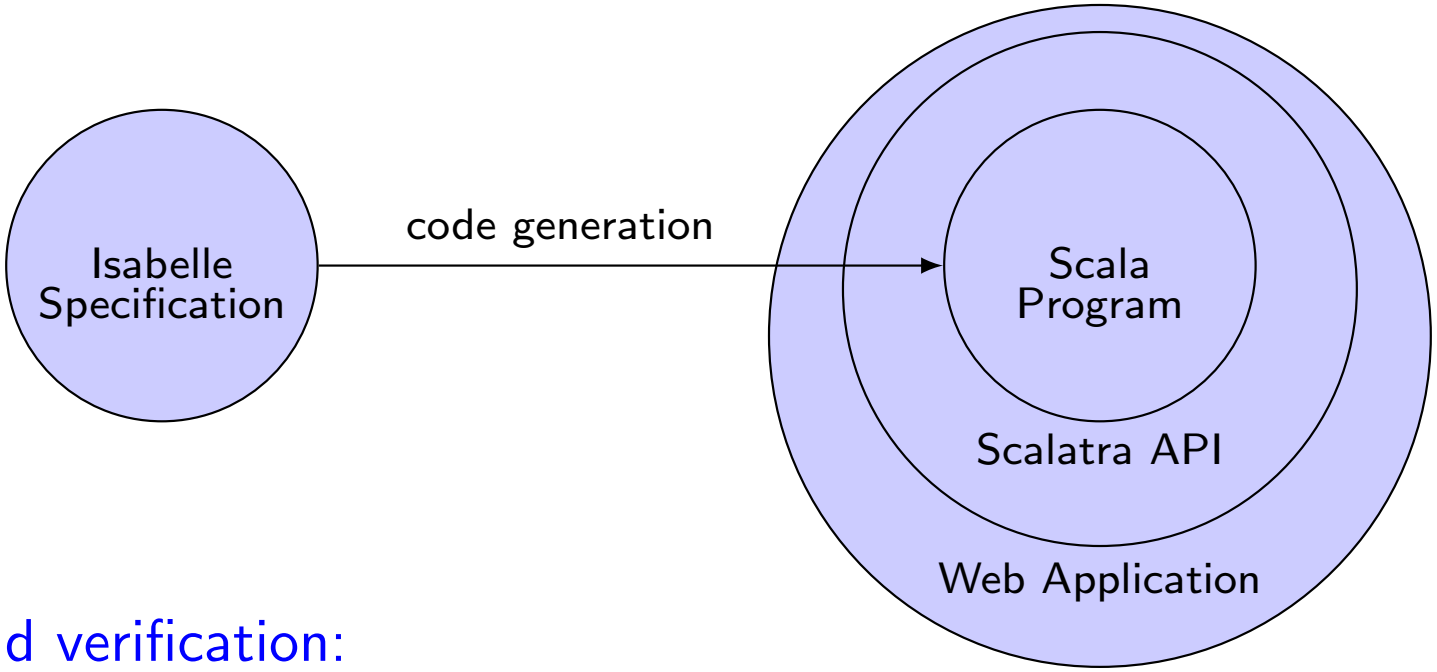


End to end verification:
Verify thin API layer

Future Work: End to End Security



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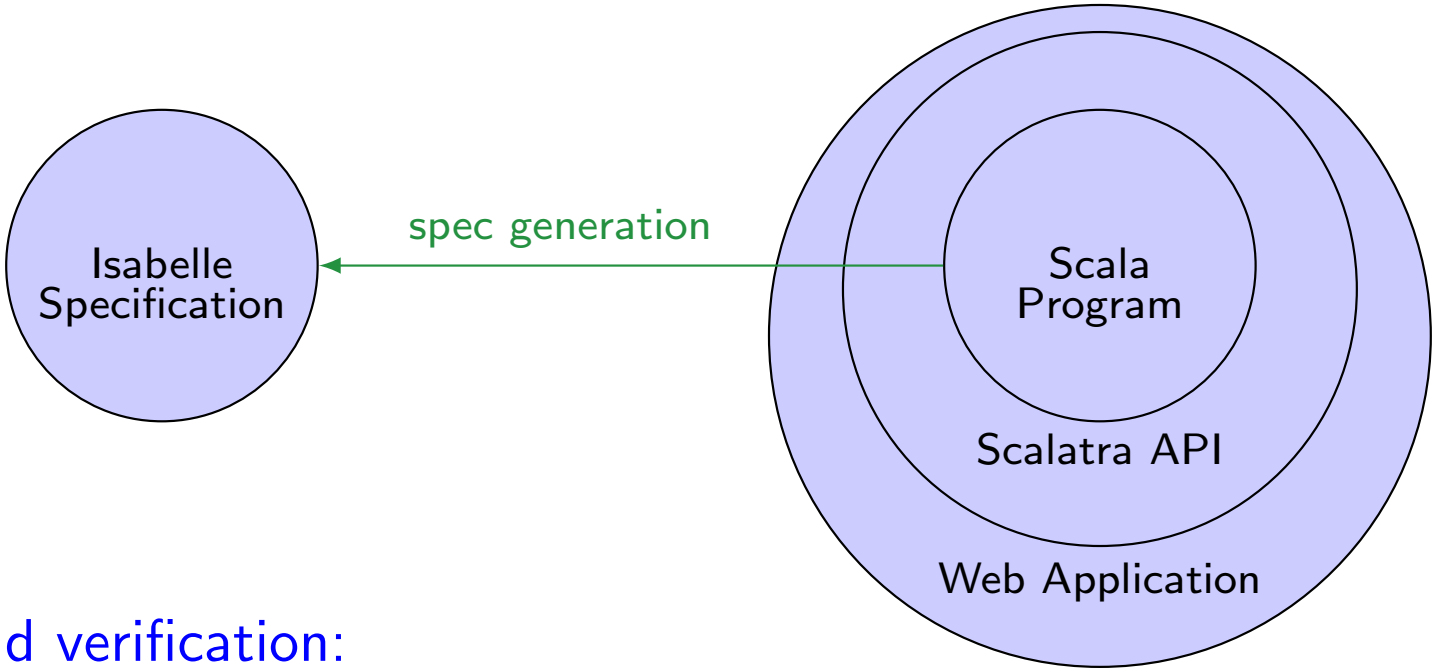

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Don't ask the programmer to use Isabelle – let them use a web framework

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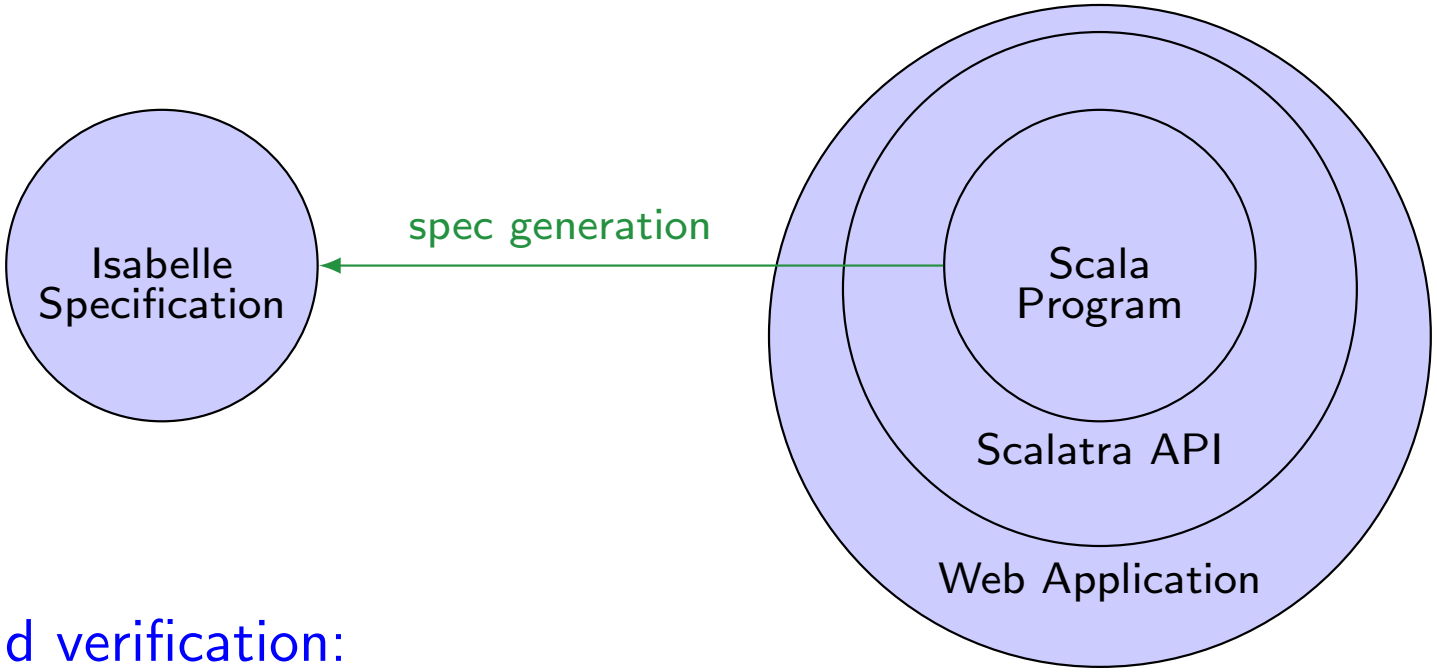

End to end verification:

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More scalable verification (VOWS): Model-check BD security

My Overall Goal

CoCon is starting to replace EasyChair at mainstream conferences

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- ITP 2016
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Towards this goal:

- Improved automation for proof assistants 
- Better abstraction mechanisms
- More robust logical foundations

CoCon

Andrei Popescu

Middlesex University London
Technical University Munich

Joint work with
Peter Lammich, Sergey Grebenshchikov,
Sudeep Kanav and Thomas Bauereiß