STRL

Deriving Enforcement Mechanisms from Policies

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Policy 2007, 14th June 2007, in Bologna, Italy

Motivation

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- Policies describe protection requirements in an abstract, often denotational form.
- In security critical applications an unambiguous and concise semantics of policies is required.
- Abstract policies must be translated (interpreted) and enforced.

- How to ensure that enforcement mechanisms are *correct*?
- Can we accurately define what *correct* means?
- What optimisation of the enforcement is possible?
- Is the approach constructive and can it be automated?

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Expressions

$$e \quad ::= \quad \mu \mid a \mid A \mid g(e_1, \ldots, e_n) \mid \bigcirc v \mid \text{fin } v$$

Formulae

$$f \quad ::= \quad p(e_1, \ldots, e_n) \mid \neg f \mid f_1 \wedge f_2 \mid \forall v \cdot f \mid \text{skip} \mid f_1 \; ; \; f_2 \mid f^*$$

- μ is an integer value,
- a is a static variable (doesn't change within an interval),
- A is a state variable (can change within an interval),
- v is a static or state variable,
- g is a function symbol and
- p is a predicate symbol

Motivation
ITL
Policy Rules
Enforcement
Summary

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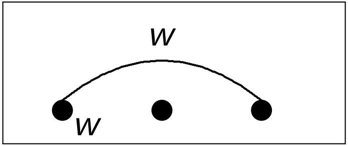
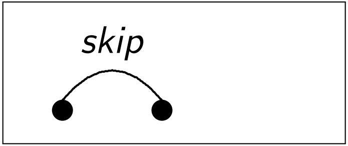
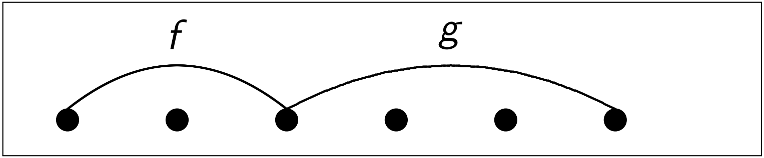
State Formula



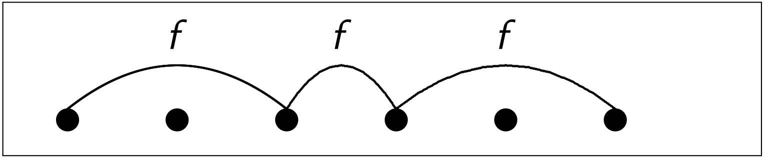
Skip (Unit Interval)



Chop (Sequence)



Chopstar (Iteration)



Policy Rule

Policy Rule

Expresses individual protection requirements in the form:

$$\textit{premise} \longrightarrow \textit{consequence}$$

- **Premise** describes the behaviour (as an ITL formula) that leads to the consequence.

  *"Subject **S** did in the past **read** object **O**"*

- **Consequence** distinguishes the type of the rule.

  *"then **S** is authorised to **read** objects from the same dataset"*

Semantics of Rules

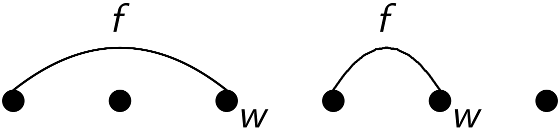
Definition (Always Followed By)

The operator *always-followed-by*, is defined as:

$$f \mapsto w \mathrel{\widehat{=}} \boxdot((\Diamond f) \supset fin\ w)$$

where f stands for any ITL formula, and w is a state formula.

$f \mapsto w$



A policy defines access control decisions $autho(s, o, a)$ in each state of the interval.

We define the execution of requests such that:

- *done(s,o,a)* is true iff the action was successful.
- *failed(s,o,a)* is true iff the action failed.

Definition (Correct Enforcement — Access Control)

We say a policy is *correctly* enforced iff:

$$E_{autho} \mathrel{\widehat{=}} \text{keep}\,(\bigcirc done(s, o, a) \supset autho(s, o, a))$$

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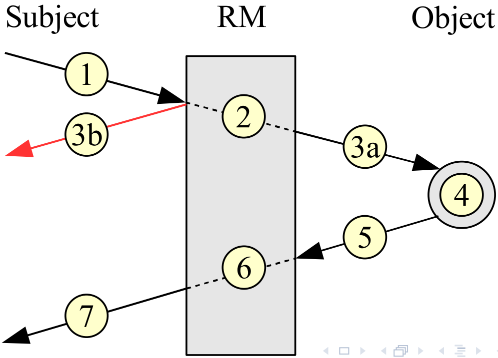
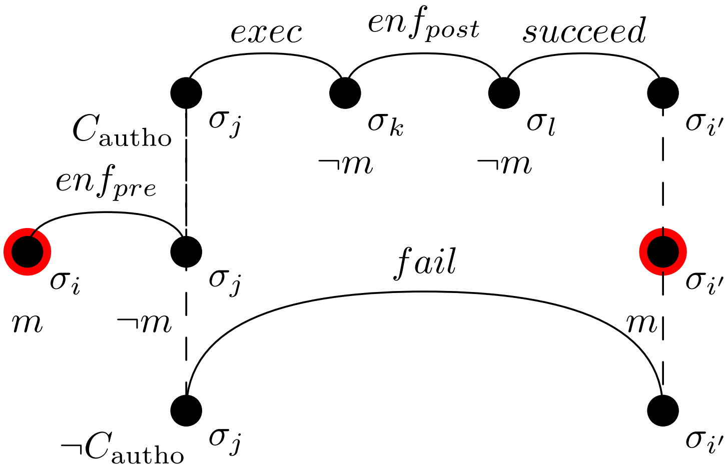
Rules define *history-based* access control. Their enforcement must:

- Determine the history that is required for policy decisions.
- Maintain this history.
- Optimise enforcement efficiency and decide timely.

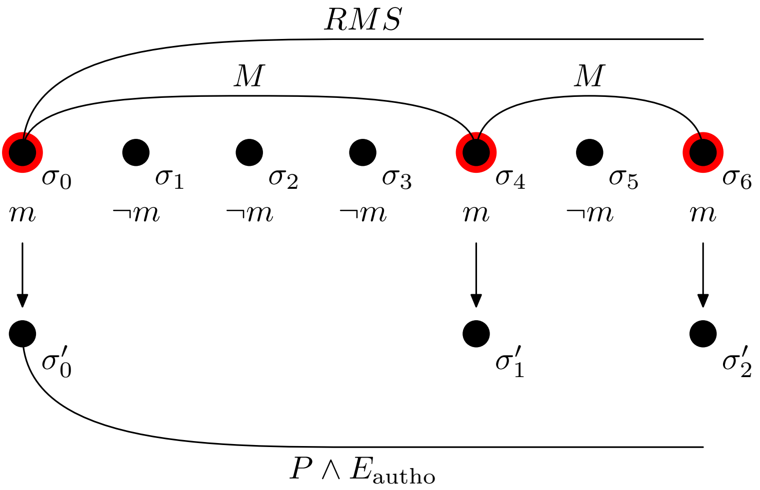


STRL



Requests are defined at fine level of temporal granularity. Policy enforcement takes place in enf_{pre} and enf_{post} and is reflected in the condition C_{autho}.

Enforcement
Mapping between Policies and Enforcement



We use *temporal projection* to map between the more coarse policy reference interval and the fine grained RM specification.

Enforcement
A Simple Rule

Subject s is authorised to perform a on o if s was not acting in the role admin in the state before.

$$1 : \neg\, in(s, admin) \;\mapsto\; autho(s, o, a)$$

We stepwise refine the temporal operators. It is clear that only the current and the last value of the role assignments are required. This allows to refine the pre-update as.

$$enf_{pre} \mathrel{\widehat{=}} \forall s \in \mathcal{S} \bullet$$
$$H_{\mathrm{in,s,admin}}[1], H_{\mathrm{in,s,admin}}[0] \leftarrow H_{\mathrm{in,s,admin}}[0], \mathrm{in}(s, \mathrm{admin})$$

where H is a list of history variables for the observed subscript.

The (parallel) temporal assignment can be refined into the following sequence:

$$enf_{pre} \mathrel{\widehat{=}} \text{for } s \text{ in } \mathcal{S} : \{ \quad H_{\mathrm{in,s,admin}}[1] := H_{\mathrm{in,s,admin}}[0]; \quad H_{\mathrm{in,s,admin}}[0] := \mathrm{in}(s, \mathrm{admin}) \quad \}$$

As the relevant history is now available, we can express the actual access decision in terms of these variables.

$$C_{autho} \mathrel{\widehat{=}} T \geq 1 \wedge \neg H_{\mathrm{in,s,admin}}[1]$$

Summary

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- Policies define history-based access control decisions at an abstract level.
- Enforcement defines the concrete mechanism behaviour at a very concrete level of abstraction.
- We use temporal projection to map between this level.
- Correctness of the enforcement is defined as a property on this mapping.
- The different abstraction levels allow for the introduction of states that define code required for the maintenance of a history.
- This code can be derived from the high-level policy specification.
- The formal underpinning allows for (correctness preserving) optimisations.

Thank you for your Questions and Comments!

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Abbreviations

$\bigcirc f$	$\widehat{=}$	skip ; f
more	$\widehat{=}$	skip ; true
empty	$\widehat{=}$	$\neg$ more
inf	$\widehat{=}$	true ; false
finite	$\widehat{=}$	$\neg$ inf
$\Diamond f$	$\widehat{=}$	finite ; f
$\Box f$	$\widehat{=}$	$\neg \Diamond \neg f$
fin f	$\widehat{=}$	$\Box$(empty $\supset$ f)
$\Diamond_i f$	$\widehat{=}$	f ; true
$\Box_i f$	$\widehat{=}$	$\neg \Diamond_i \neg f$
$w \; ? \; f : g$	$\widehat{=}$	$(w \wedge f) \vee (\neg w \wedge g)$