Foundations of Access Control for Secure Storage

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Formal techniques for secure communication

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- process calculi, type systems, logics, other foundations
- **rigorous** design/analysis of communication protocols!

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Formal techniques *for secure storage?*

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- reading/writing a file $\approx$ receiving/sending on a channel

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Similar applications of **cryptography**

- secure communication on untrusted channels
  $\approx$ secure storage on untrusted servers

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But careful about carrying the analogies too far...

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Can access control improve security? How?

Sophisticated **dynamic** effects

- *runtime checks*
- *runtime controls*

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- focus on **correctness** proofs for implementations of access control
- exploit correct "black-box" access control in proofs of **end-to-end security** properties

Automated analysis techniques derived from logic

Protocol for secure file sharing on untrusted storage

The Plutus file system

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Keys can be revoked by owner (**dynamic access control**)
New keys generated/distributed appropriately.

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Implementation relies heavily on RSA tricks.

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Applied pi calculus $\longrightarrow$ Horn logic $\circlearrowleft$ **Resolution**

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Expected properties?

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Expected properties? *Who knows?*

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Expected properties? *Specify what seems reasonable...*

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Demo!

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Processes, objects tagged with security labels.

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- Trust the executable? Endorse as `High` and run!

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The Windows Vista operating system

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Processes can

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- read, write, or execute objects
- lower their own labels
- control labels of objects

under suitable **constraints**

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Are information-flow attacks possible?
Can we eliminate them (by static analysis/runtime monitoring)?

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Can we verify applications written on Asbestos?

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Finer analysis techniques derived from PL

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Attacker as any program in this language.

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- ...Identify redundant access control?

Secrecy by typing and access control[3]

[Communication] *secrecy* $\approx$ restrictions on knowledge.

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  - as principals, secrecy levels

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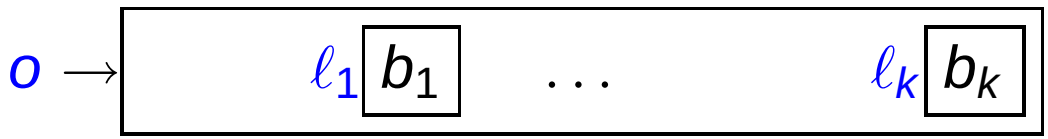
Idea! **Dynamic** access control + **polymorphic** types

Indirections for dynamic access control



conventional object

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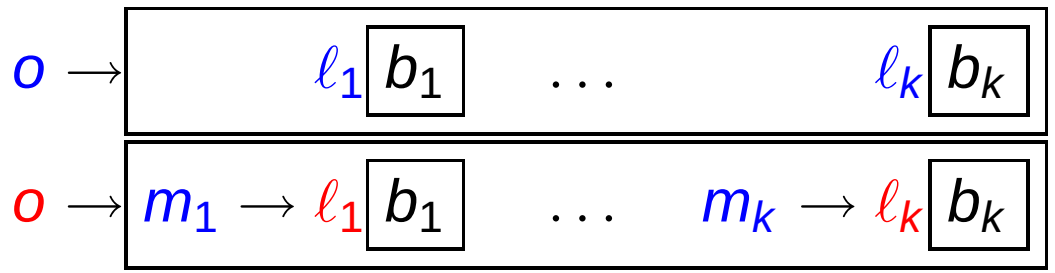

conventional object

object with *indirections*

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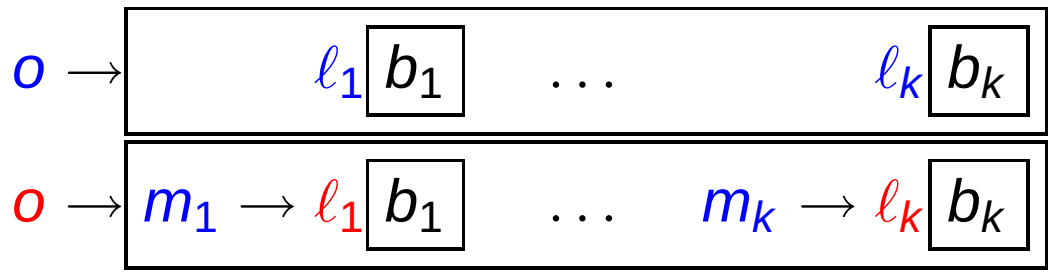

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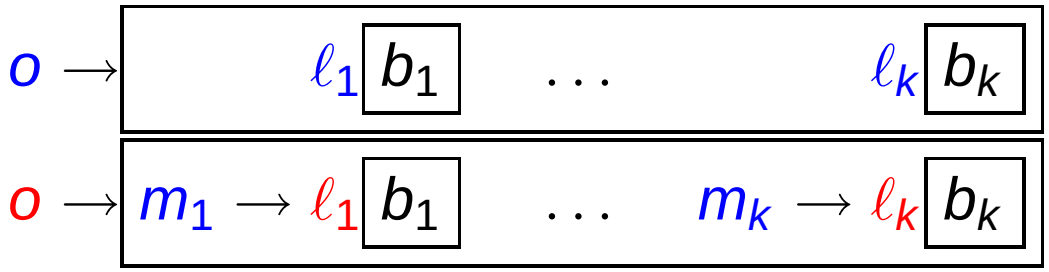

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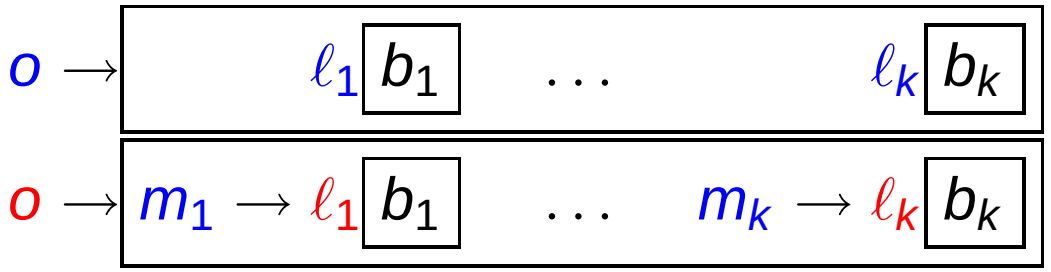

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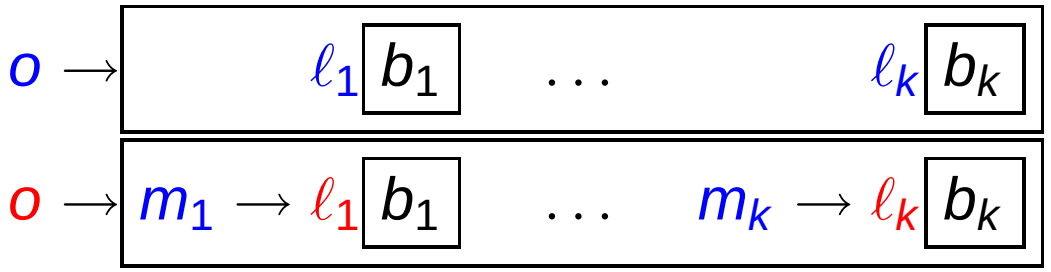

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Knowing o necessary for controlling indirections, methods.

Polymorphic types and dynamic access control[4]

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$$f : \mathrm{Obj}[\texttt{read} : X,\ \texttt{write} : X \to 1]$$

[4] [CONCUR 2006]

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$$r^T : \mathrm{Ind}(T)$$
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r^T and w^T are indirections for methods at type T.

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Cryptographic objects

$$s : \mathrm{Obj}[\texttt{key} : X,\ \texttt{encrypt} : Y \to \mathrm{Ind}(X \to Y)]$$

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Dynamic labels and security types[5]

A **calculus** for Windows Vista's security environment.

[5] [with Sriram Rajamani *et al.*, PLAS 2008]

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Specify the target security property in the calculus.
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Enforce the target security property by (hybrid) typing.
(Access control crucial for sanity.)

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Certified code?

Typechecking is decidable!

Translate low-level code to our calculus, preserving attacks of interest.
(**Very much future work!**)

Typecheck translated programs.

Data-Flow Integrity (DFI)

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These insights may apply more generally...