It's My Privilege: Controlling Downgrading in DC-Labels

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11th International Workshop on Security and Trust Management

Information Flow Control

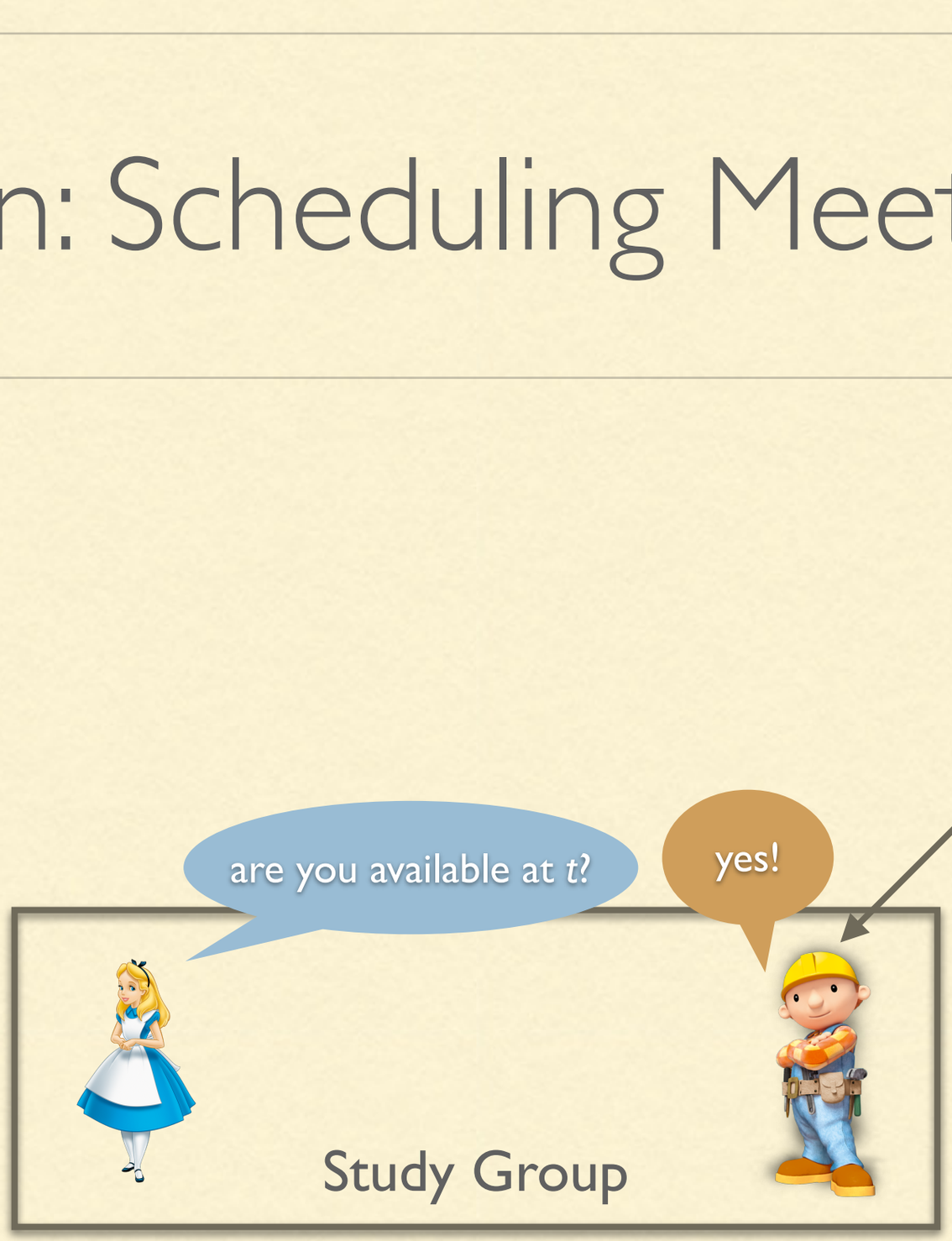
- Can provide strong enforceable security guarantees
  - Noninterference [Goguen and Meseguer 1982]
  - Jif [Myers et al. 2001], LIO [Stefan et al. 2011], and many others
- But programs can **downgrade** information!
  - Breaks noninterference
  - Need semantic security conditions that still hold in the presence of downgrading

This work: reasoning about global security properties in Information Flow Control (IFC) systems with downgrading

Motivation: Scheduling Meetings

Alice's Calendar

Bob's Calendar



group members can discover each other's availability

Scheduling Meetings: constraints

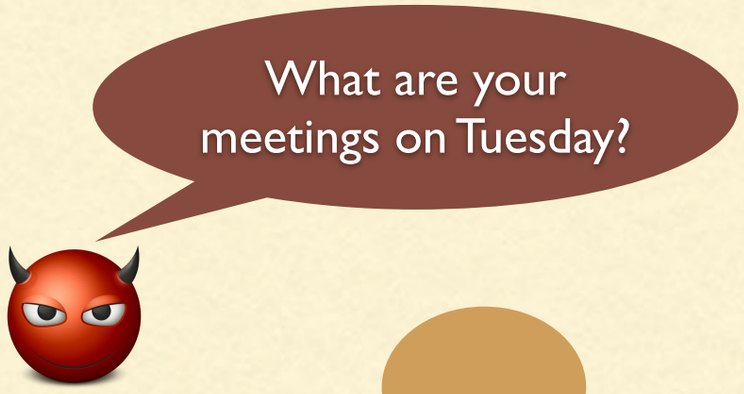
Alice's Calendar

Bob's Calendar

only group members can discover availability

Scheduling Meetings: constraints

Alice's Calendar



Bob's Calendar

meeting details are secret to everyone but the owner

Scheduling Meetings with DC Labels

Disjunction Category (DC) labels provide a way to enforce our security policies

[Stefan et al. 2011]

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Data labeled with information flow policy:

- Confidentiality: who may read the data
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- inside a computational context that has a *floating label*, which reflects the policies of the data that it has used

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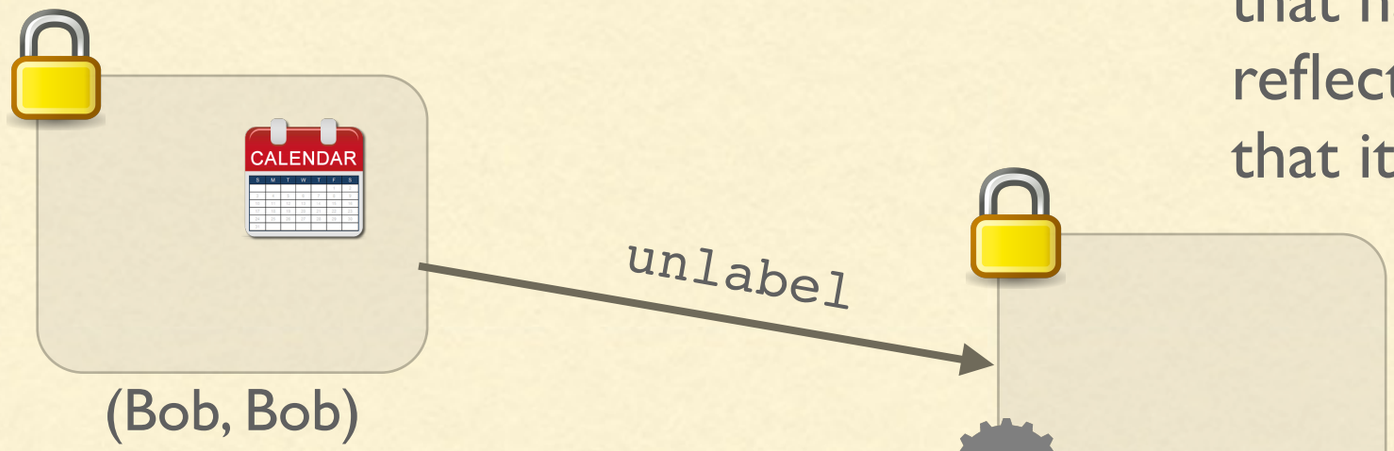

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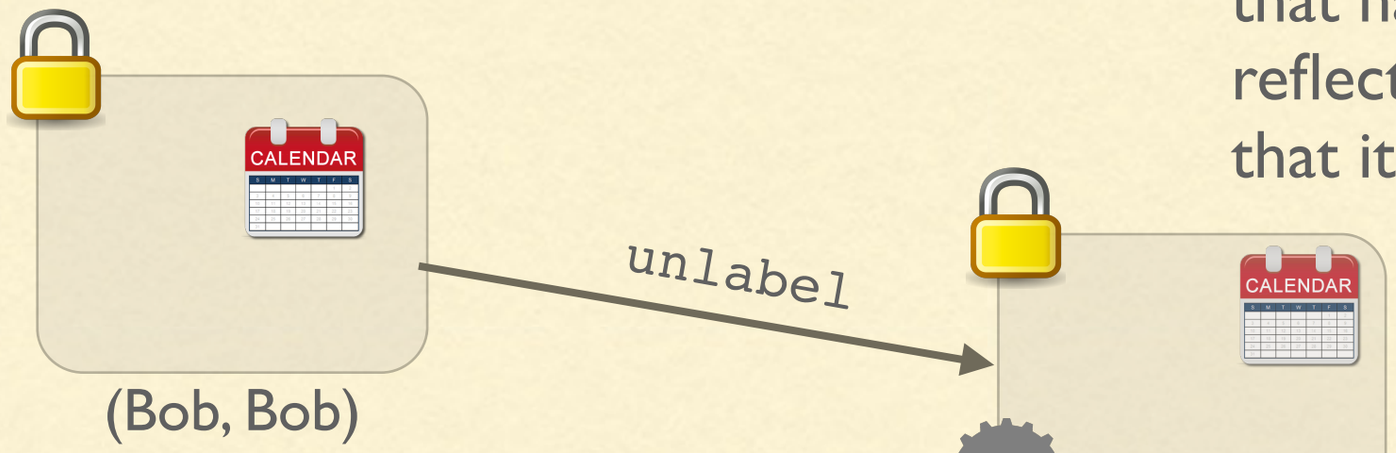

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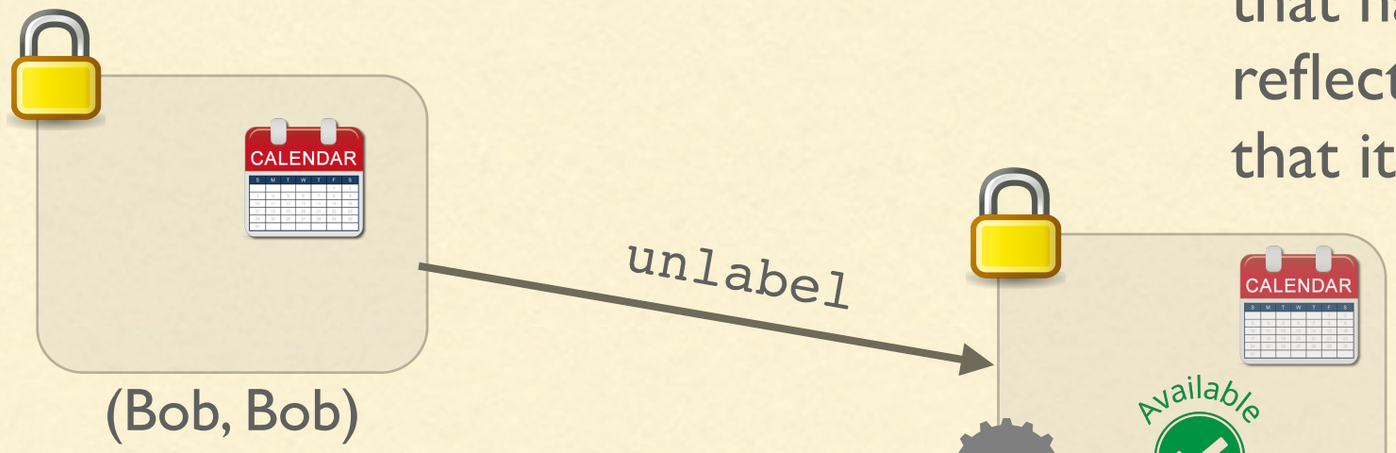

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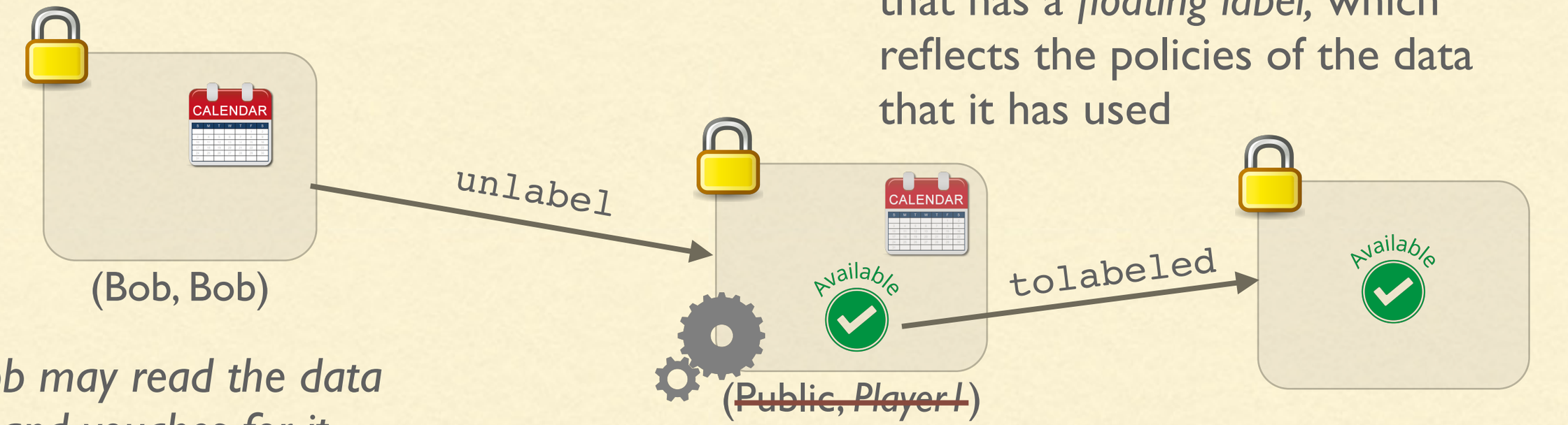

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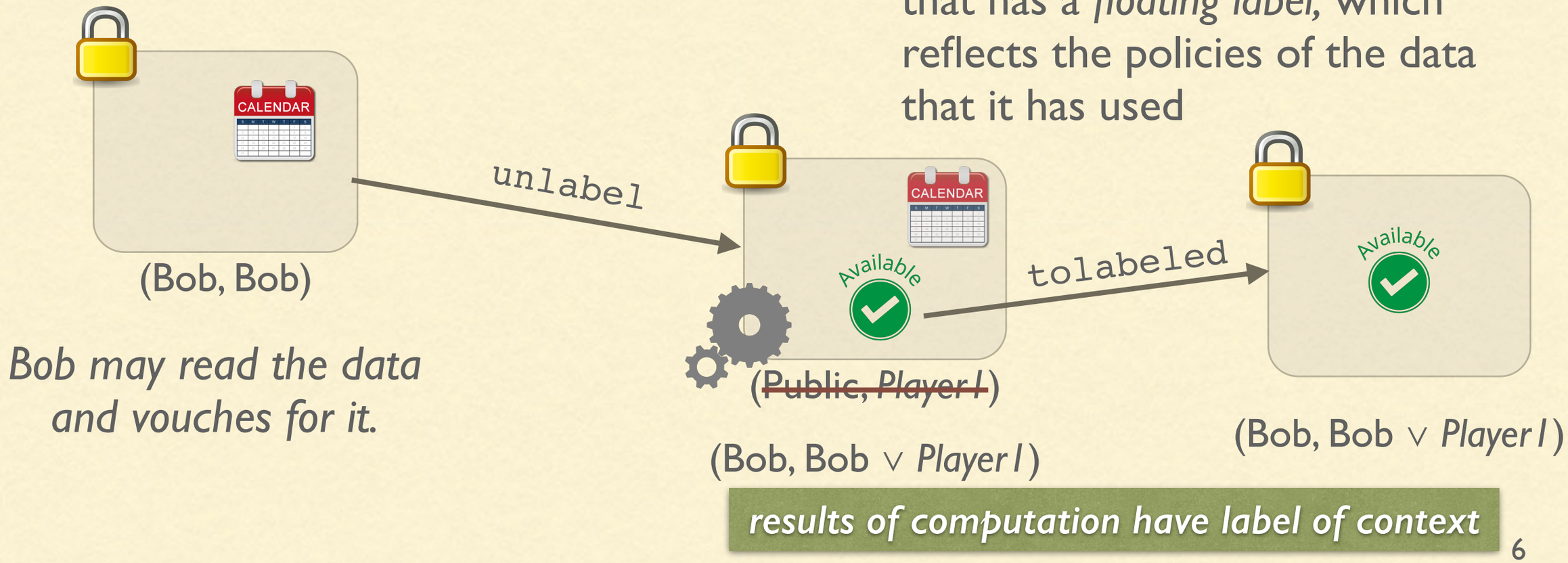

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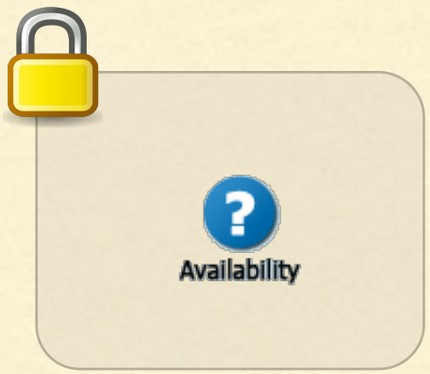

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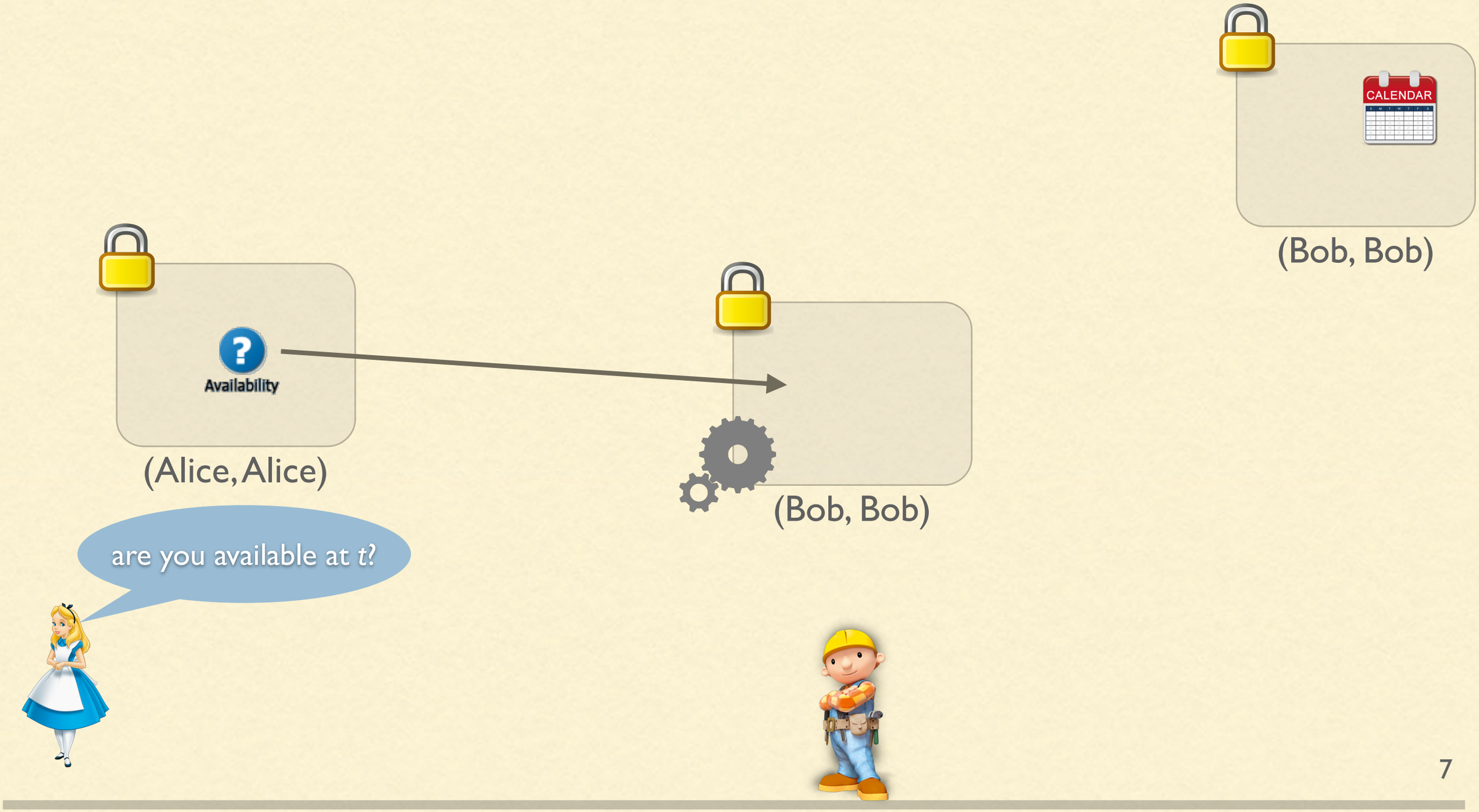

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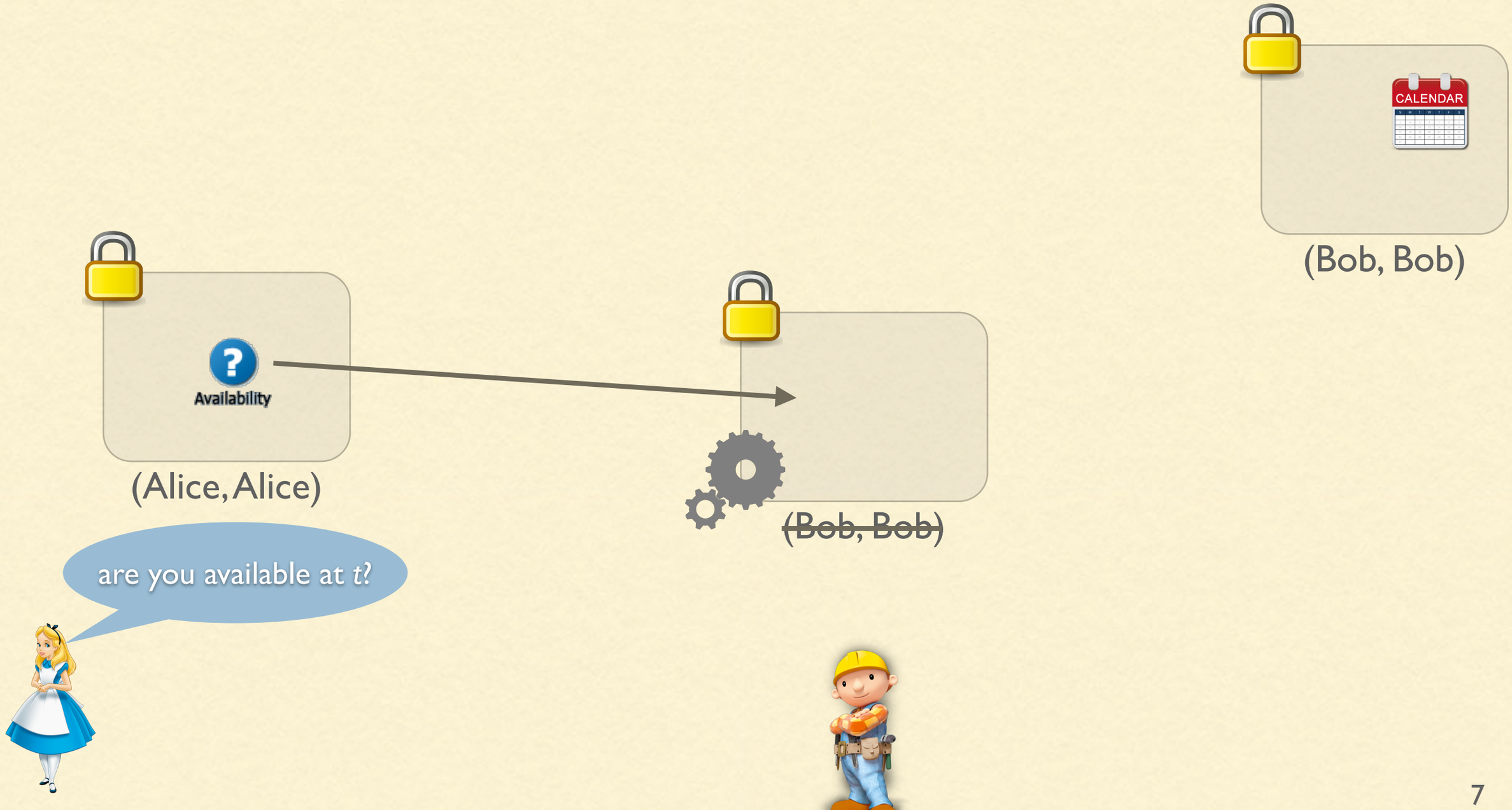

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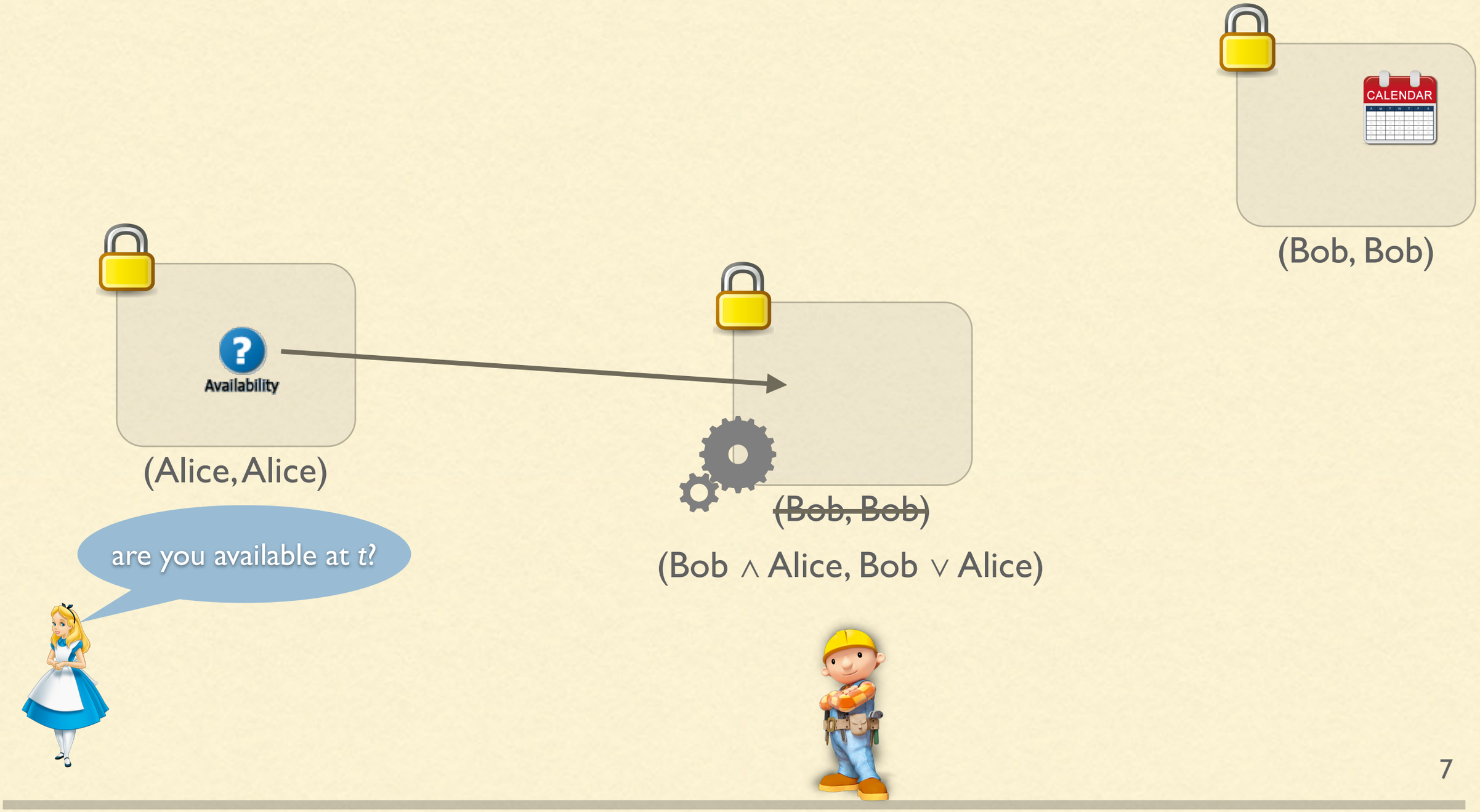

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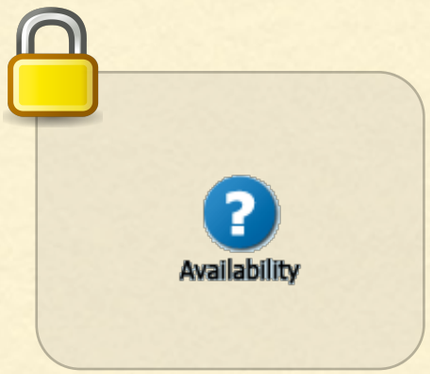

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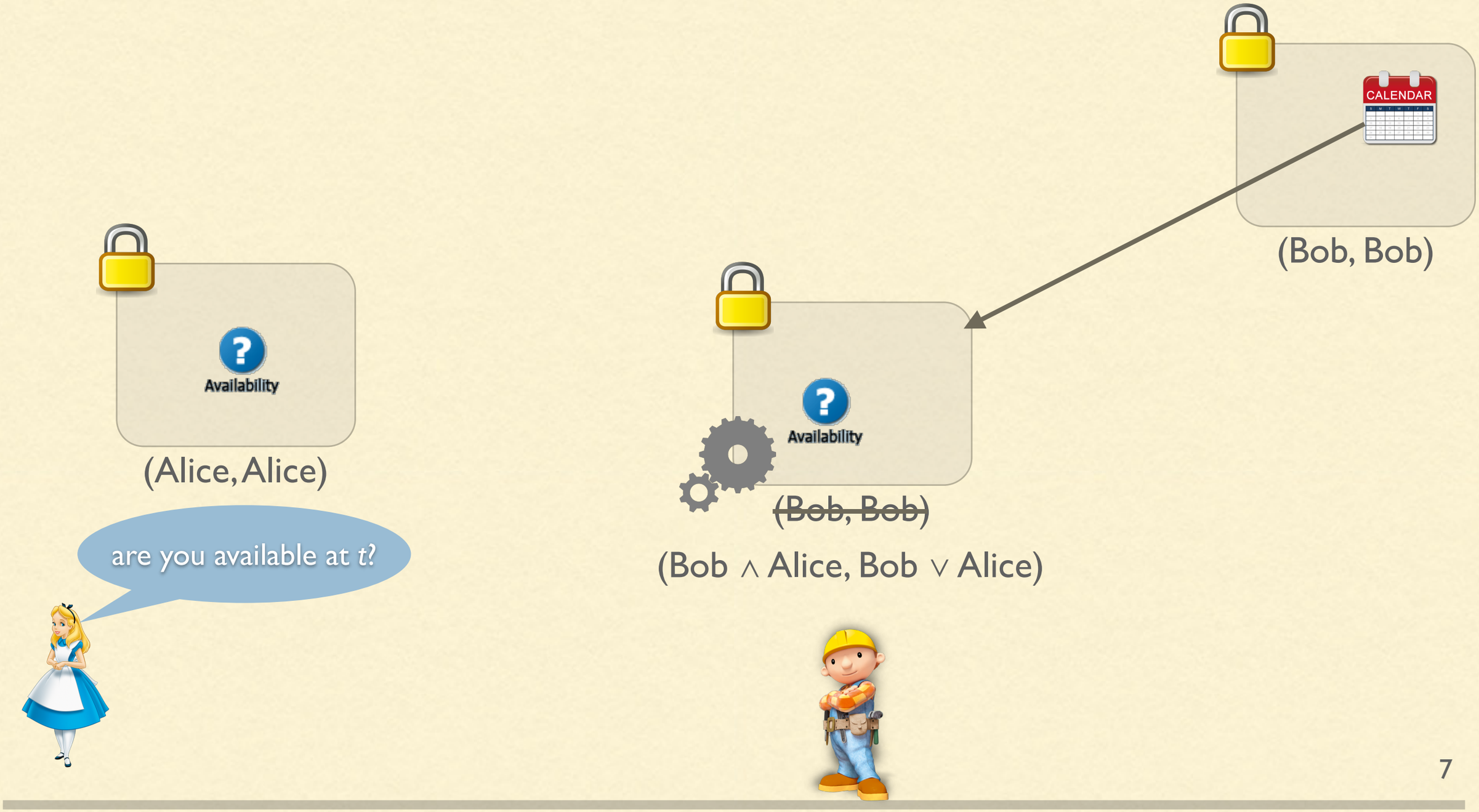

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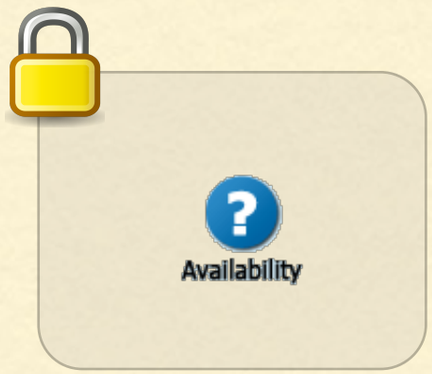

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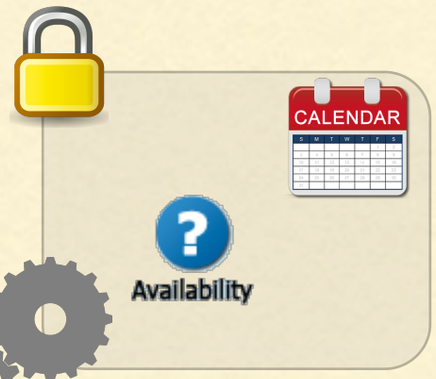

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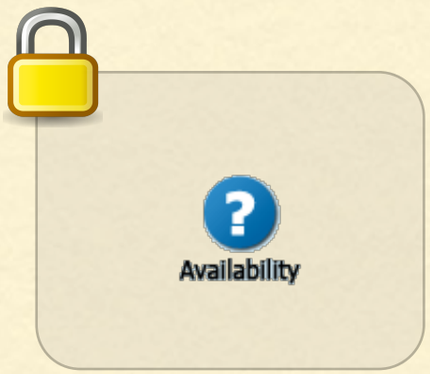

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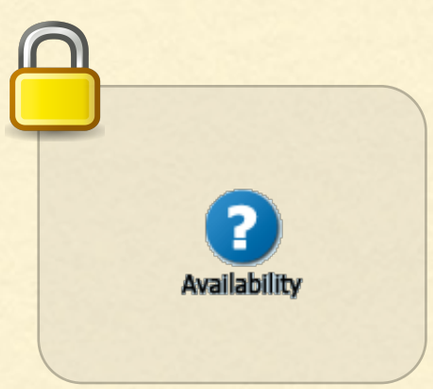

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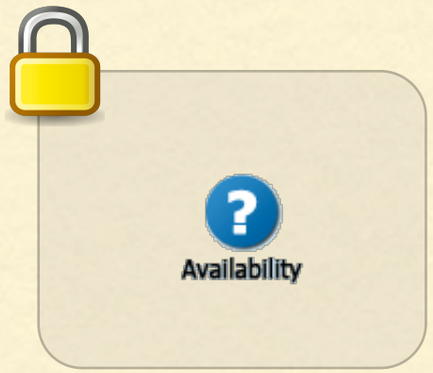

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unreadable by Alice

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Privilege: capability-like runtime value that represents a principal's authority to downgrade information

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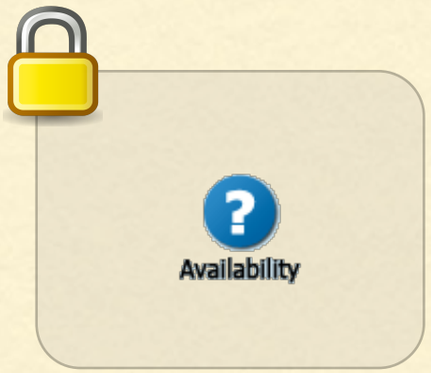

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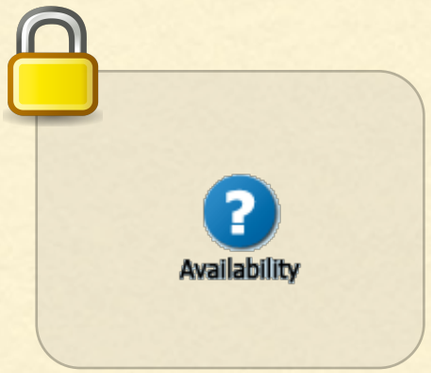

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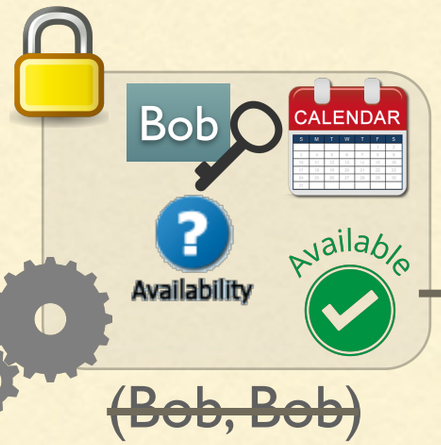

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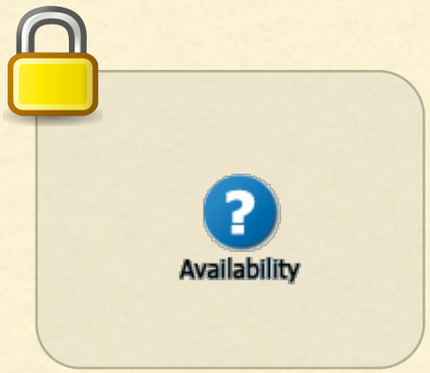

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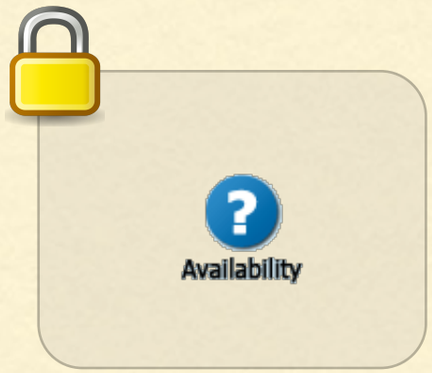

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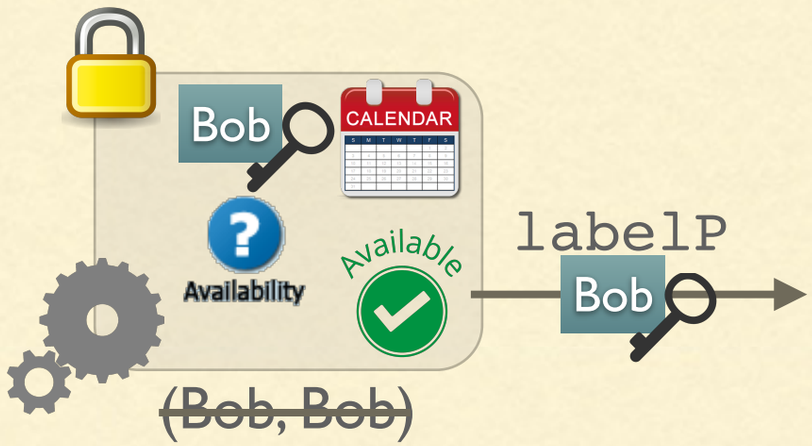

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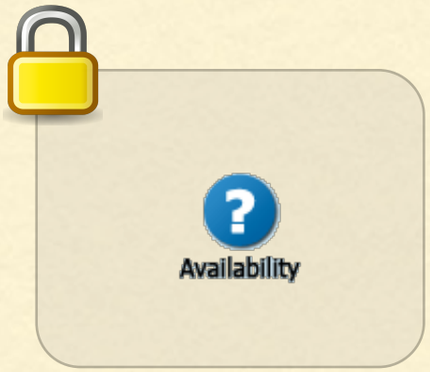

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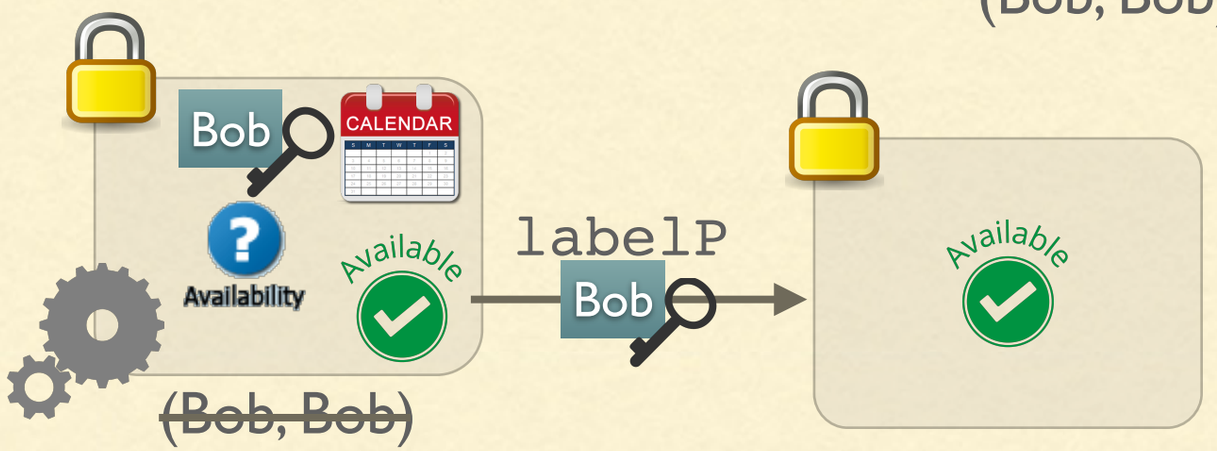

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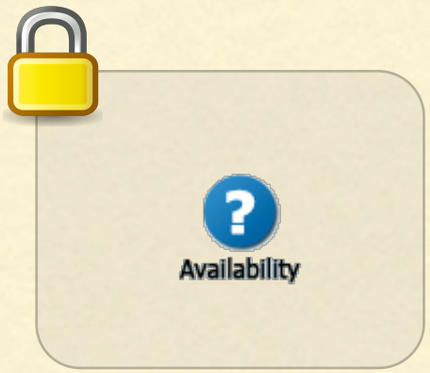

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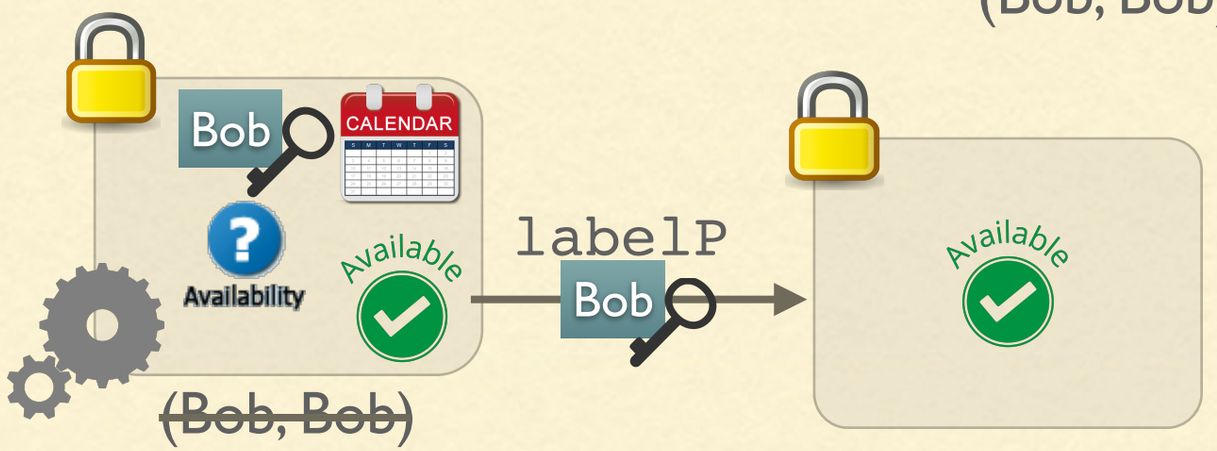

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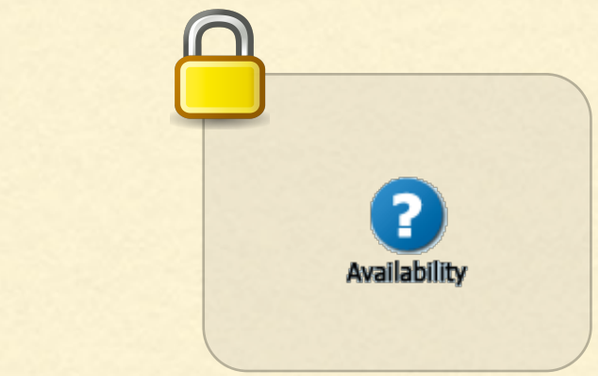
Dangerous Downgrading



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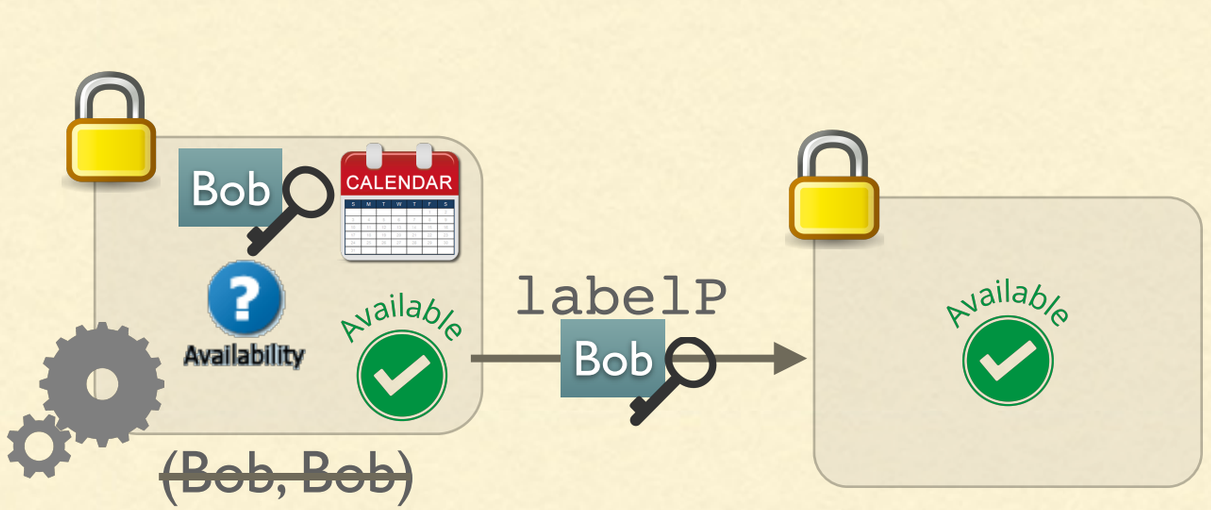
(not in Bob's study group)



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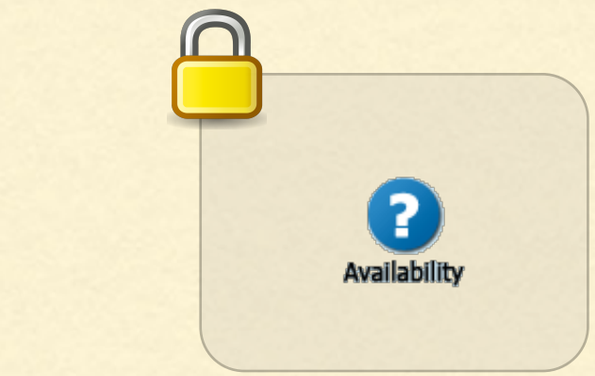

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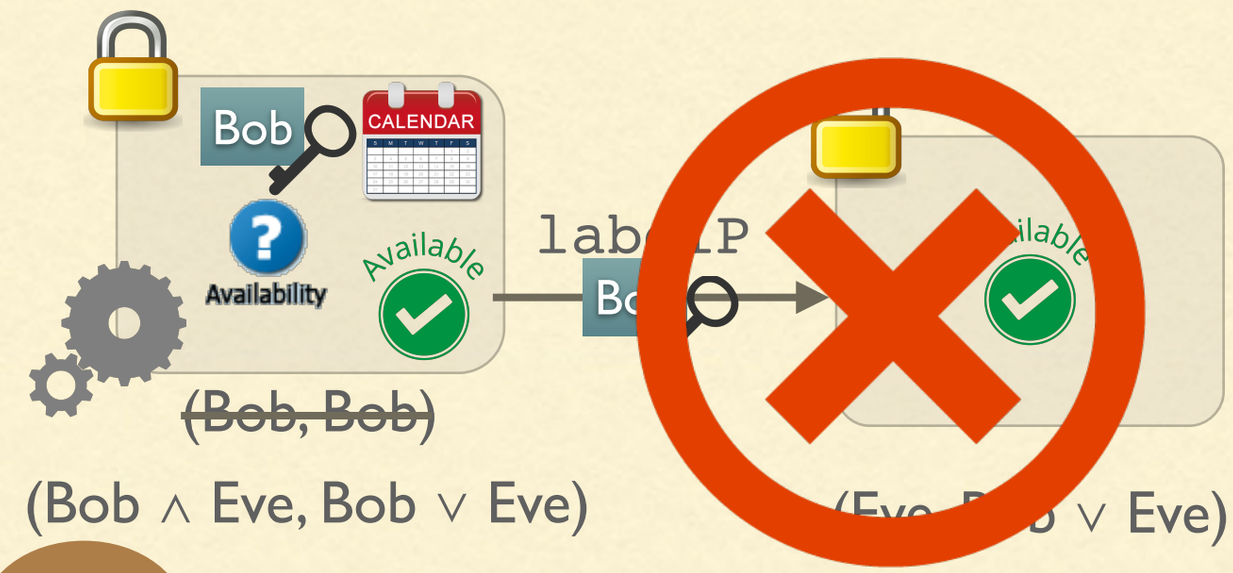

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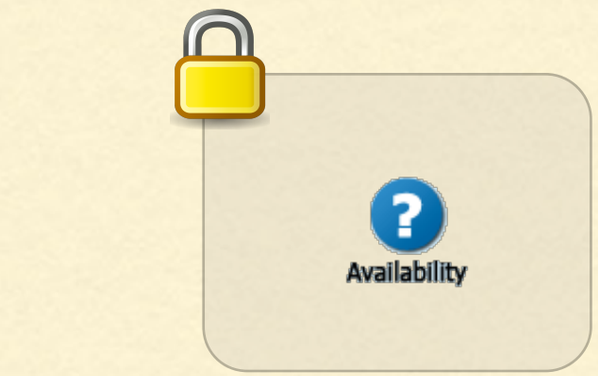
Dangerous Downgrading

Correctness of some security properties requires reasoning about the use of dangerous operations in the application



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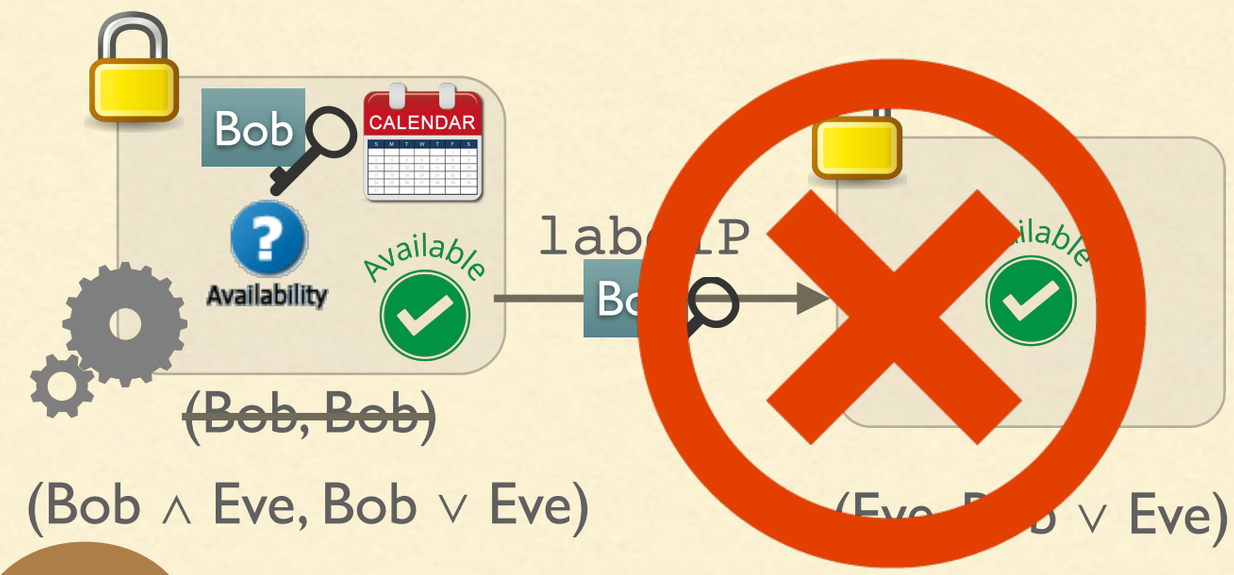

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(Eve, Bob ∨ Eve)

This work

Problem: does app use privileges correctly? May require examining all app code!

- even minor mistakes can violate security (see paper)

Our solution: restricted privileges

- declarative restrictions on privileges
- enable local reasoning about global security

We present a semantic characterization of how restricted privileges limit downgrading and evaluate their usefulness in a case study

Restricted Privileges

- **Bounded Privileges**
  - Bounds where in the security lattice downgrading can occur

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- **Bounded Privileges**
  - Bounds where in the security lattice downgrading can occur
- **Robust Privileges**
  - Restricts downgrading of information so that those influencing the declassification do not benefit from it

Bounded Privileges

Bounds *where* [Sabelfeld and Sands 2005] in the security lattice a downgrading may occur.

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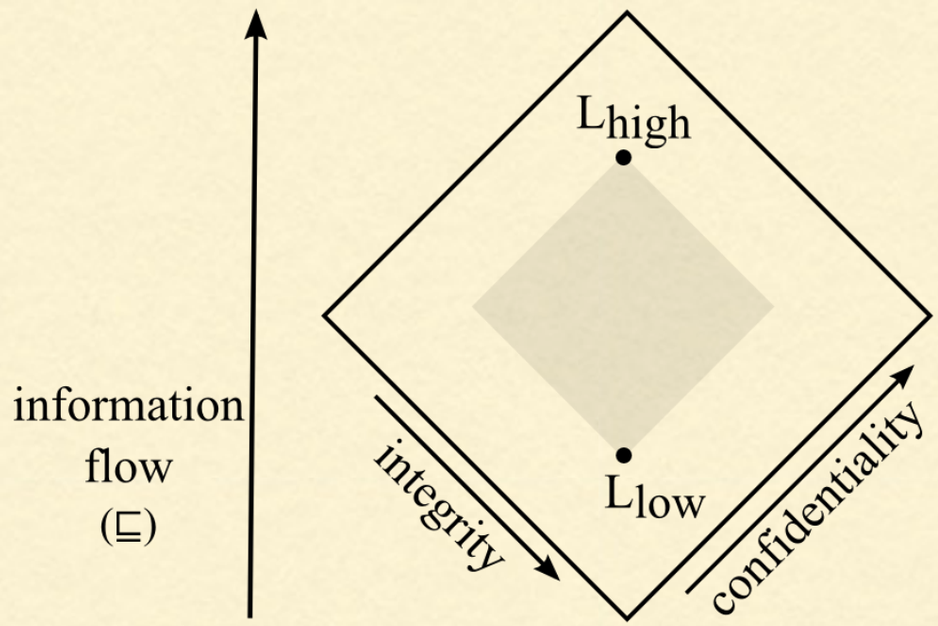

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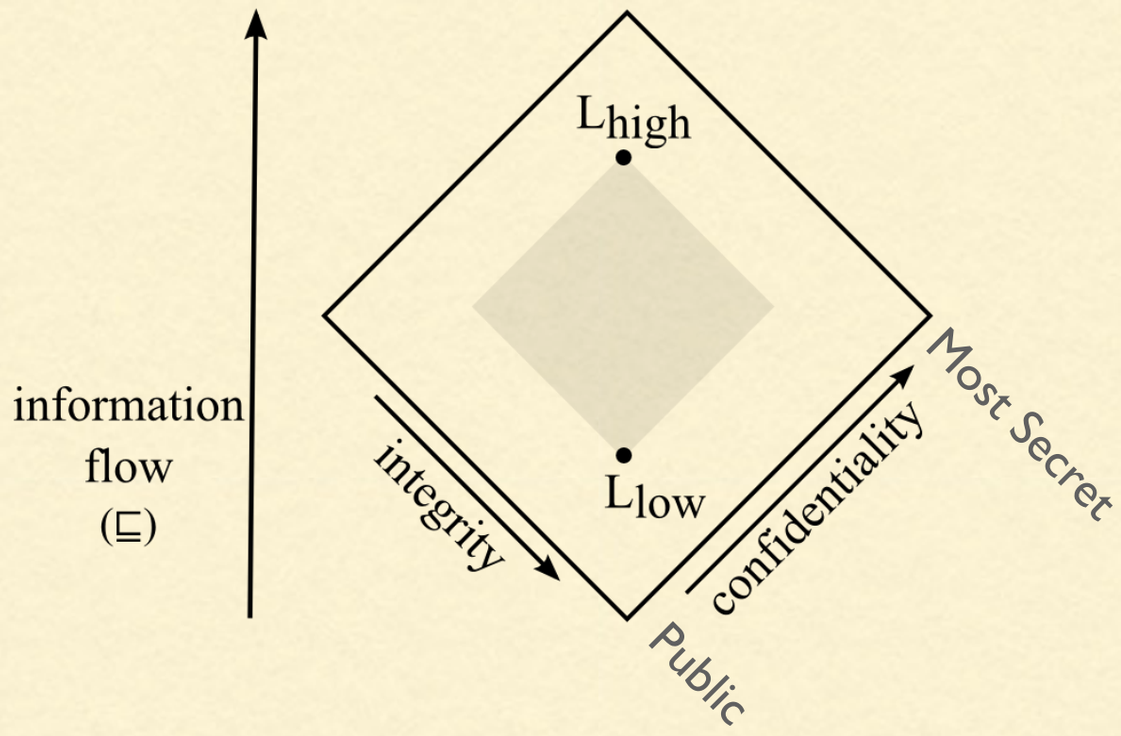

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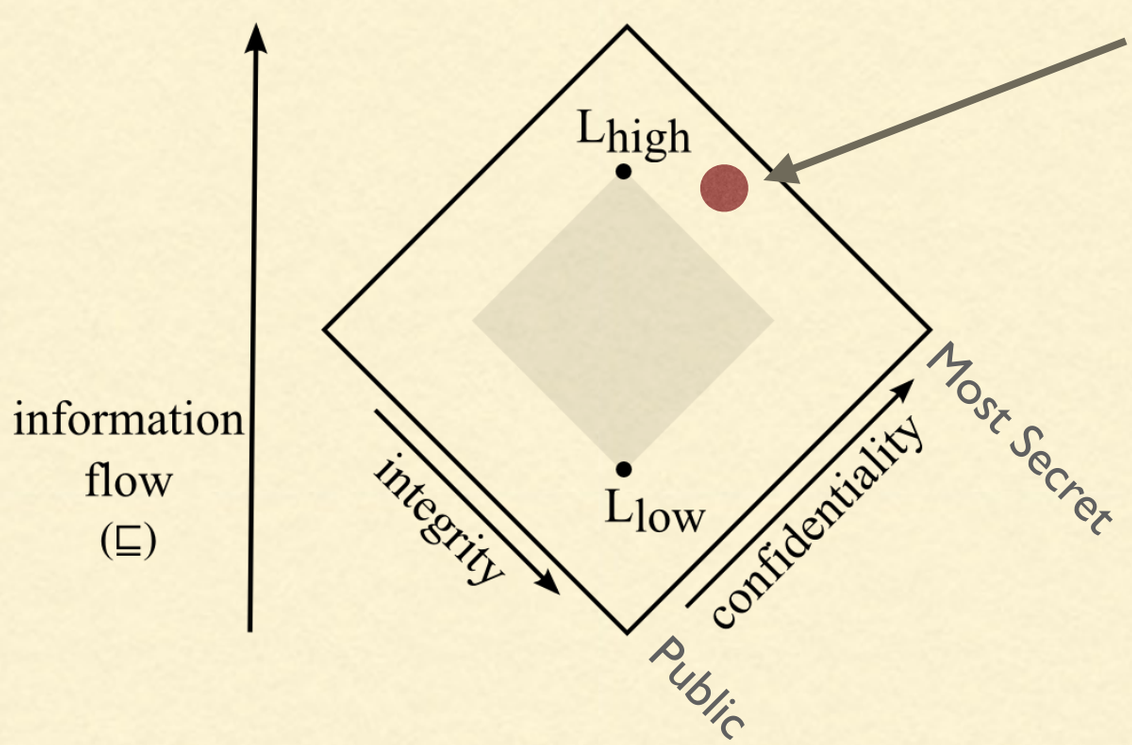

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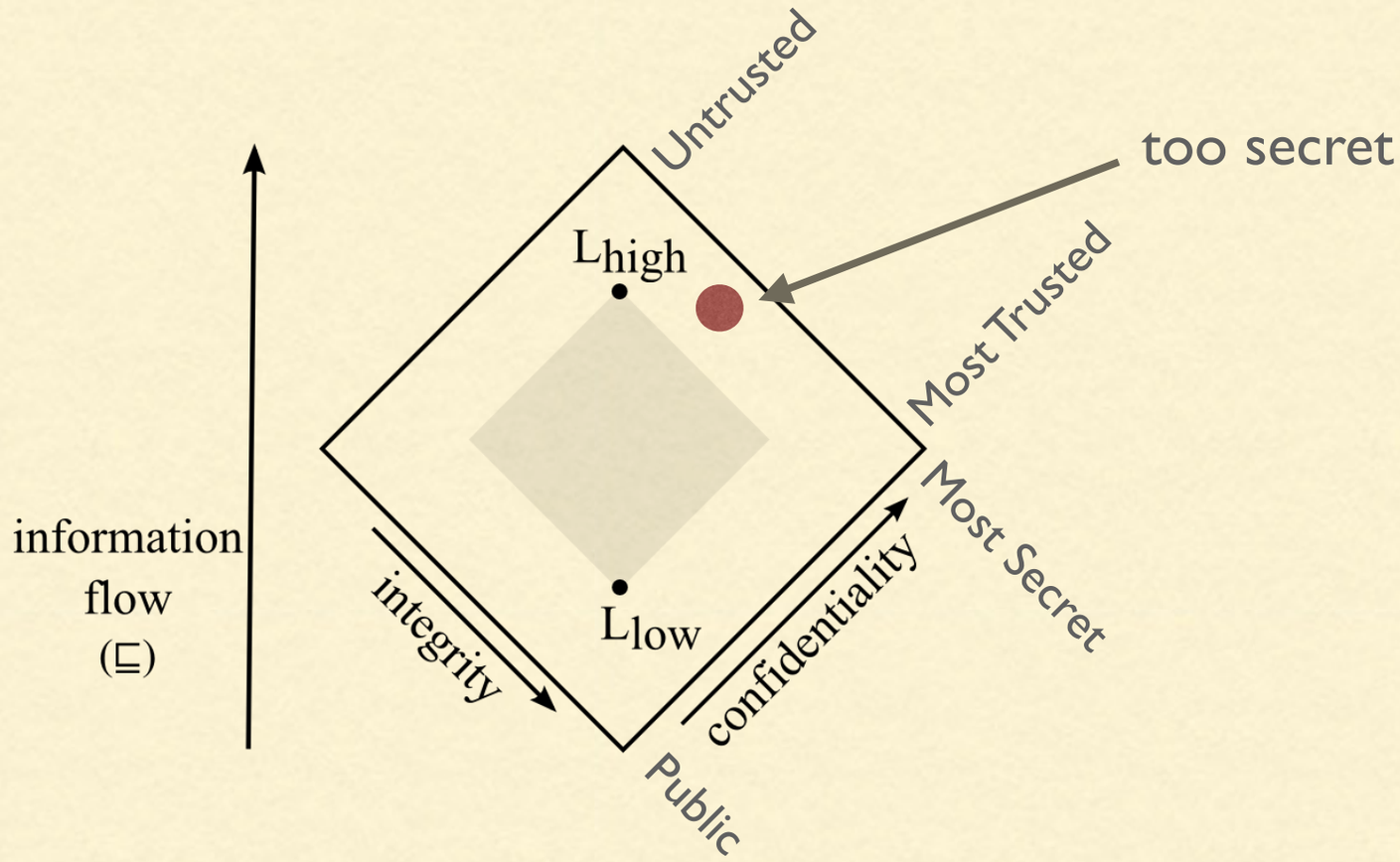

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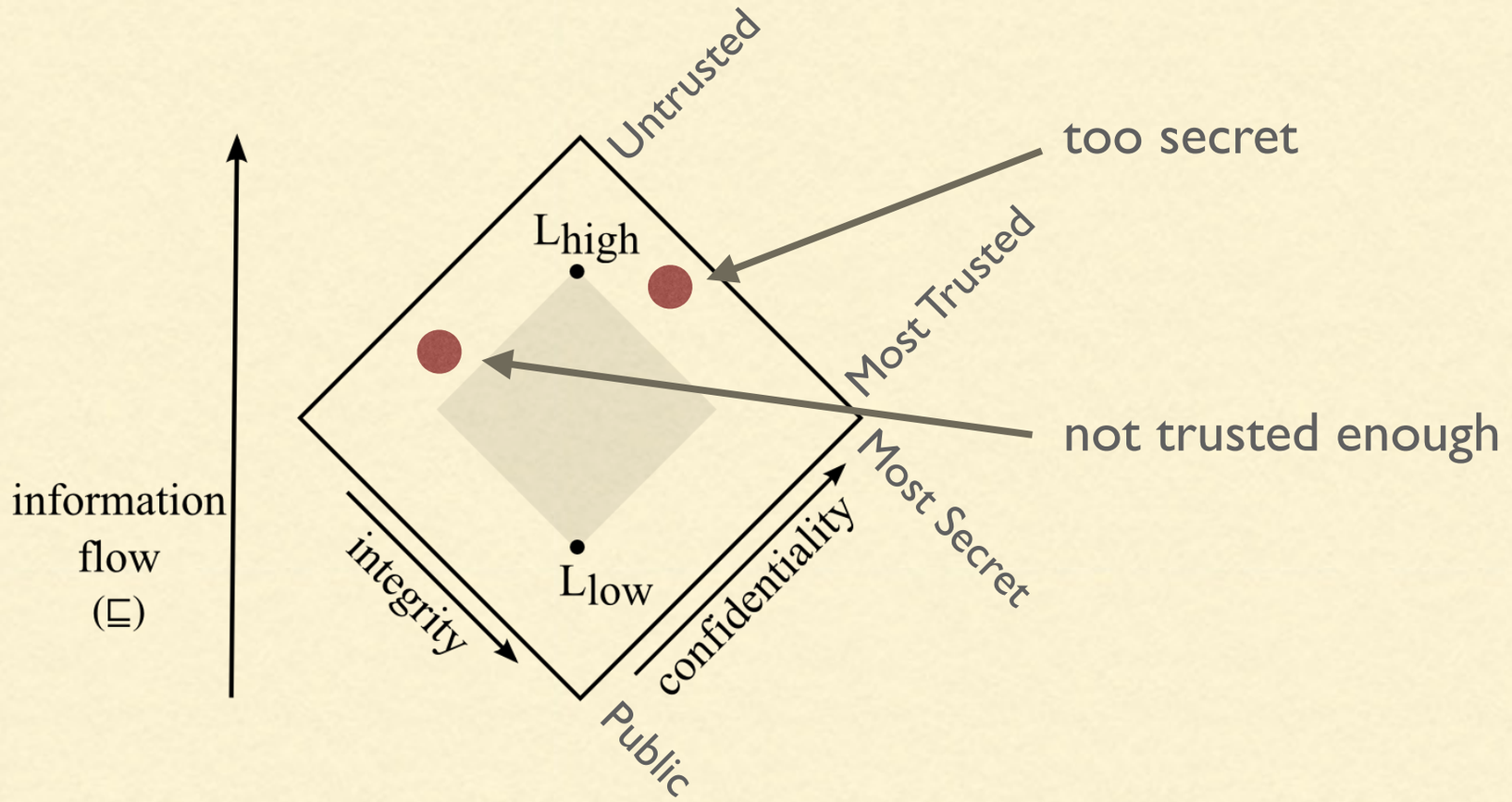
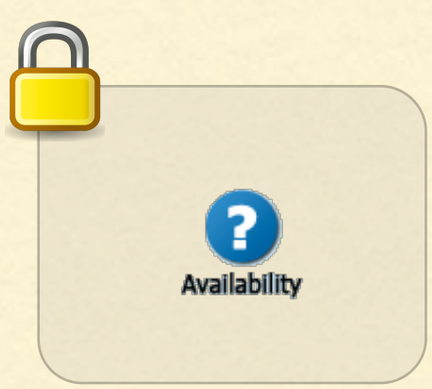


Bounded Privileges

Upper bound: (*Most Secret*, *Untrusted*)

Lower bound: (Alice, *Most Trusted*)

(Bob, Bob)

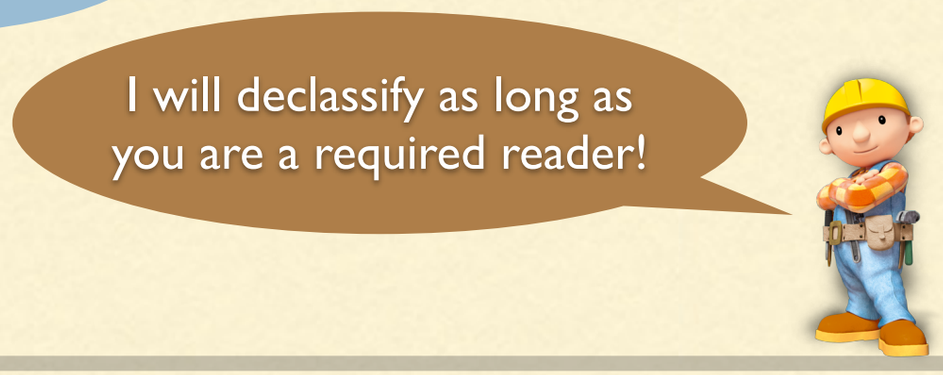


(Alice, Alice)

(Bob ∧ Alice, Bob ∨ Alice)

labelP

(Alice, Bob ∨ Alice)



Robust Privileges

- Based on **robust declassification** [Zdancewic and Myers 2001]
- Restricts *who* [Sabelfeld and Sands 2005] can influence a declassification
- **Intuition**: those who benefit from a declassification had no influence on the data or the decision to declassify.

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A formula is robust, *if:*

For all boolean formulas of principals `A`, *if*

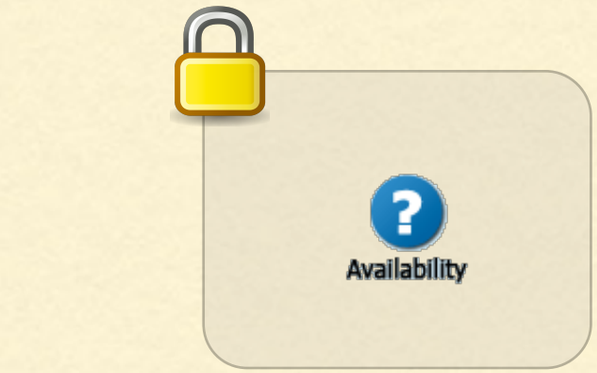
`A` can read the data but could not before the declassification

then,

`A` was not (even partially) responsible for the data, and

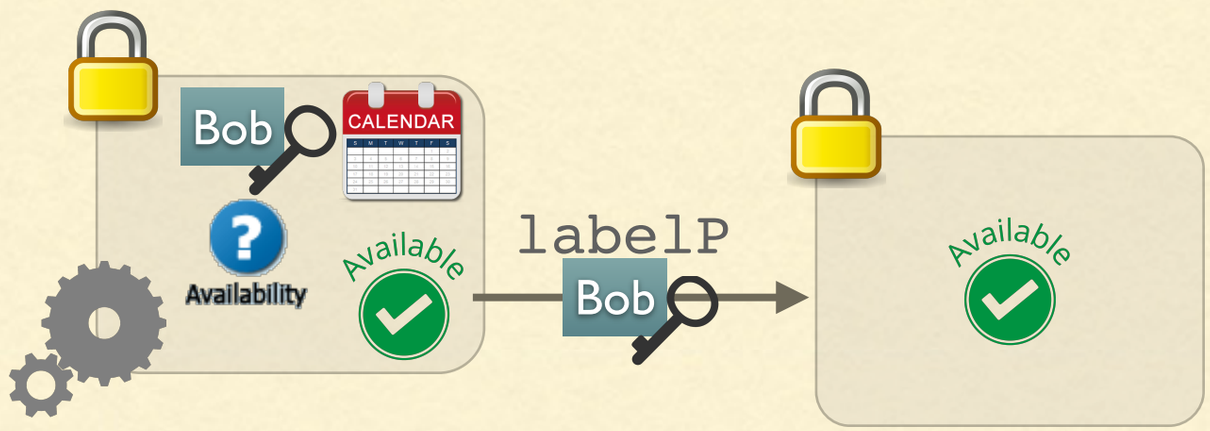
`A` was not (even partially) responsible for the current computational context performing the declassification.

Dangerous Downgrading Revisited



(Eve, Eve)

(not in Bob's study group)

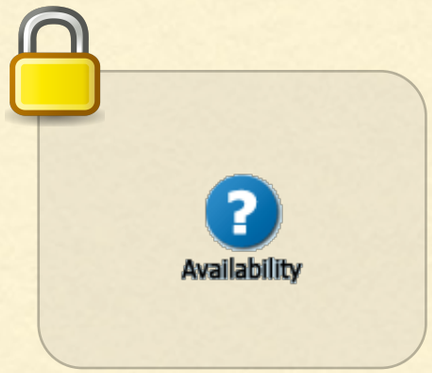


(Bob ∧ Eve, Bob ∨ Eve)

(Eve, Bob ∨ Eve)

Dangerous Downgrading Revisited

L_{from}: (Bob ∧ Eve, Bob ∨ Eve)
L_{PC}: (Bob ∧ Eve, Bob ∨ Eve)
L_{to}: (Eve, Bob ∨ Eve)



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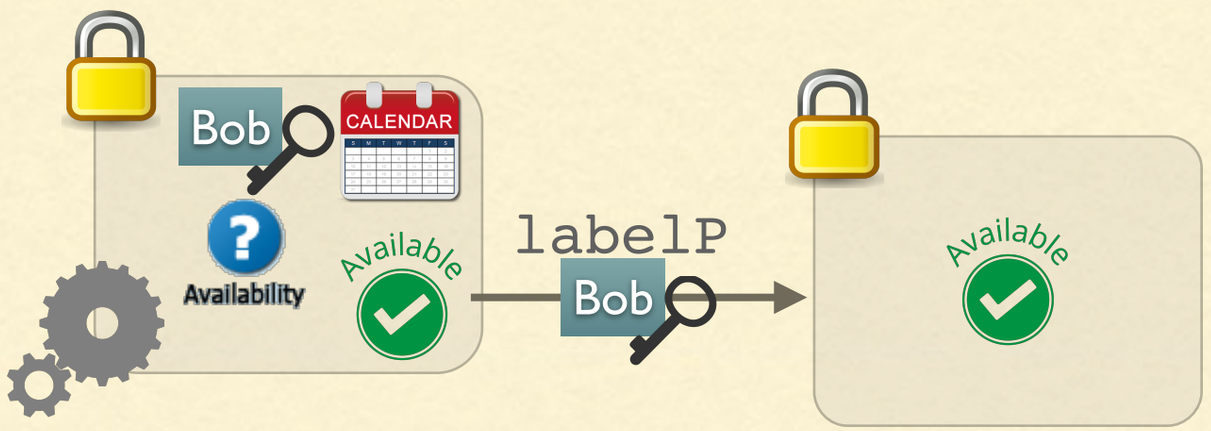
(not in Bob's study group)



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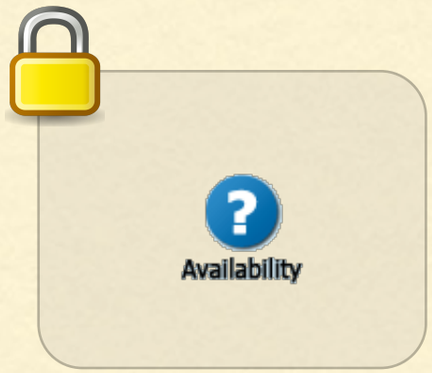
Since Eve influenced the declassification but will learn from it, declassification is not robust.



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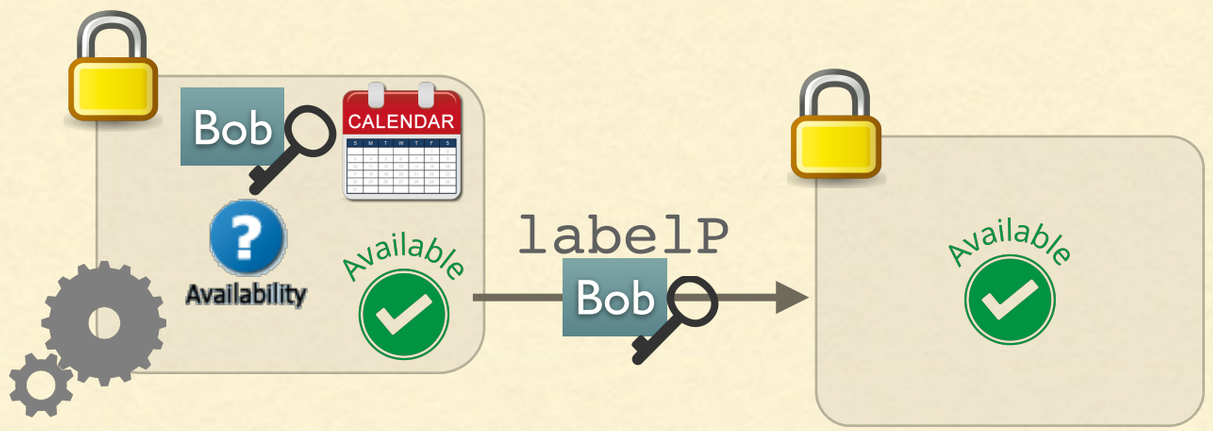

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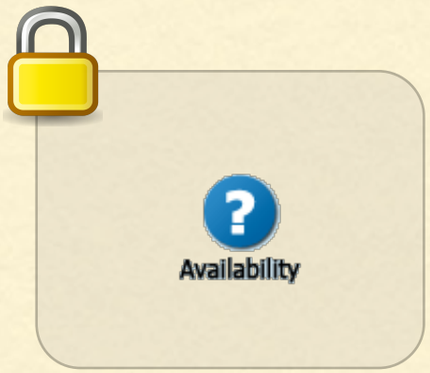
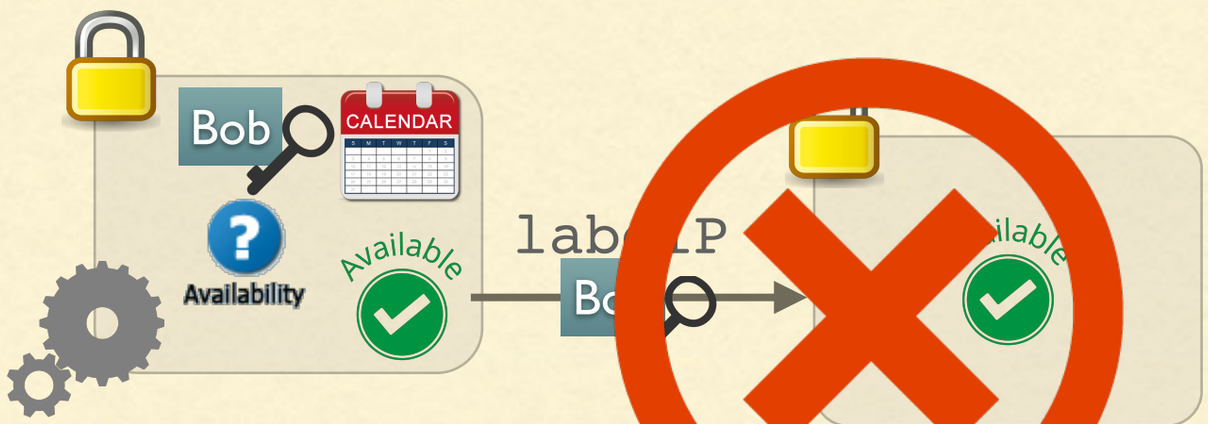


(Eve, Eve)



(Bob ∧ Eve, Bob ∨ Eve)

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(not in Bob's study group)

Composing Privileges

Composing Privileges

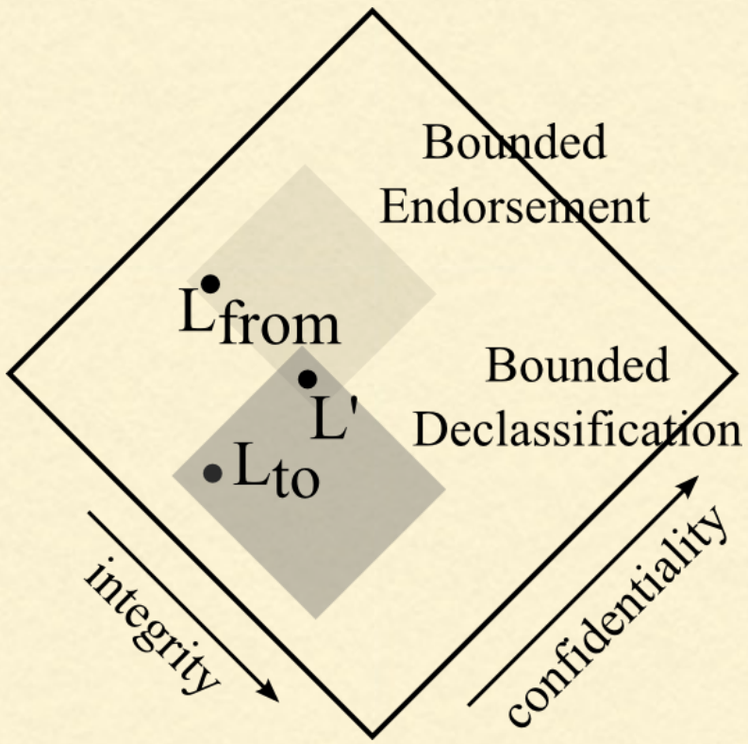
Restricted privileges can be composed with other privileges

- Bounded privilege around another bounded privilege must satisfy both bounds
- A robust declassification can be used so long as it mains some amount of secrecy (e.g., must stay within the organization)

Multiple Privileges

System may have multiple privileges available to it

- **Example**:
  - A bounded endorsement privilege can be used to go to L'
  - Then a bounded declassification privilege can go from L' to L_{to}.



Calendar Case Study

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No need to inspect how the code uses the privileges

Conclusions

- Privileges are a relatively recent and novel approach to downgrading information in IFC systems.
- Restricted privileges are a new mechanism to control downgrading in DC-labels.
- Also in the paper:
  - relationship of privileges to known semantic security guarantees
  - description of security bug in DC-labels application
  - efficient runtime checks and proofs of soundness and completeness w.r.t. formal definitions

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Restricted privileges are a **declarative** mechanism for reasoning about **global** security properties without inspecting how they might be used.