Mandatory Access Control

COS 316: Principles of Computer System Design

Amit Levy & Ravi Netravali

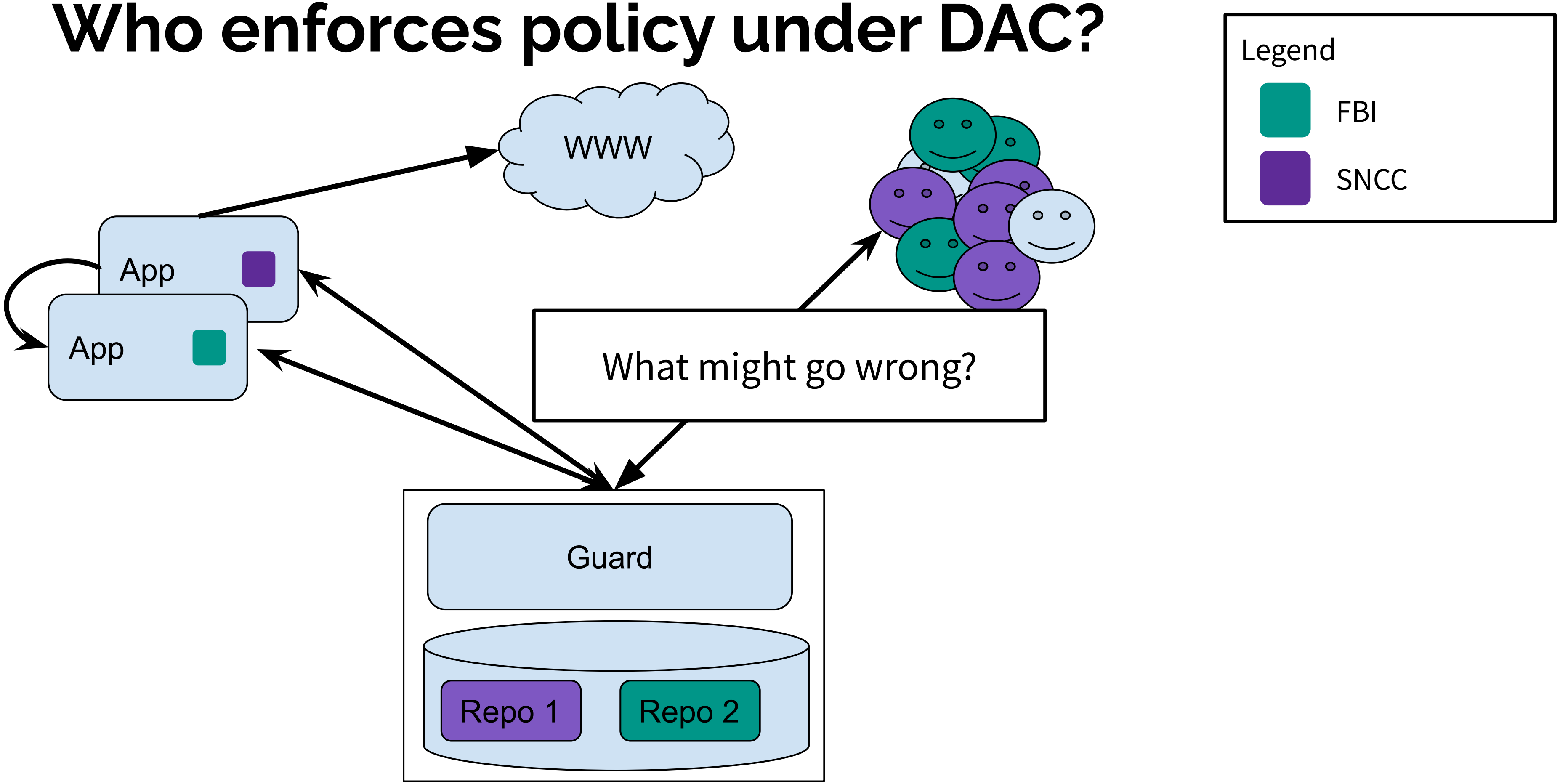
Last Times - Discretionary Access Control

Discretionary Access Control - *[Access] controls are discretionary in the sense that a subject with a certain access permission is capable of passing that permission (perhaps indirectly) on to any other subject (unless restrained by mandatory access control).*

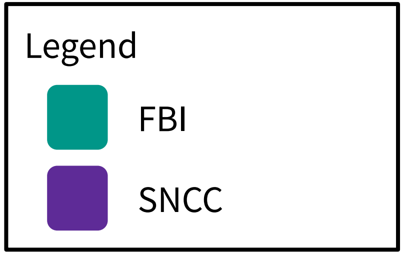
- Trusted Computer System Evaluation Criteria, 1985 (the "Orange Book")

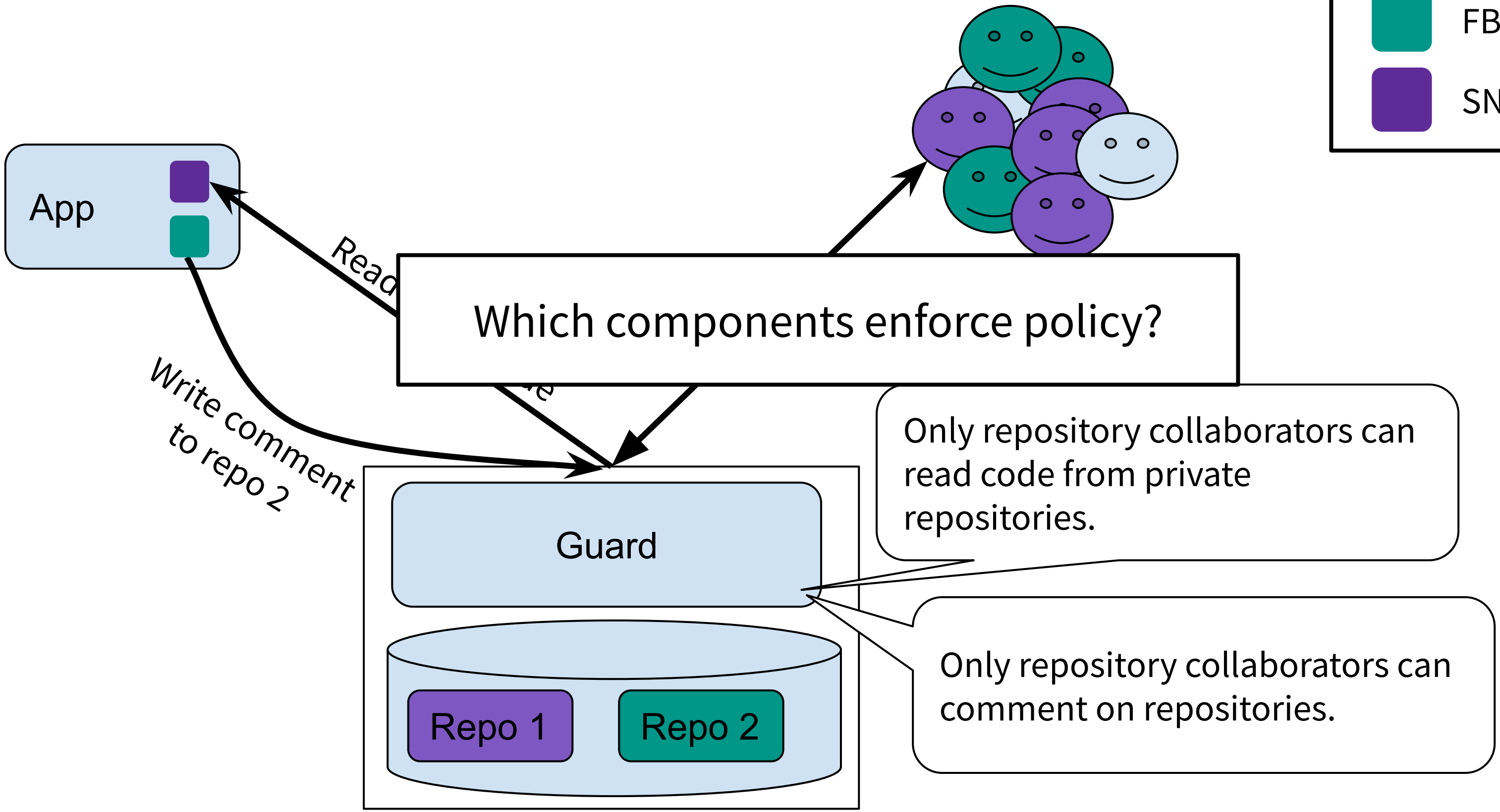
- Most prevalent form of access control system
- Access Control Lists
  - Restrict access to objects based on the identity of subjects
  - Subjects can pass object contents after reading
- Capabilities
  - Restrict access to objects based on possession of a capability
  - Capabilities can be passed directly to other subjects
  - Subjects can pass object contents after reading

Who enforces policy under DAC?

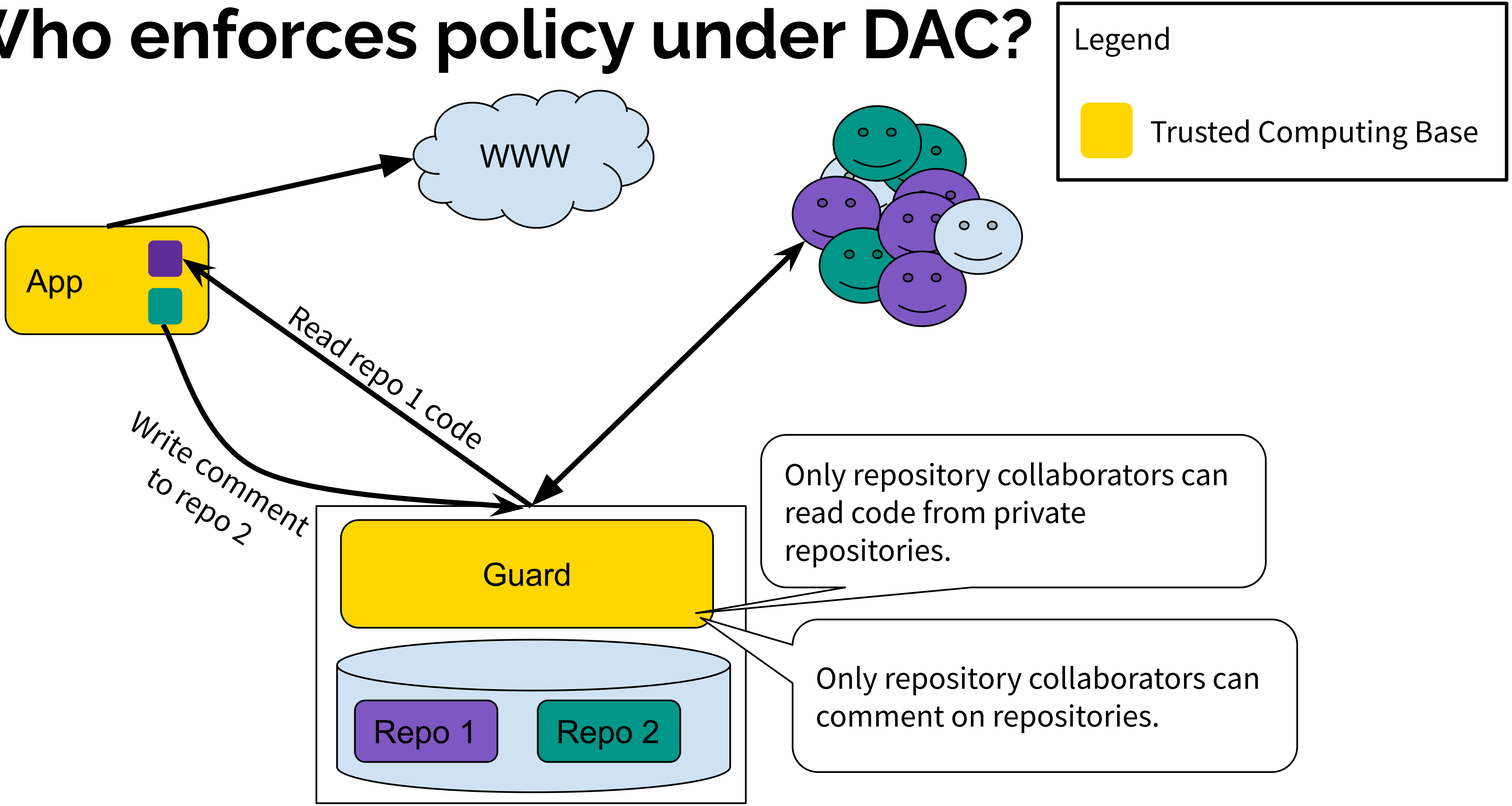


Who enforces policy under DAC?





Who enforces policy under DAC?



Limitations of Discretionary Access Control

- Discretionary means *subjects* with access to *objects* can propagate information:
  - UNIX process reads `~/.ssh/ida_rsa` and writes output to public log
  - In UNIX, owners determine read/write/execute access for themselves, group, and "other"
  - Subject can pass capabilities to anyone
  - Can't (trivially) revoke capabilities
- This is *one* reason it is sufficient to compromise a single high privilege application, not whole system, in order to extract private data

The non-interference property

Informally:

A program is non-interferent if it’s transformations of data in low security domains (*low*) are not influenced by data in higher security domains (*high*)

The non-interference property

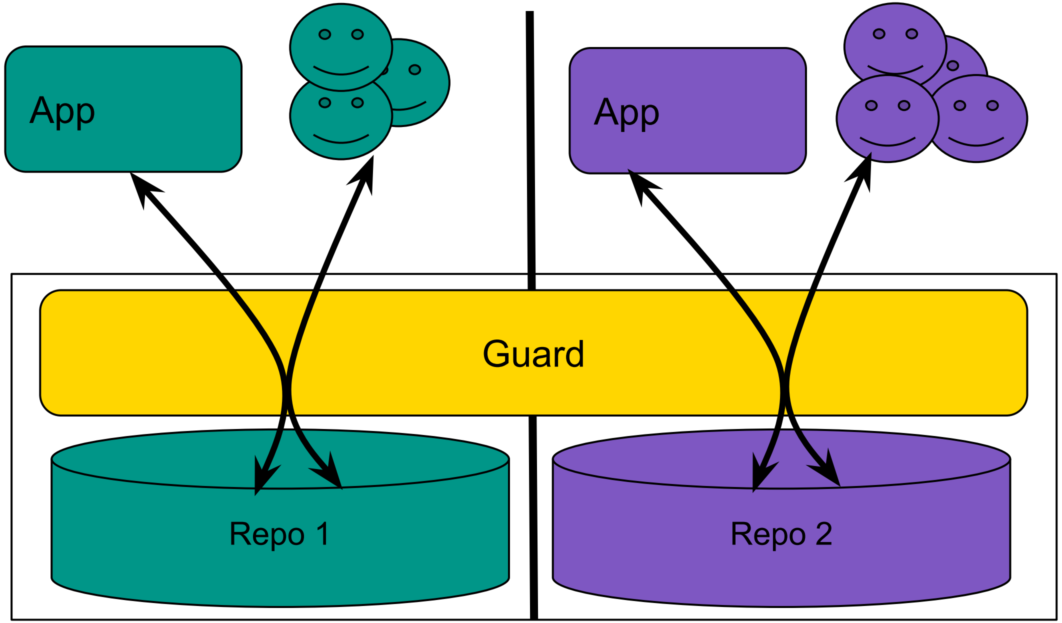
M, a memory state including *low* and *high* memory, M_H and M_L, respectively

P: $(M) \rightarrow M^*$, a non-interference program execution over a memory state resulting in a new memory state, if:

$$
\begin{aligned}
\forall\, M1, M2 \text{ s.t. } & M1_L = M2_L \\
& \wedge\ P(M1) \rightarrow M1^* \\
& \wedge\ P(M2) \rightarrow M2^* \\
\Rightarrow\ & \boldsymbol{M1^*_L = M2^*_L}
\end{aligned}
$$

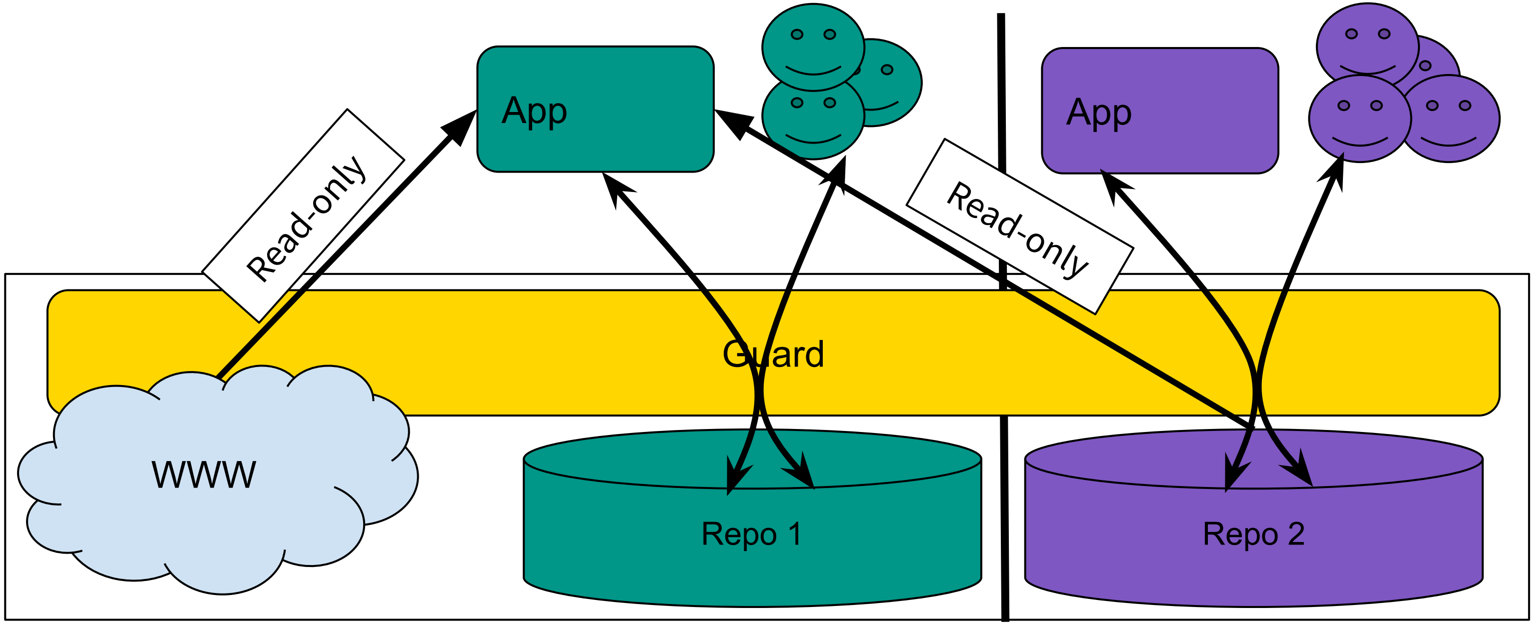
Enforcing Non-Interference with DAC

Discretionary Access Control policies can enforce non-interference by completely partitioning the system



Enforcing Non-Interference with DAC

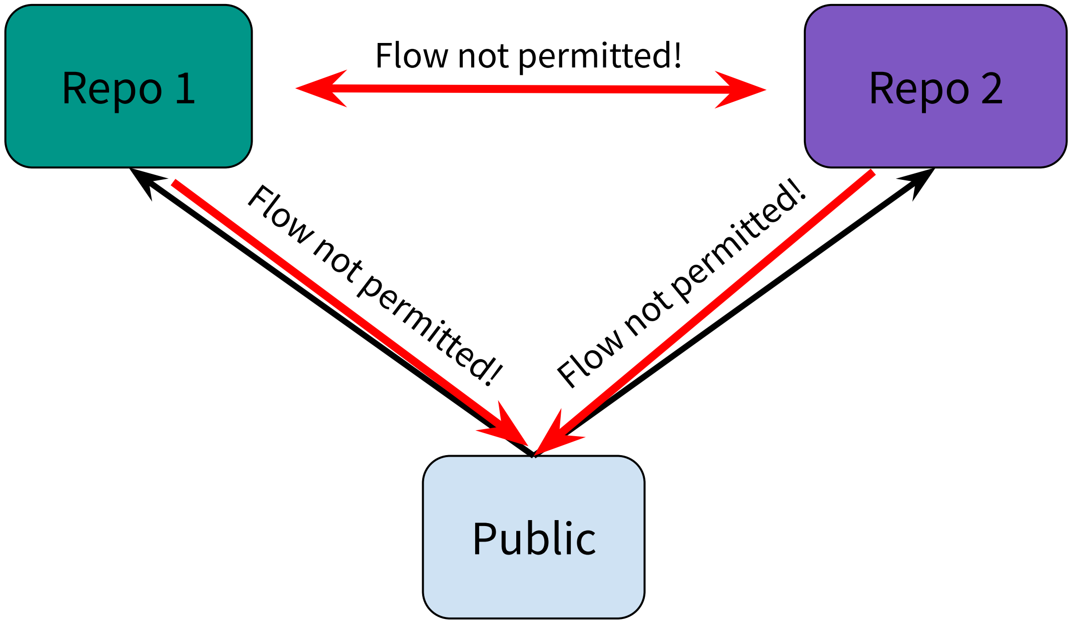
Discretionary Access Control policies can enforce non-interference by completely partitioning the system, or with careful, static sharing



Mandatory Access Control (MAC)

- Goal: data secrecy & integrity don't rely on trusting applications *at all*
- All resource accesses governed by a global policy
- Subjects cannot change or circumvent global policy
- Typically policy articulated in terms of data sources and sinks
- E.g.
    - *label* data with it's sensitivity
    - define permitted flows between labels
    - Permit operations as long as information flow rules are not violated

A simple security label lattice



Implementing MAC

There are very few MAC systems used *in practice*:

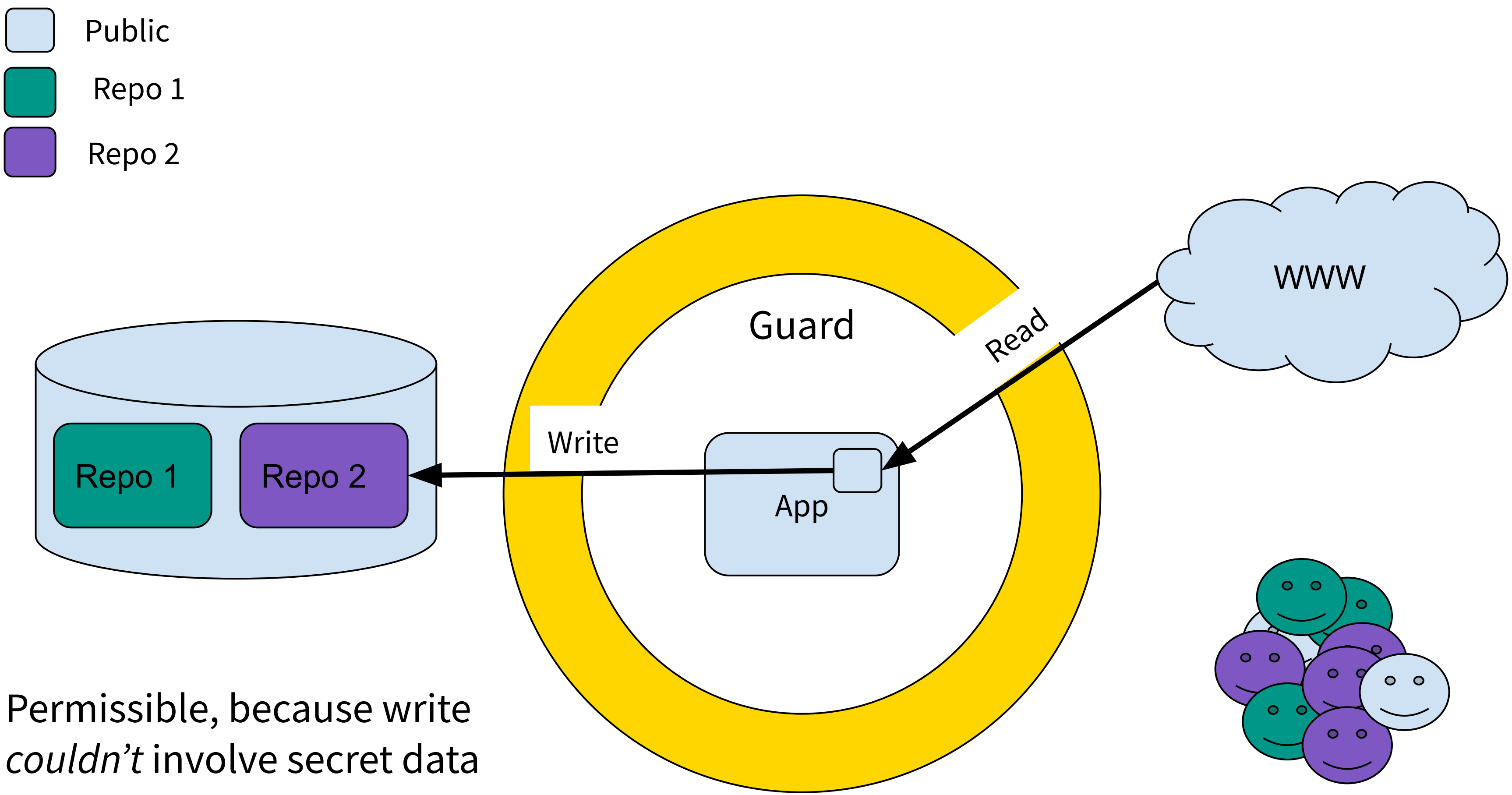
- SELinux - an extension to Linux originating from the NSA
  - Used in Android
- Mandatory Integrity Control - a Windows kernel subsystem limited to integrity
- TrustedBSD (in development)

But lots of *research* systems

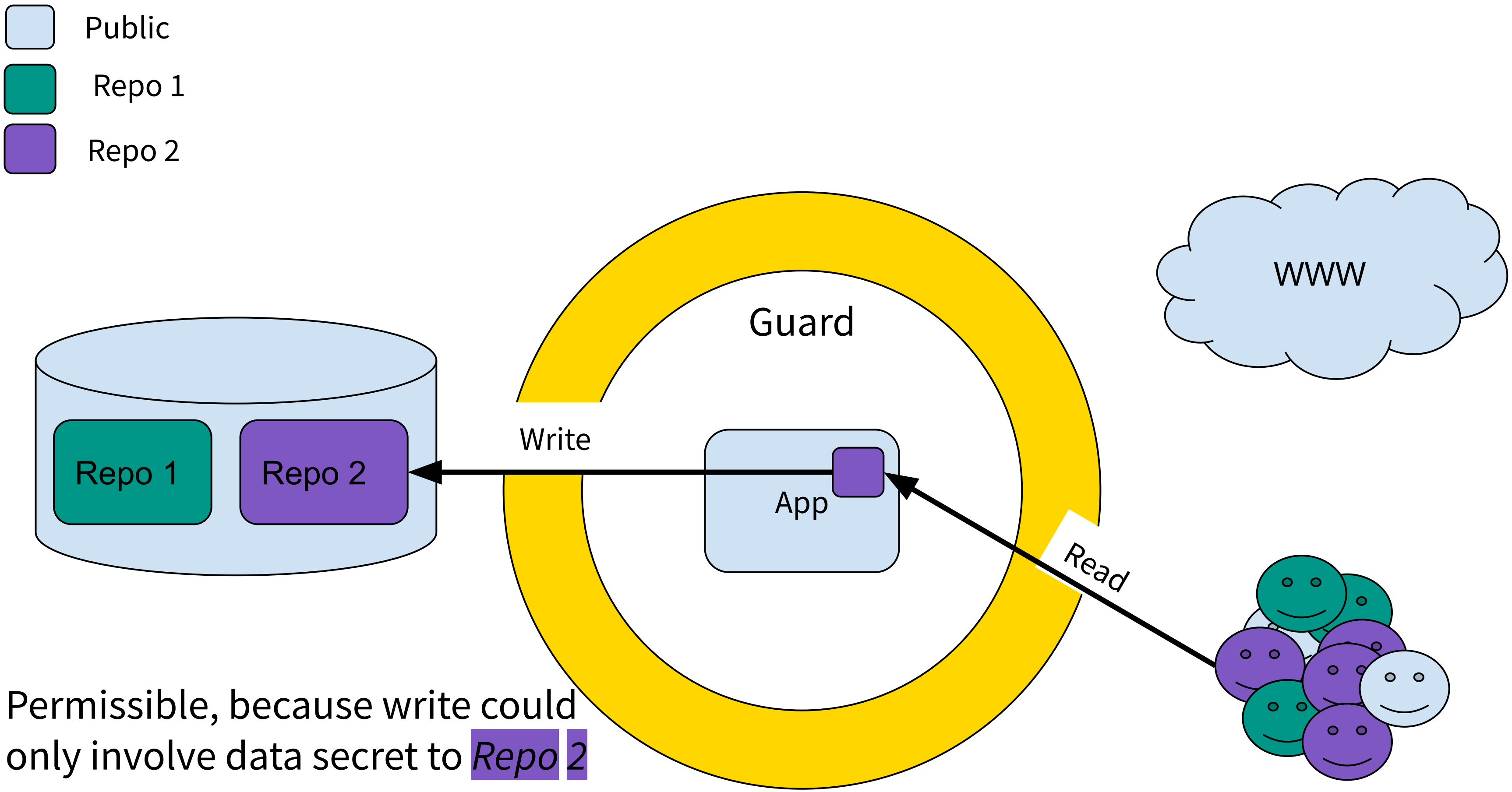
Implementing MAC

One general approach:

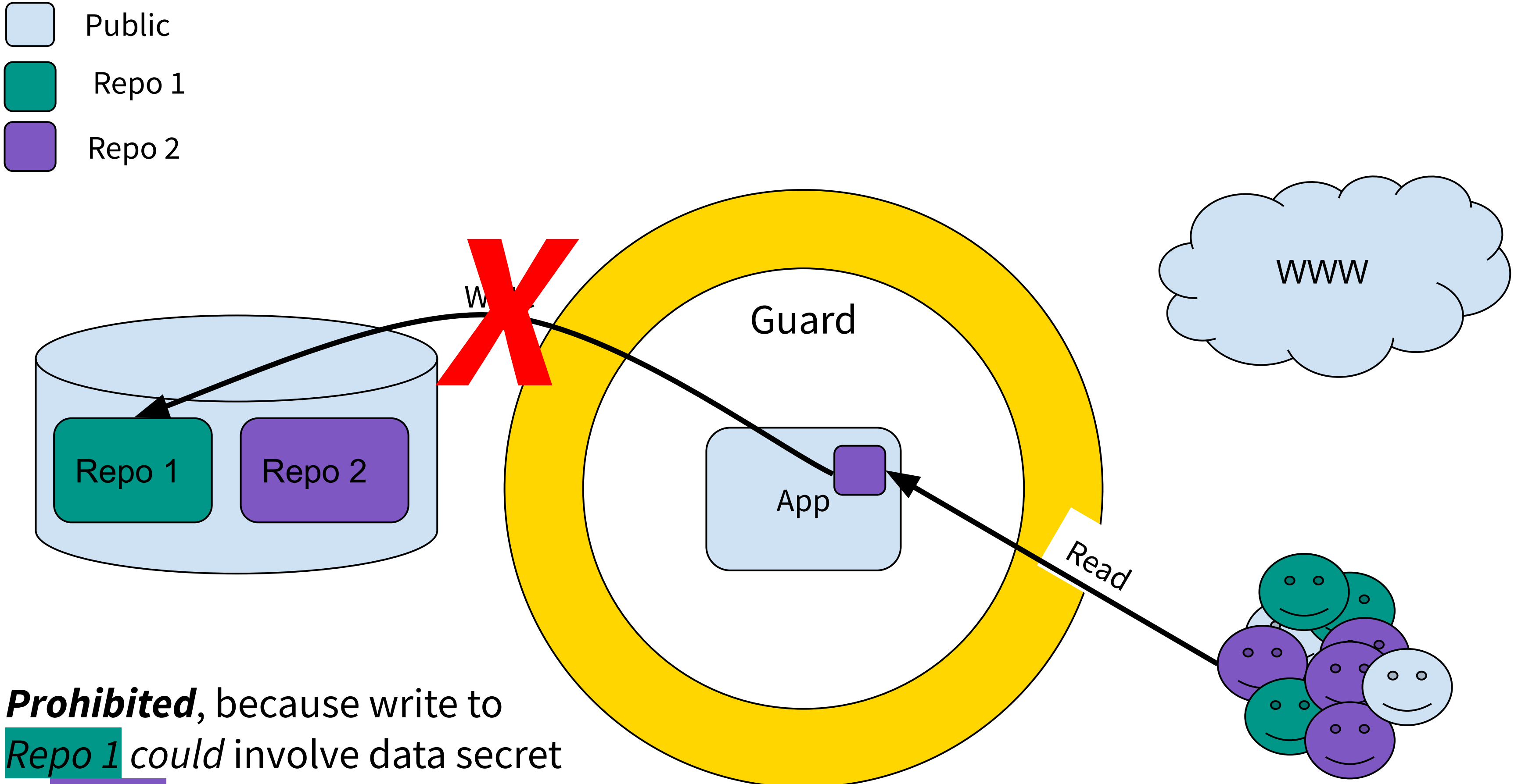
- Assign a security label to object (file, network endpoint, console, etc)
- Assign a *floating* label to subjects (running processes)
    - “Floating” because it changes dynamically
- Whenever moving/copying data, check that source label *can flow to* sink label
- Allow subject to “raise” its floating label, but not to “lower” it



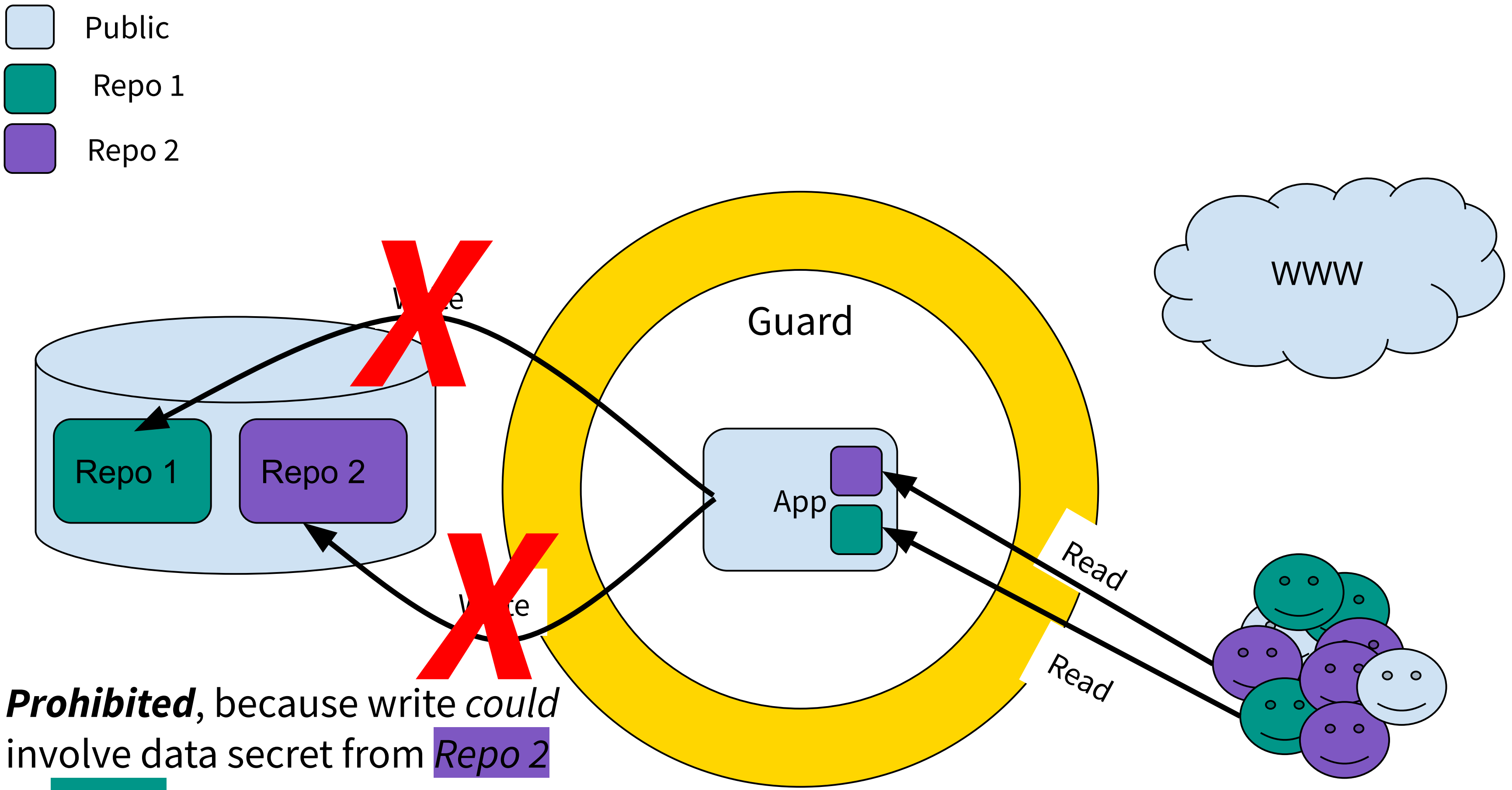
Permissible, because write *couldn't* involve secret data



Permissible, because write could only involve data secret to *Repo 2*



Prohibited, because write to *Repo 1* *could* involve data secret to *Repo 2*



Prohibited, because write *could* involve data secret from *Repo 2* or *Repo 1*

Mandatory Access Control in Practice

- Dates back to at least 1983
  - Defined in the DoDs *Trusted Computer System Evaluation Criteria* (aka the Orange Book)
- Very powerful guarantee!
  - Security policies on data *do not* rely on application correctness
- Why is it not more prevalent?

Why isn't MAC more prevalent?

- Complexity: implementing MAC can be hard to get right
- Performance: lattice checks can be slow
- Flexibility: by design, applications cannot get around security policy
- Simplicity: MAC is harder to administer