Access Control

COS 316: Principles of Computer System Design

Lecture 14

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Access Control

- Restrict access to resources based on the principle trying to access them
  - Canvas:
    - Only Wyatt & Rob can update grades
    - Only you and course staff can see your grades
  - File system on my laptop:
    - Only Wyatt can update or read /Users/wlloyd/.ssh
    - Everyone can read /usr/bin/
  - Facebook:
    - Only I can create posts as me
    - Only the selected audience (global, friends, …) can read the posts

A (Slightly) Formal Model

- Resources: the things being accessed
  - A file, network socket, satellite imagery of “nuclear facilities,” missile launcher...
- Subjects: an entity that requests access to an resource
  - A process, network endpoint, …
  - Principal: some unique a account or role, such as a user

Ad-hoc Access Control

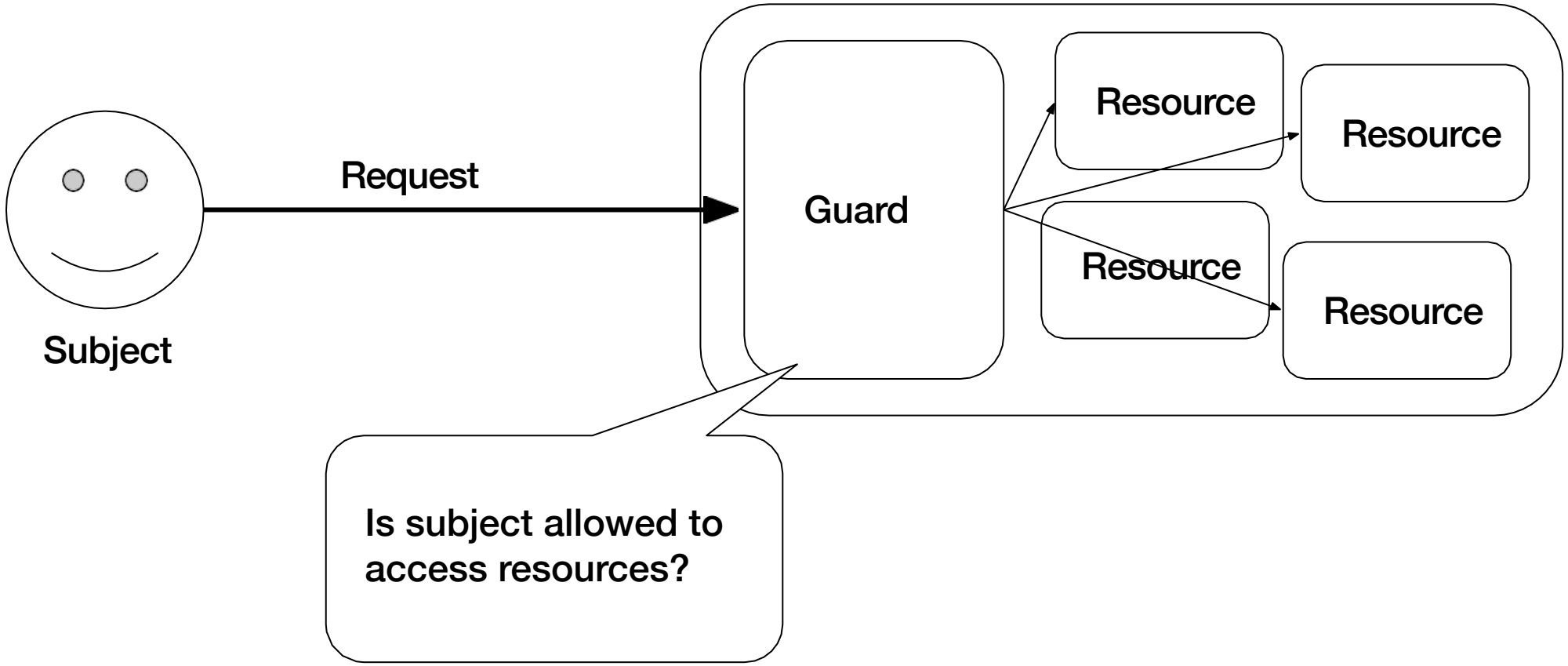
- Access policy enforcement is scattered throughout system

```
fn (profile *Profile) viewProfile(user) (HTML) {
   if profile.public ||
       profile.friends.contains(user) {
      return profile.HTML
   } else {
      return HTML.Forbidden
   }
}
```

```
  fn (profile *Profile) viewFullName(user) (HTML) {
     if profile.public || user.handle ==
                                  “NSA_Backdoor” {
      return profile.FullName.HTML
   } else {
      return HTML.Forbidden
   }
}
```

- *Why is this a bad idea?*

The Guard Model



Examples of the Guard Model

- Kernel
  - File system permissions: as long as resources modeled as files, access checks are centralized
  - Reference monitor
- Networks
  - Firewall
  - Apache HTTP Server's .htaccess rules

The Guard Model

- A mechanism, leaves us with many questions:
  - How do we ensure applications only interact via the guard?
  - What kinds of rules does the guard enforce?
  - Who gets to set or change the rules?
  - What is the granularity of subjects and resources?
  - Who gets to create new principles?

- Answers to these questions help determine the expressivity, performance, and security of the system.

Enforcing the Guard Through Isolation

- Key idea, either:
  - Don't “connect” resources directly to applications, only to guard
  - Ensure (somehow) resources access embed guard rules
  - Some combination

- There are three basic kinds of isolation:
  - Hardware enforced:
    - memory protection
    - put the guard and resources on different machines
  - Language-based isolation: use restrictive language to express applications
    - type-safe languages
  - Static validation: symbolic execution, software fault isolation

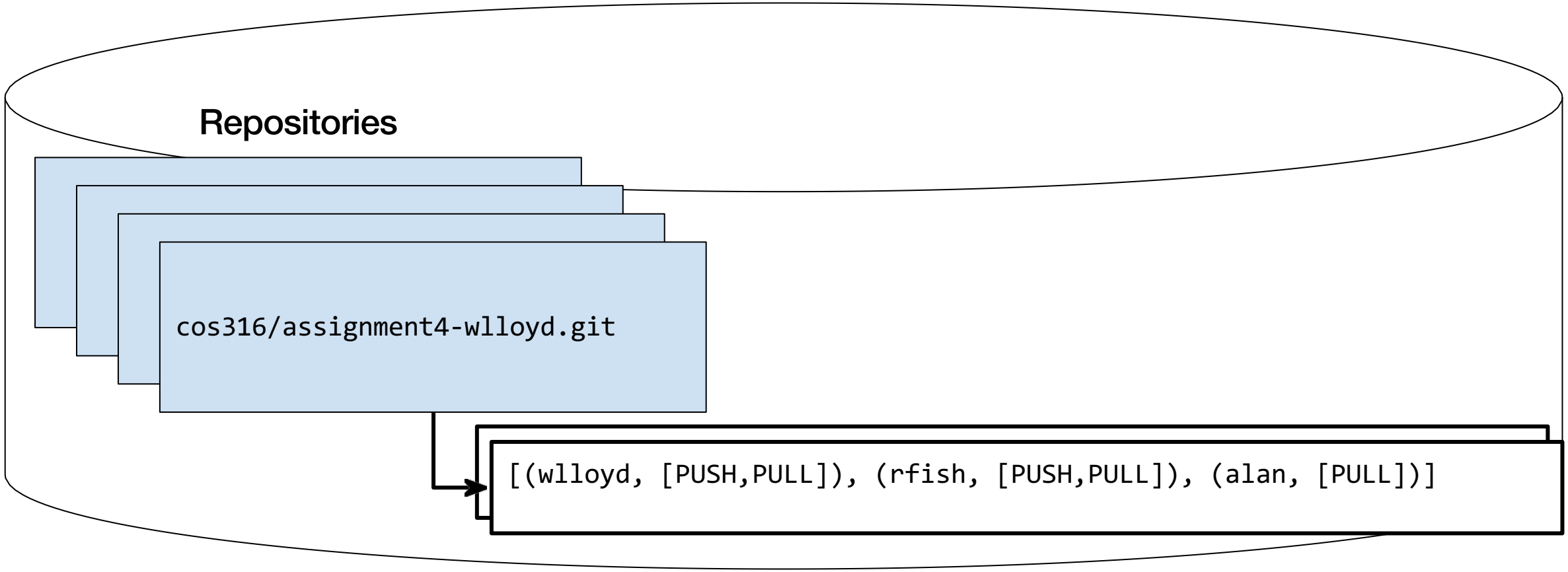
What kinds of rules?

- There are many “policy languages”
  - Access control lists: which subjects can read/write which resources
  - Capabilities: unforgeable tokens that encode specific rules on resources
    - Subjects unnamed
  - Information flow: the relationship between data sources and data sinks
    - Neither subjects nor resources named

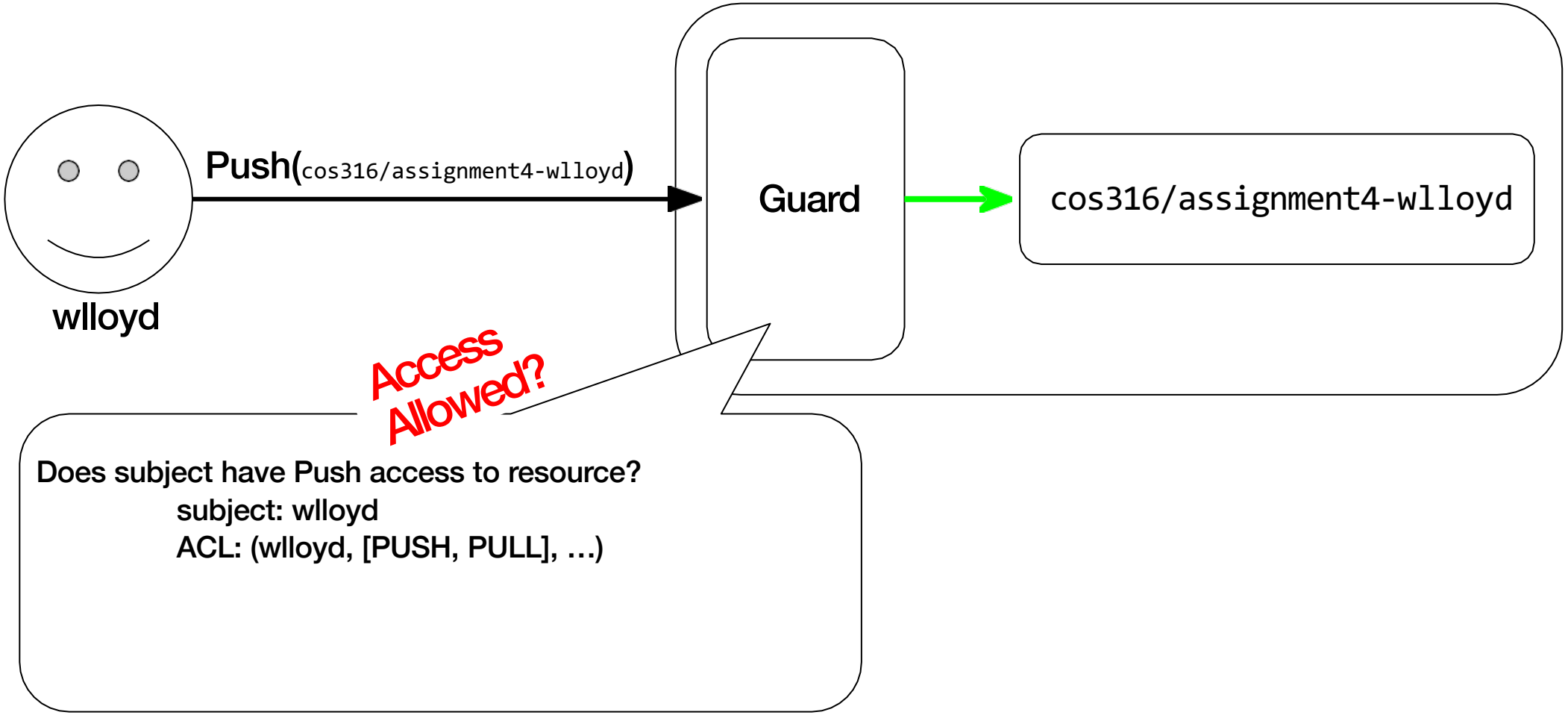
Access Control Lists (ACLs)

Let's Start with User Permissions

- Associate a list of (user, permissions) with each resource



ACLs in Action



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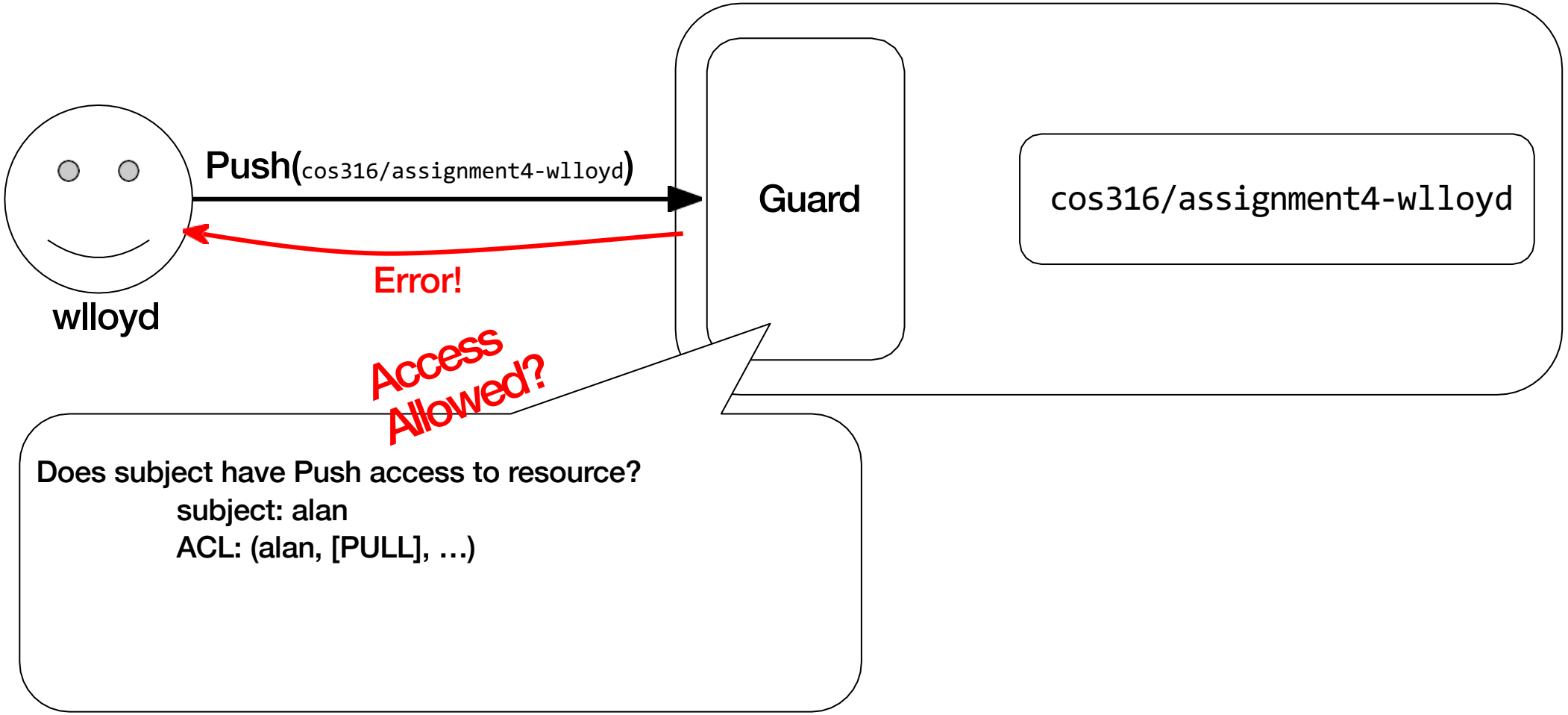

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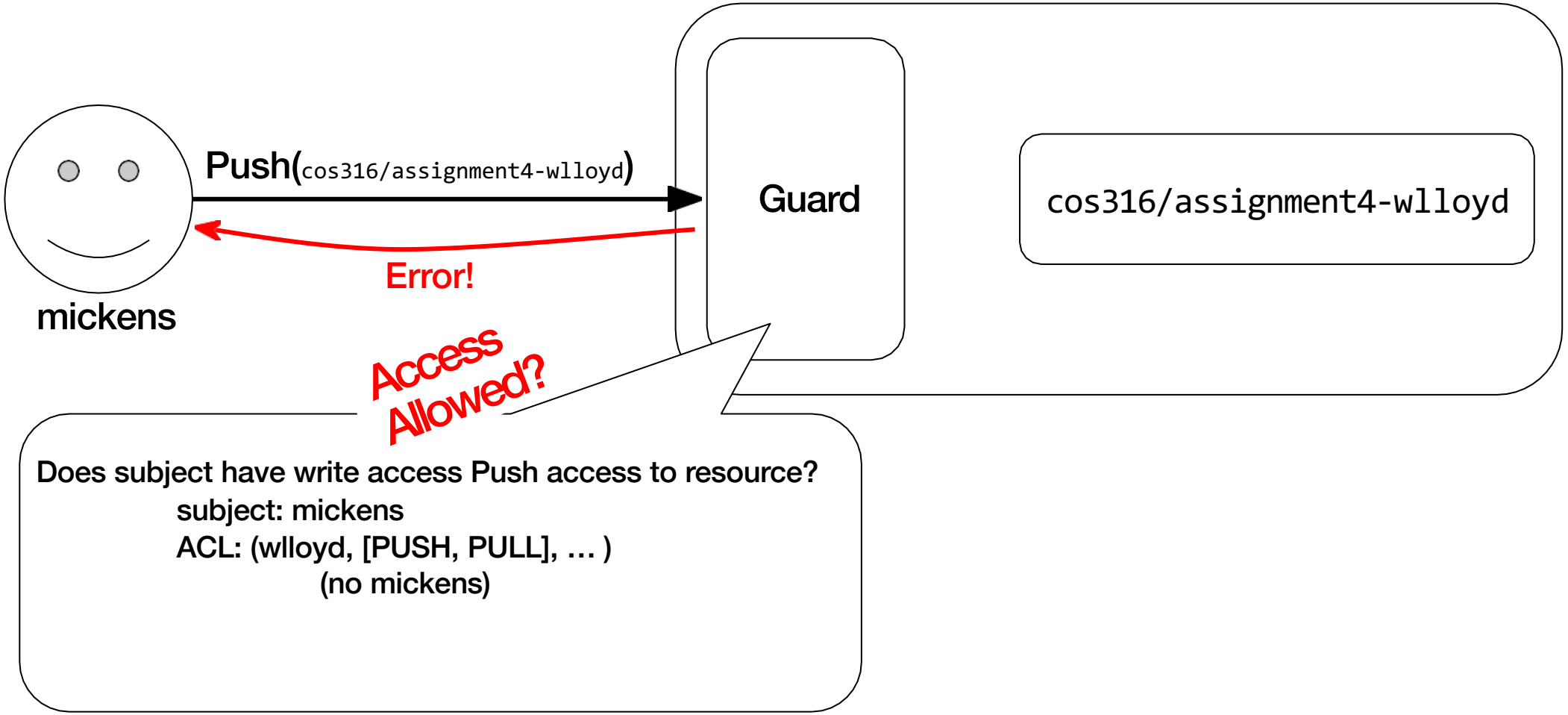

ACLs in Action Q & A

- How do we know subject?
  - Authenticate use username/password, ssh key, …

Extending ACLs to Apps: a-la UNIX

- Applications act on behalf of users
- When an application makes a request, it uses a particular user's credentials
  - Either one user per application
  - Or different users for different requests
- Works great for:
  - Alternative UIs, e.g., the `git` client vs. the GitHub Web UI both act on behalf of users

Extending ACLs to Apps: Special Principles

- Create a unique principles for each app
  - E.g., the “autograder” principle
  - Acts just like a regular user
- When applications make request, they use their own, unique, credentials
- Add application principles to resource ACLs as desired

- Works when
  - Applications need to operate with more than one user's access
    - e.g., the autograder needs to access private repositories owned by different students
  - and less than any one user's access (e.g., less than mine)
    - E.g. the autograder shouldn't be able to access non COS316 repositories

Access Control Lists

Advantages

- Simple to implement
- Simple to administer
- Easy to revoke access

Drawbacks

- Tradeoff granularity for simplicity
  - More granular permissions require more complex rules in the guard
- Doesn't scale well
  - e.g., need up to Users * Repos * Access Right entries in ACL table

Summary

- Access control is a reflection of some real-world policy
  - Design with care
- Ad-hoc access control is very common, but problematic, so prefer systems
- The guard model separates security enforcement from other functionality
- Behavior of a security system is determined by:
  - Isolation mechanism
  - Policy rules
  - Granularity of subjects/resources
- Access Control Lists:
  - Common, but some limitations…