

# Privileged Programs & Program Inputs

## The Set-UID Mechanism & Environment Variables (Part I)

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CSCI 476 - Computer Security  
Spring 2020

Some slides and figures adapted from Wenliang (Kevin) Du's  
**Computer & Internet Security: A Hands-on Approach (2nd Edition)**.  
Thank you Kevin and all of the others that have contributed to the SEED resource!

# Today

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## Announcements

- We need a note taker for the class! ➔ **Contact ODS if interested**
- Lab 00 ➔ ***It's up!***
- Lab 01 ➔ ***Will be posted Thursday***
- **REMINDER:** Bring your laptops (especially on Thursdays!)
- **REMINDER:** Sign-up for Slack ASAP!

## Goals & Learning Objectives

- Wrap up review of basic Linux commands + basic ideas in Linux security
- Understand the need for privileged programs
- Understand how the Set-UID mechanism works + attack surface of (Set-UID) programs

# How would you protect your computer & its resources?

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**Ideas?!**



Convenience / ease of use

vs.

Security / privacy

VPNs  
Privacy  
anonym.

vs.

Authentication  
passwords  
Users

Be smart  $\Rightarrow$  exercise caution / take care  
~~Don't be dumb~~

Restricted  
Usage

encryption / hashing (crypto)

Daemon — Service

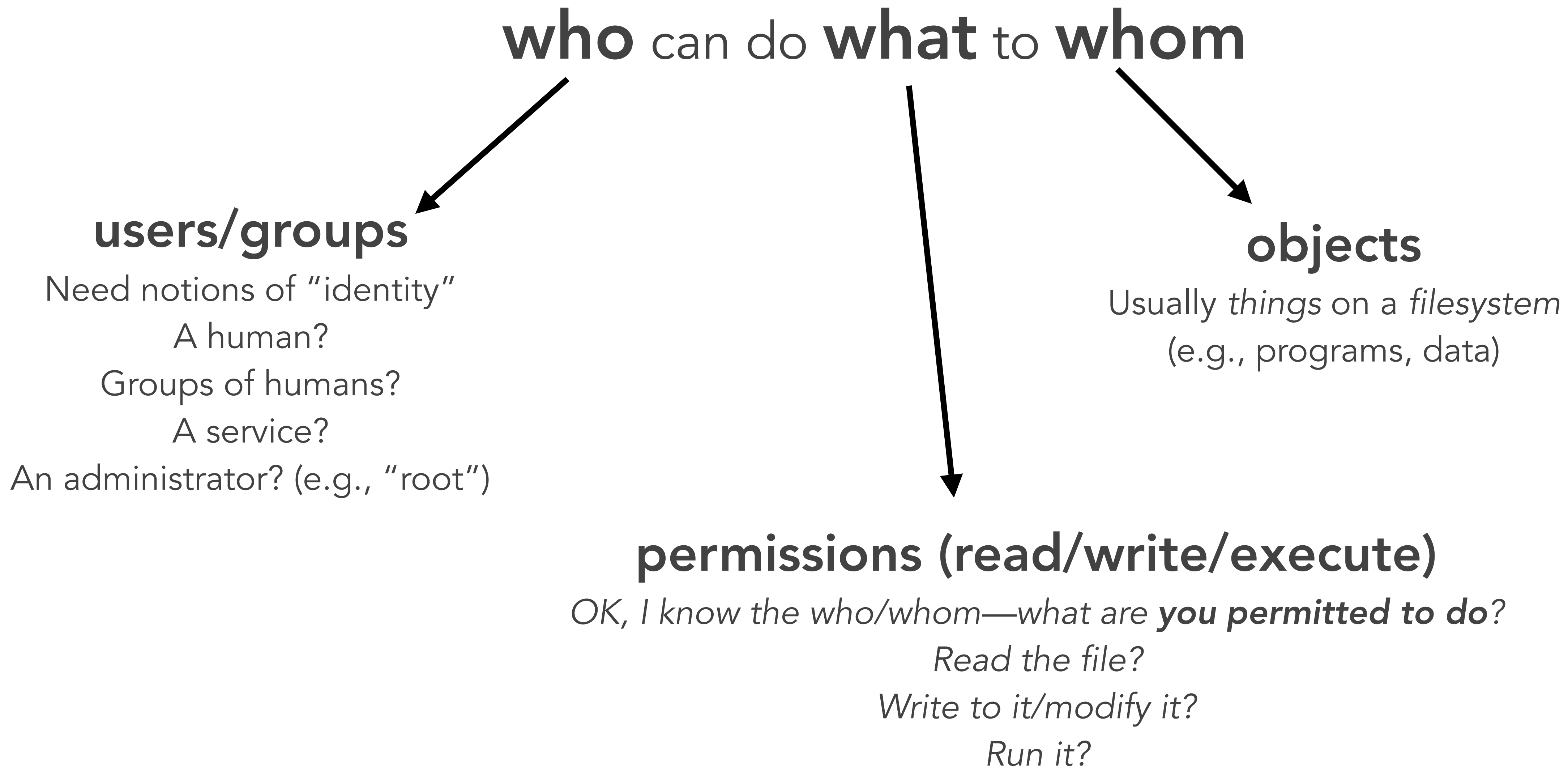
Context / location  
"Domains" public/private

File-based permissions  
(access control)



# How would you protect your computer & its resources?

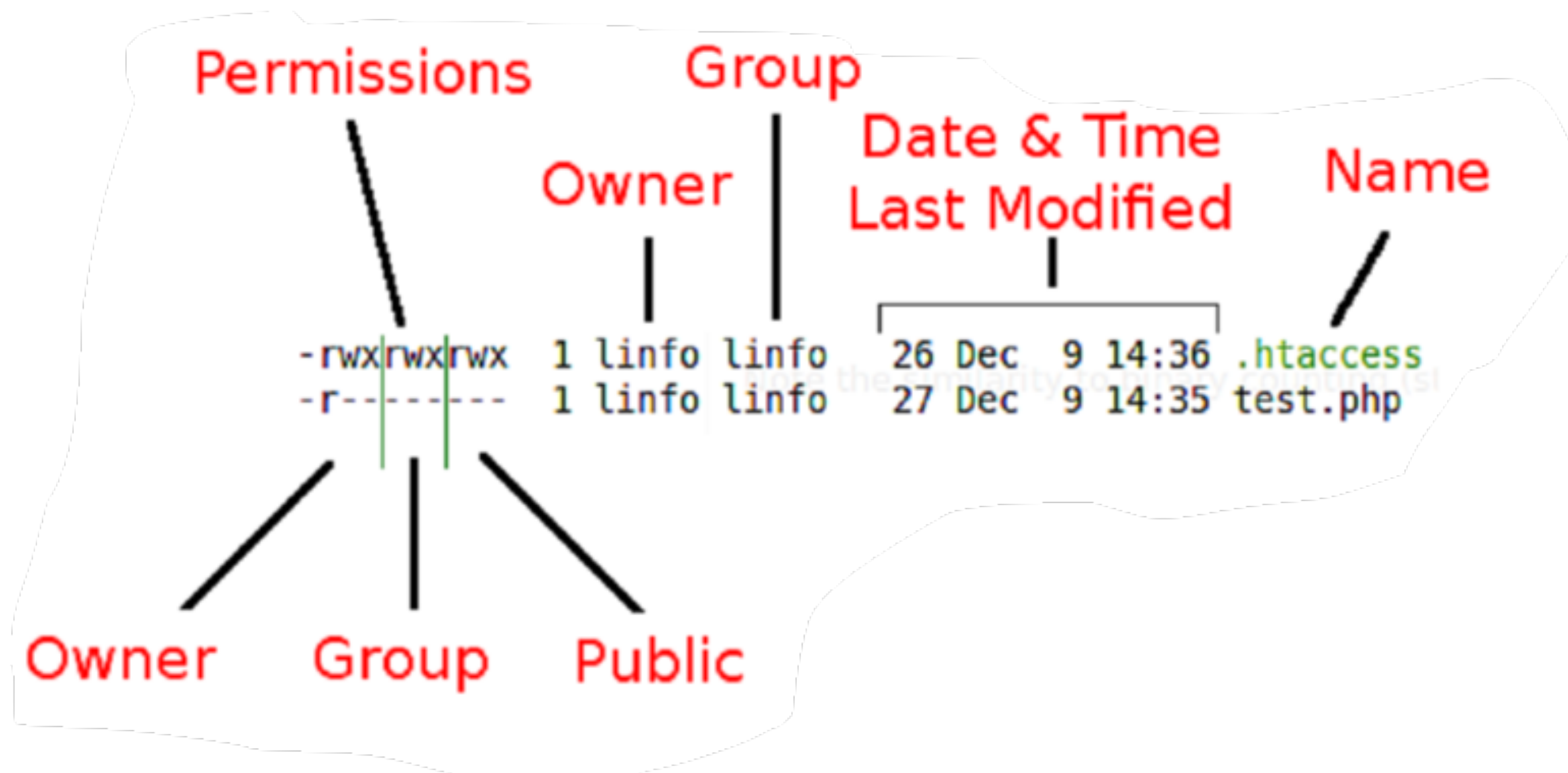
*Modeling and managing system security the UNIX-y way: file permissions & access control*



# How would you protect your computer & its resources?

*Modeling and managing system security the UNIX-y way: file permissions & access control*

**Every file has...**



# A Typical **who** can do **what** to **whom** Flow

If **user A** asks to perform **operation O** on a **file object F**, the OS checks:

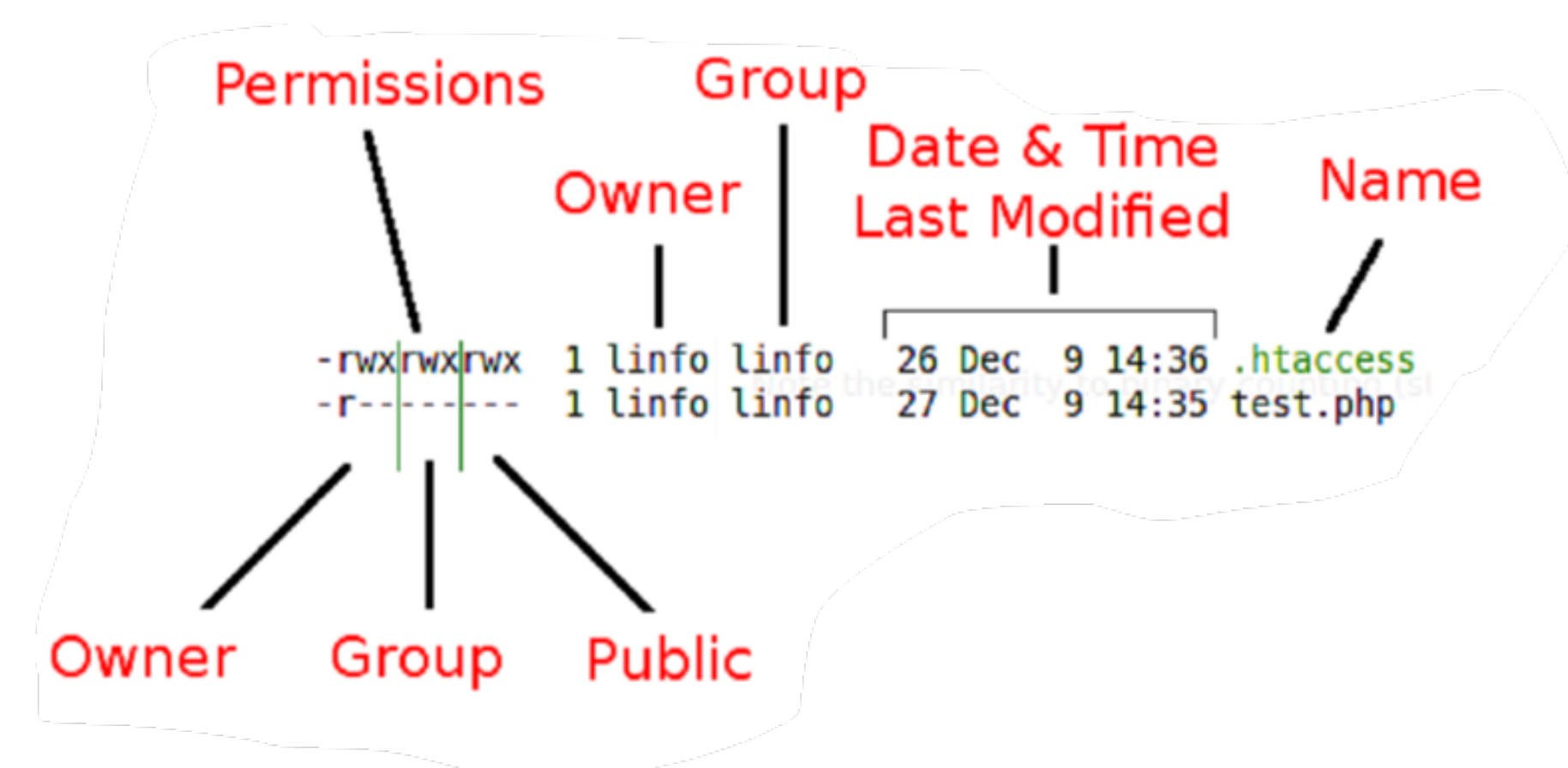
1. Is **A** the owner of **F**? >>> use **owner permissions** to decide whether A can do operation O.

*A is not F's owner*

2. Is **A** a member of **F's** group? >>> use **group permissions** to decide...

*A is not F's owner or a member of F's group*

3. >>> use the **"everyone else" / "others"** permissions to decide...



*Some in class exploration — let's take a quick look at these ideas in a VM.*



# The Limitations of File-Based Access Control

## Question

How can a non-privileged user 'champ' change their own password?

```
-rw-r----- 1 root shadow 1443 May 23 12:33 /etc/shadow
```

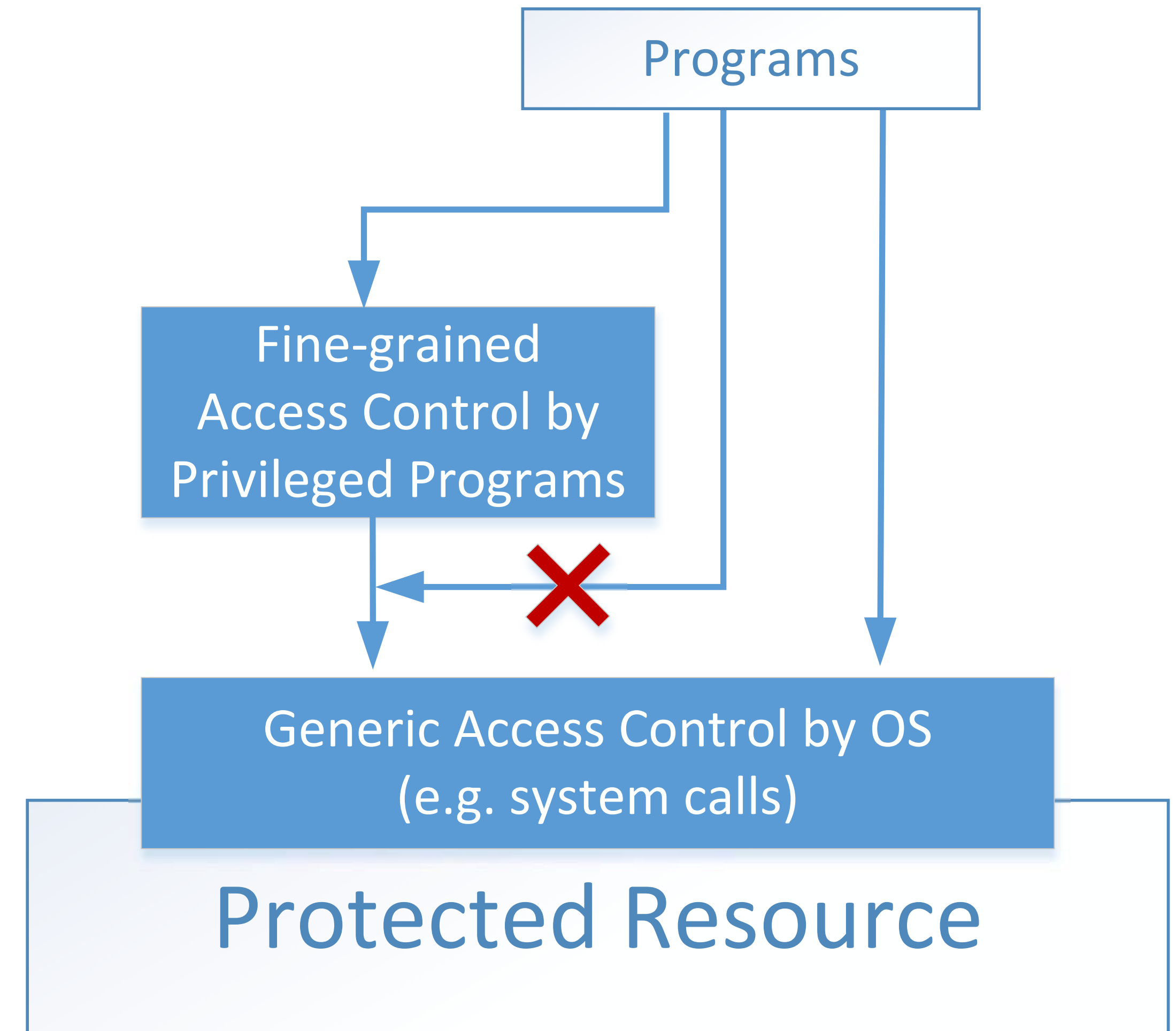
↑ Only writable to the owner

- **Idea:** grant access to user 'champ' to edit /etc/shadow  
*Good idea or bad idea?*
- **Better Idea:** grant access to user 'champ' to edit ONLY its own entry in /etc/shadow  
*Good idea or bad idea?*
- **BETTER Idea:** let user 'champ' run a special program that has one purpose:  
to edit the /etc/shadow file with inputs to the program  
*Good idea or bad idea?*



# Two-Tier Approach to Access Control

- Implementing fine-grained access control in the OS makes OS code really complicated  
(*we generally try to avoid this...*)
- OS relies on other extensions/features to enforce fine-grained access control
- “Privileged programs” are such extensions





# Types of Privileged Programs

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- **Daemons**

- Computer program that runs in the background
- Needs to run as root or other privileged users

- **Set-UID Programs**

- Widely used in UNIX systems
- A normal program... but marked with a special bit

# Superman's Past *(The Stories You Never Heard...)*

- **Superman's 1st Attempt—The Power Suit**
  - **Superman** got tired of saving *everyone*
  - **Superpeople**: give normal people superman's power!
  - **Problem**: not all superpeople are good...
- **Superman's 2nd Attempt—Power Suit 2.0**
  - Power suit w/ a sweet computer in it
  - Power suit can only perform a specific task
  - No way to deviate from the pre-programmed task.....



**The Set-UID mechanism is a lot like superman's power suit 2.0  
(but implemented in UNIX systems...)**



# Set-UID In A Nutshell

*There is also a Set-GID (Set Group ID), which works in basically the same way, but applies to group privileges*

- Allow user to run a program with the program **owner's** privilege
  - i.e., a UNIX mechanism for changing user/group identity
  - Allows users to run programs w/ temporarily elevated privileges
- Created to deal with inflexibilities of UNIX access control
  - *Why might this be useful?*
  - *Why might this be a bad idea?*
- Example: the **passwd** program



```
$ ls -l /usr/bin/passwd  
-rwsr-xr-x 1 root root 41284 Jan 21 2020 /usr/bin/passwd
```

# Set-UID In A Nutshell (cont.)

- Every process has two User IDs
  - **Real UID (RUID)** — identifies the owner of the process
  - **Effective UID (EUID)** — identifies privilege of the process
  - Access control decisions are based on EUID!
- When a normal program is executed,  
$$\text{RUID} == \text{EUID} \text{ (== user who *runs* the program)}$$
- When a Set-UID program is executed,  
$$\text{RUID} \neq \text{EUID} \rightarrow \text{EUID} == \text{ID of program's owner}$$



If program owner == root, the program runs with root privileges





Demos! *If* we have time... **else** look at some slides

# So Uh... How Do You Set... The Set-UID Bit Thingy

- **Change the owner** of a file to root

```
seed@VM:~/csci_sandbox$ cp /bin/cat ./mycat
seed@VM:~/csci_sandbox$ sudo chown root mycat
seed@VM:~/csci_sandbox$ ls -al mycat
-rwxr-xr-x 1 root seed 51036 Jan 21 02:02 mycat
```

- **Before** enabling the Set-UID bit

```
seed@VM:~/csci_sandbox$ mycat /etc/shadow
mycat: /etc/shadow: Permission denied
```

- **After** enabling the Set-UID bit

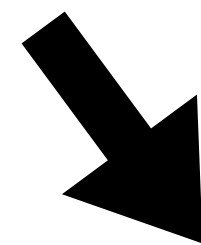
```
seed@VM:~/csci_sandbox$ sudo chmod 4755 mycat
seed@VM:~/csci_sandbox$ mycat /etc/shadow
root:$6$NrF4601p$.vDnKEtVFC2bXs1xkRuT4FcBqPpxLqW05IoECr0XKzEE
daemon*:17212:0:99999:7:::
bin*:17212:0:99999:7:::
sys*:17212:0:99999:7:::
```



## How it Works

A Set-UID program is just like any other program, except that it has a special bit set  
(*the Set-UID bit*)

```
seed@VM:~/csci_sandbox$ cp /usr/bin/id ./myid
seed@VM:~/csci_sandbox$ sudo chown root myid
seed@VM:~/csci_sandbox$ ./myid
uid=1000(seed) gid=1000(seed) groups=1000(seed),4(adm),
```



```
seed@VM:~/csci_sandbox$ sudo chmod 4755 myid
seed@VM:~/csci_sandbox$ ./myid
uid=1000(seed) gid=1000(seed) euid=0(root) groups=1000(
```

# Is Set-UID Secure?

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- Allows normal users to escalate privileges
  - This is different from directly giving escalated privileges (e.g., **sudo**)
  - Restricted behavior — similar to superman's power suit
- Unsafe to run all programs as Set-UID programs.....

## Examples?

- `/bin/sh` — *why?*
- `vi(m)` — *why?*

# Software (and Superman's PS...) Is Only As Good As We Make It...

- Shouldn't assume that user can only do whatever is coded...
- **Recall Superman: What sorts of attacks are possible on Superman's PS2.0?**

- **Mallory (v1)**

- Fly north, turn left,  
knock down wall, capture bad guy  
*Where could this go wrong?*



- **Mallory (v2)**

- Fly north, turn west,  
knock down wall, capture bad guy  
*Where could this go wrong?*

