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Systems Security

COMSM1500

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Race condition vulnerabilities

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Plan

- Race condition
- Example of race condition vulnerabilities
  - access system call
  - How (not to) implement an OS reference monitor
  - dirty cow

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What is a race condition?

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What is a race condition?

What is a race condition?

What is a race condition?

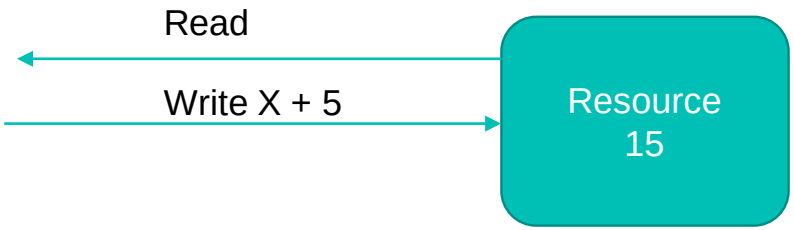
Resource
10

What is a race condition?

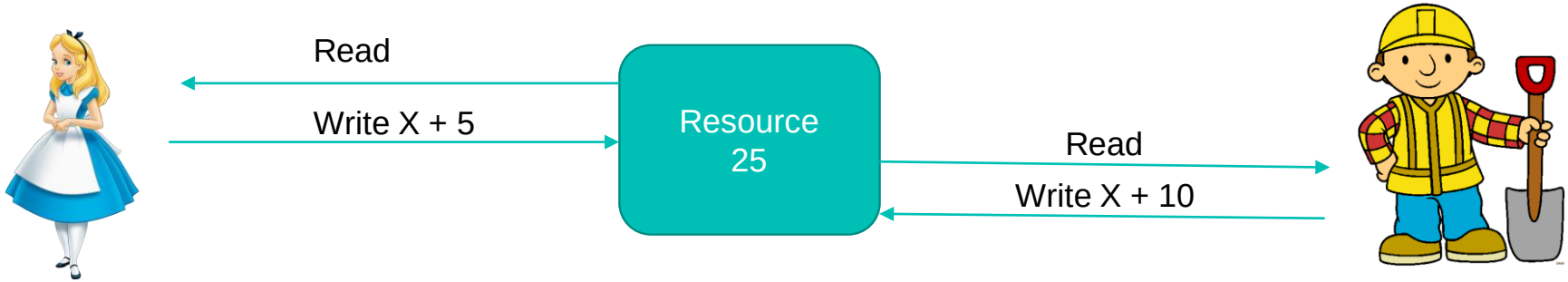
Read

Resource
10

What is a race condition?



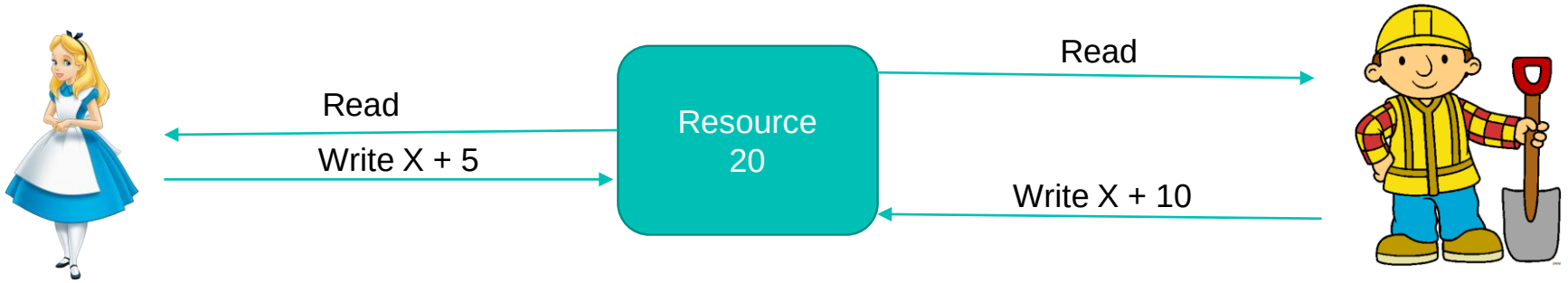
What is a race condition?



What is a race condition?

- All good here!

What is a race condition?



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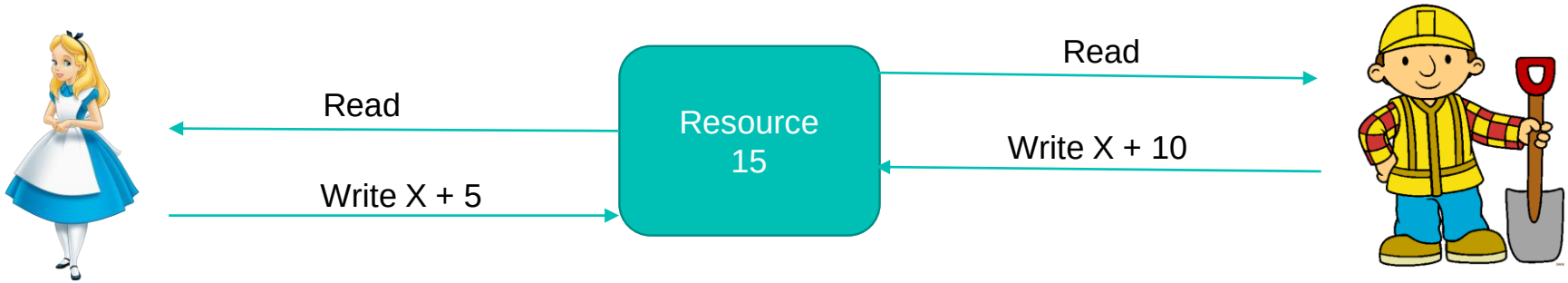

What is a race condition?

```
fcn witdraw(amount)
    balance = getBalance()
    if (balance > amount)
            balance = balance – amount
            saveBalance(balance)
    else
            print “not enough fund”
```

What is a race condition?

- Race condition:
  - System where the output is dependent on the sequence or timing of events
- Many possible permutations
- … you have seen this before
- It is a well understood problem, with solutions
  - Synchronization
  - Transactions
  - etc…

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Race condition vulnerabilities

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Exampe 1: access system call

```
if(access(“tmp/X”, W_OK)) {
        f = open(“tmp/X”);
        write_to_file(f);
} else {
        printf(“You do not own the file”);
}
```

Exampe 1: access system call

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- setuid: root
- want to make sure the “real” user own the file

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```

- setuid: root
- want to make sure the “real” user own the file
- access return either or not the operation is permitted to current user

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How can this be exploited?

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Exampe 1: access system call

```
if(access("tmp/X", W_OK)) {
        f = open("tmp/X");
        write_to_file(f);
} else {
        printf("You do not own the
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}
```

- Path hard coded
  - Program will only write to /tmp/X

Exampe 1: access system call

```
if(access("tmp/X", W_OK)) {        1
        f = open("tmp/X");         2
        write_to_file(f);
} else {
        printf("You do not own the
        file");
}
```

- Path hard coded
  - Program will only write to /tmp/X
- Symbolic Link
  - /tmp/X -> /etc/config
- 1: fail
- 2: success

Exampe 1: access system call

```
if(access("tmp/X", W_OK)) {        1
        f = open("tmp/X");         2
        write_to_file(f);
} else {
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        file");
}
```

- Exploited race condition
- Changed value between check and use
- time of check to time of use
  - TOCTOU

access man

Warning: Using **access**() to check if a user is authorized to, for example, open a file before actually doing so using ***open****(2)* creates a security hole, because the user might exploit the short time interval between checking and opening the file to manipulate it. **For this reason, the use of this system call should be avoided**. (In the example just described, a safer alternative would be to temporarily switch the process's effective user ID to the real ID and then call ***open****(2)*.)

access man

Homework/exam question:
access system call is vulnerable to race condition. Explain how it can be exploited.

Warning: Using **access**() to check if a user is authorized to, for example, open a file before actually doing so using ***open****(2)* creates a security hole, because the user might exploit the short time interval between checking and opening the file to manipulate it. **For this reason, the use of this system call should be avoided**. (In the example just described, a safer alternative would be to temporarily switch the process's effective user ID to the real ID and then call ***open****(2)*.)

Example 2: implementing OS reference monitor

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What is a reference monitor?

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What is a reference monitor?

Seen in access control lecture on October 30th!

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Example 2: implementing OS reference monitor

- *a **reference monitor** is a secure, always-used and fully-testable module that controls all software access to data objects or devices*

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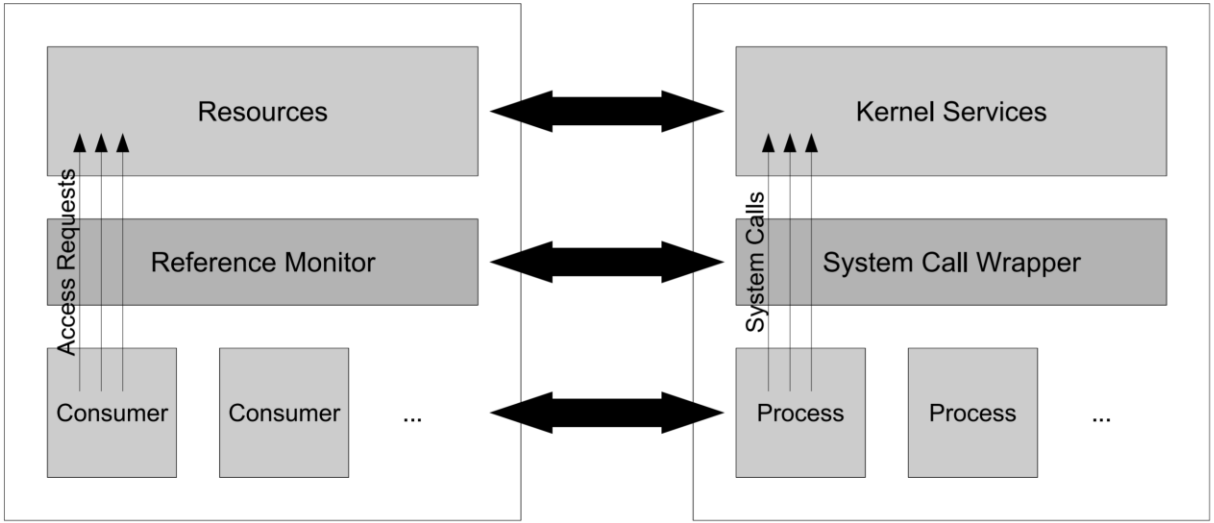
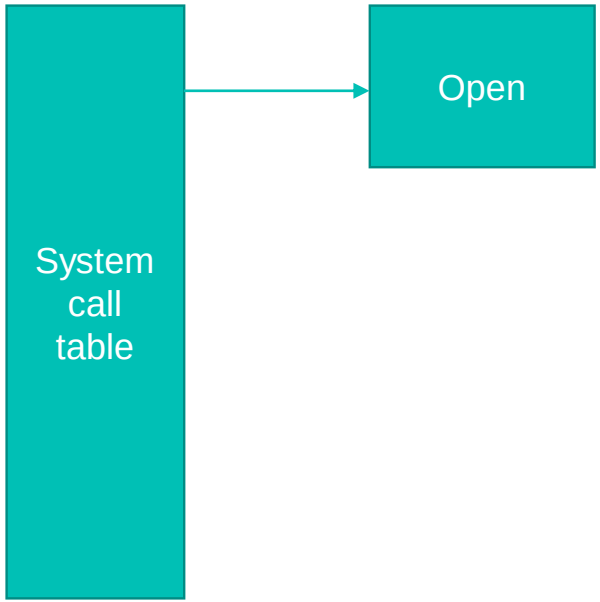


Example 2: implementing OS reference monitor



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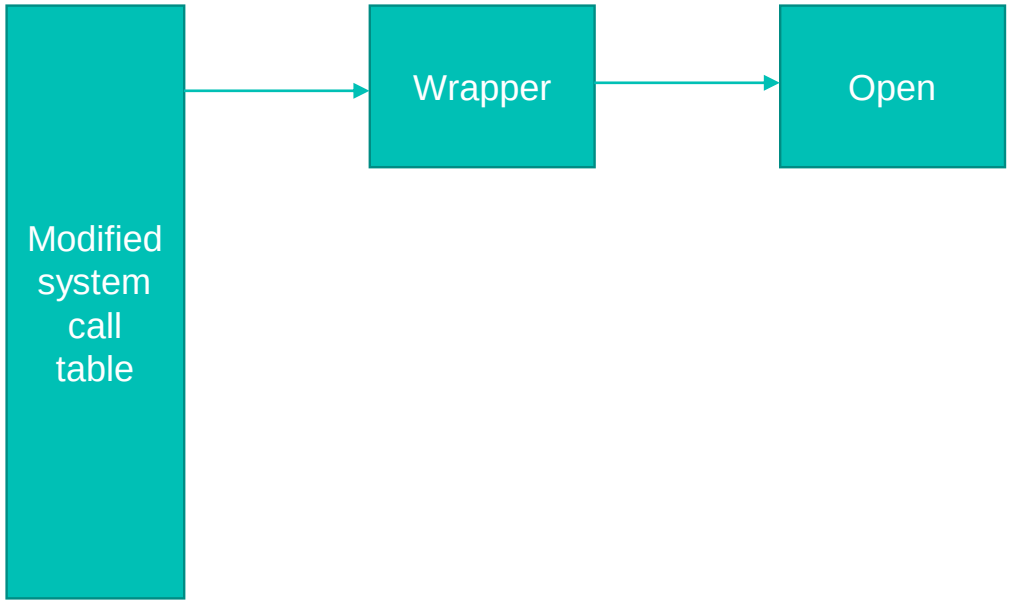

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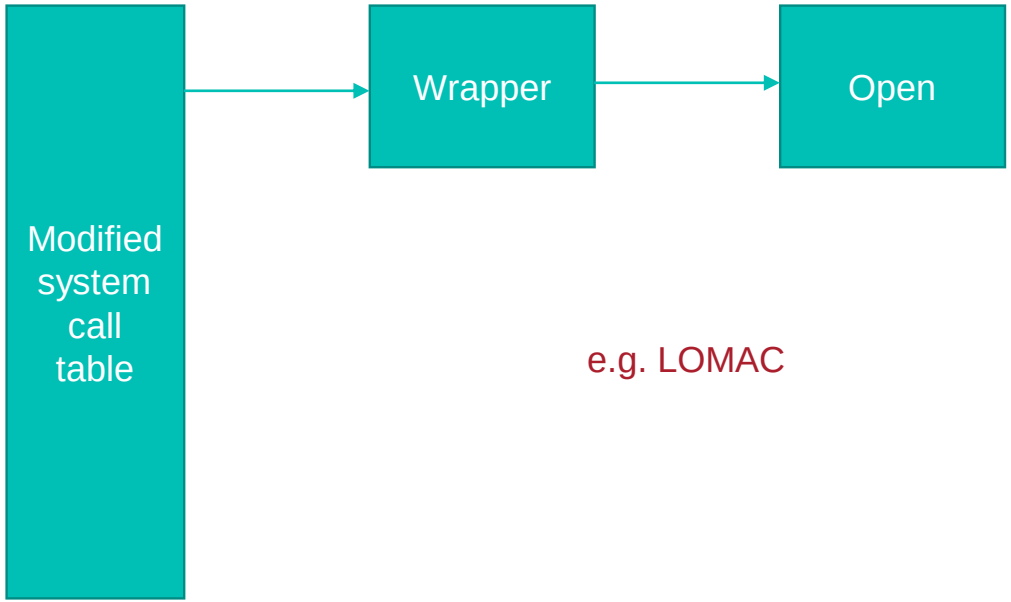
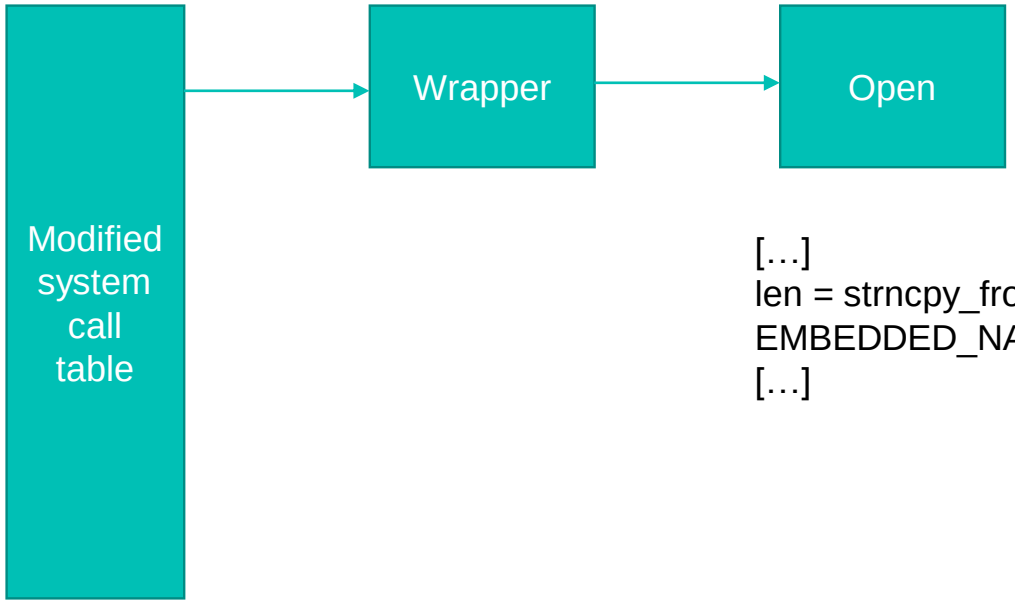


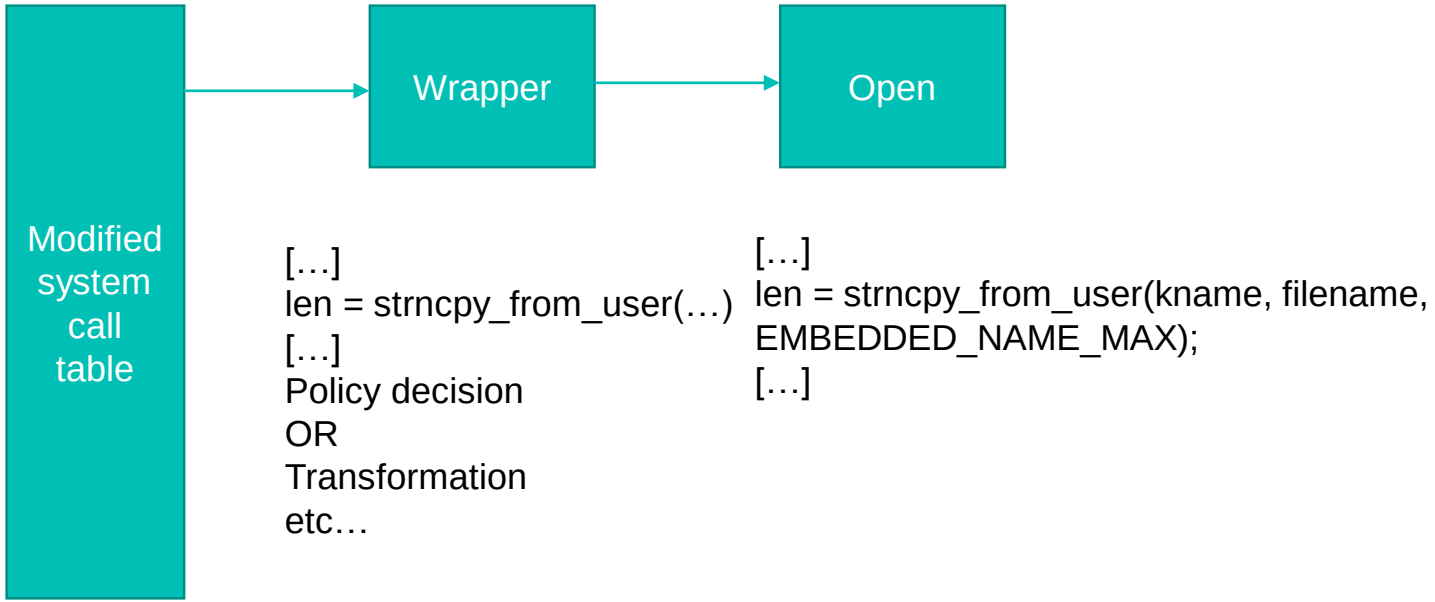
e.g. LOMAC

Example 2: implementing OS reference monitor




```
[…]
len = strncpy_from_user(kname, filename,
EMBEDDED_NAME_MAX);
[…]
```

Example 2: implementing OS reference monitor



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Problem?

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Example 2: implementing OS reference monitor

- Wrapper and syscall work on two different copy of the buffer!
- User space controlled buffer
  - Can be controlled by an attacker
- The value checked to enforce policy!=value seen by syscall

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- Check LSM paper for how to properly implement a reference monitor!

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- Wrapper and syscall work on two different copy of the buffer!
- User space controlled buffer
  - Can be controlled by an attacker
- The value checked to enforce policy!=value seen by syscall
- Check LSM paper for how to properly implement a reference monitor!
- Check Robert Watson's paper for "real" exploit to syscall wrapper

Example 2: implementing OS reference monitor

- Wrapper and syscall work on two different copy of the buffer!
- User space controlled buffer
  - Can be controlled by an attacker
- The value checked to enforce policy!=value seen by syscall

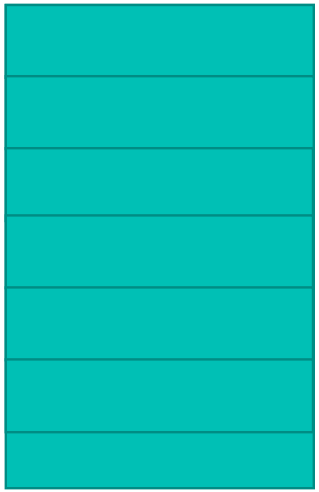
Homework/exam question:
Explain why system call wrapper should not be used to implement access control.

Example 3: dirty cow

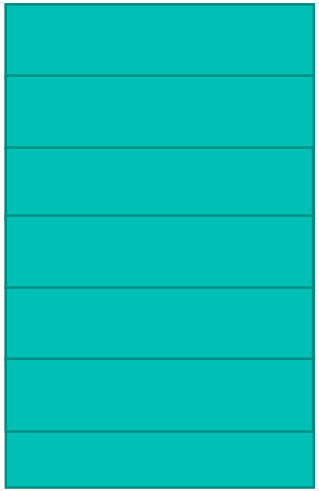
Example 3: dirty cow

- CVE-2016-5195
- Linux vulnerability that could be exploited to gain root access
- Concurrency issue relating to how memory is managed

Example 3: dirty cow

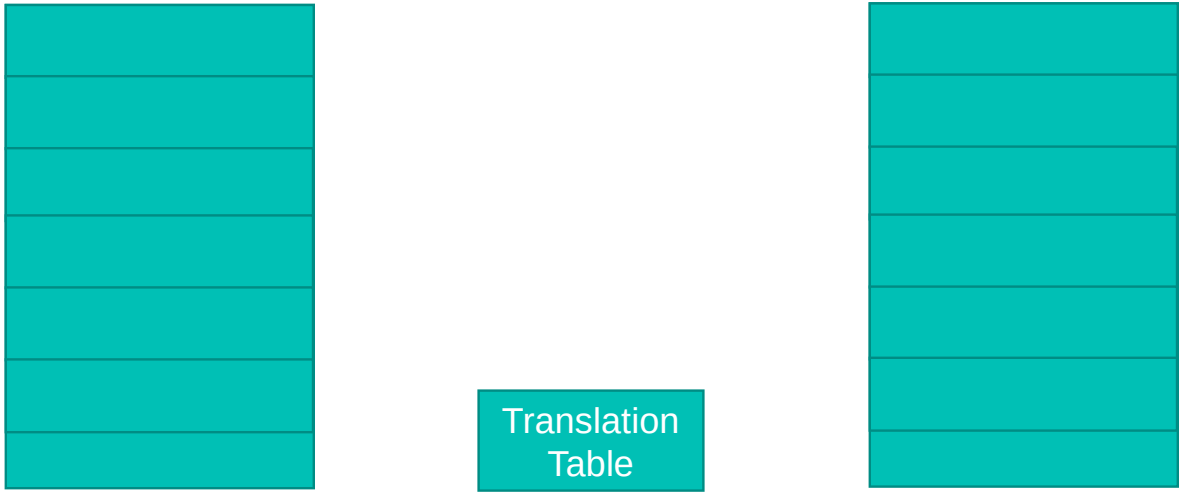


Process memory



Physical memory

Example 3: dirty cow



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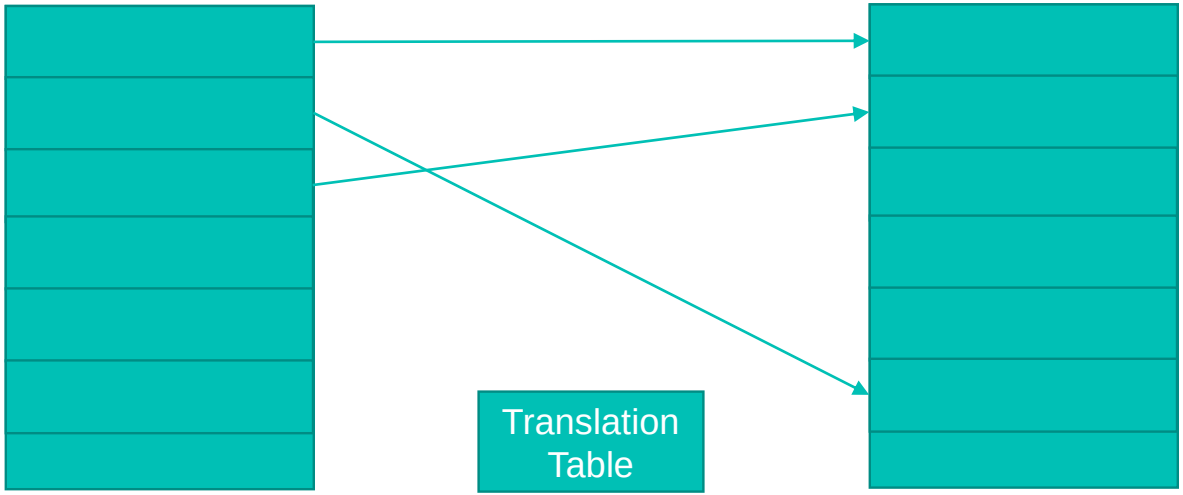

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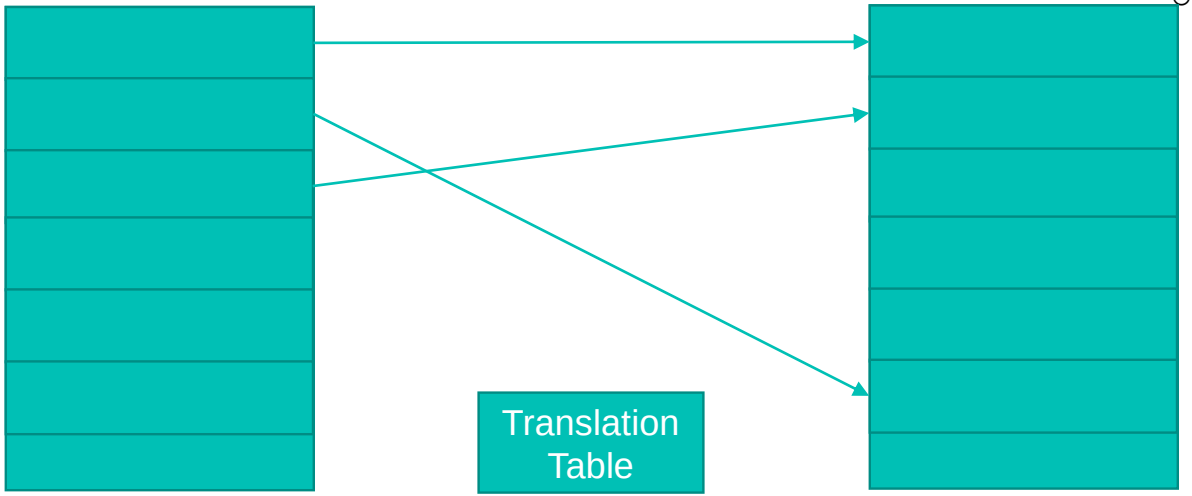
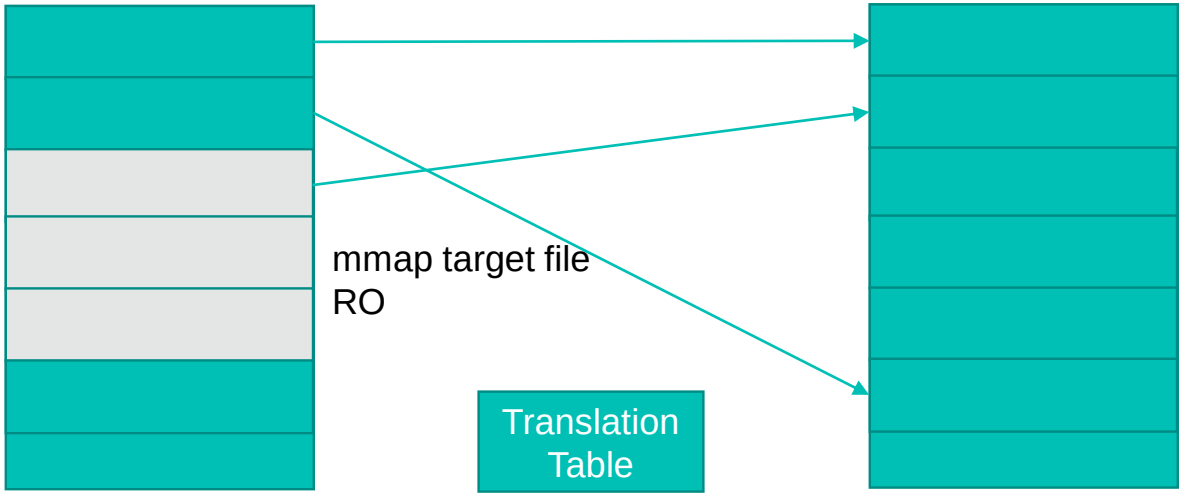


- Optimization
  - Two process have same value in memory
  - Use the same physical address
  - Fine if only READ!
  - If want to read
    - COPY
    - CHANGE TT
    - WRITE
    - COW

Example 3: dirty cow



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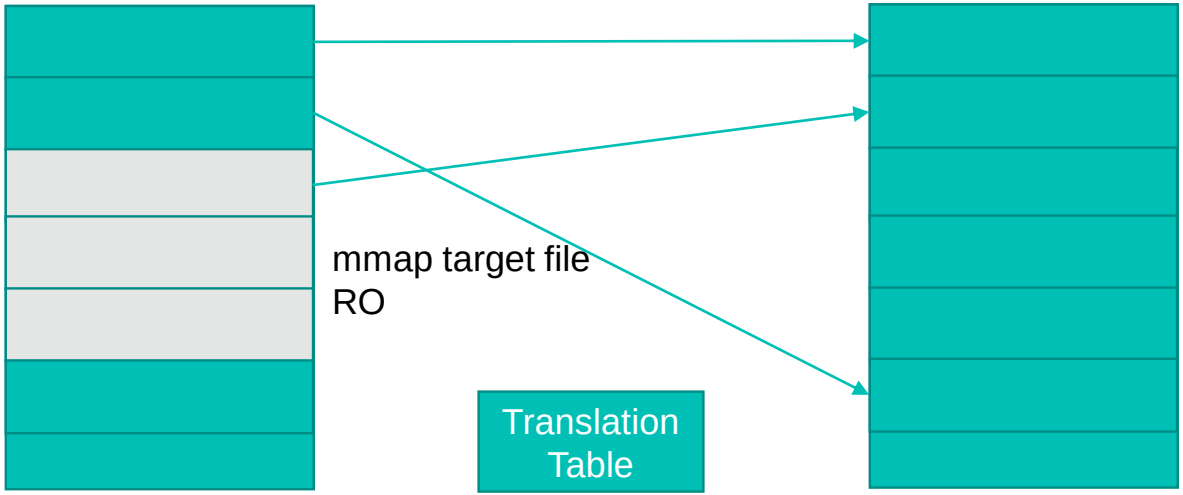
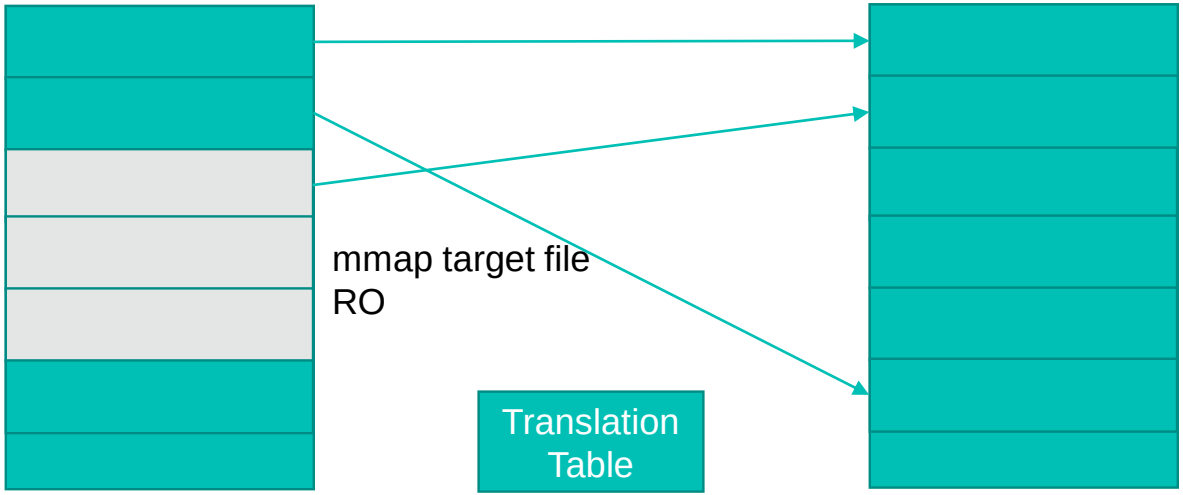


Thread 1
Do not need memory can page out

Thread 2
Try to write on mmaped memory

Example 3: dirty cow

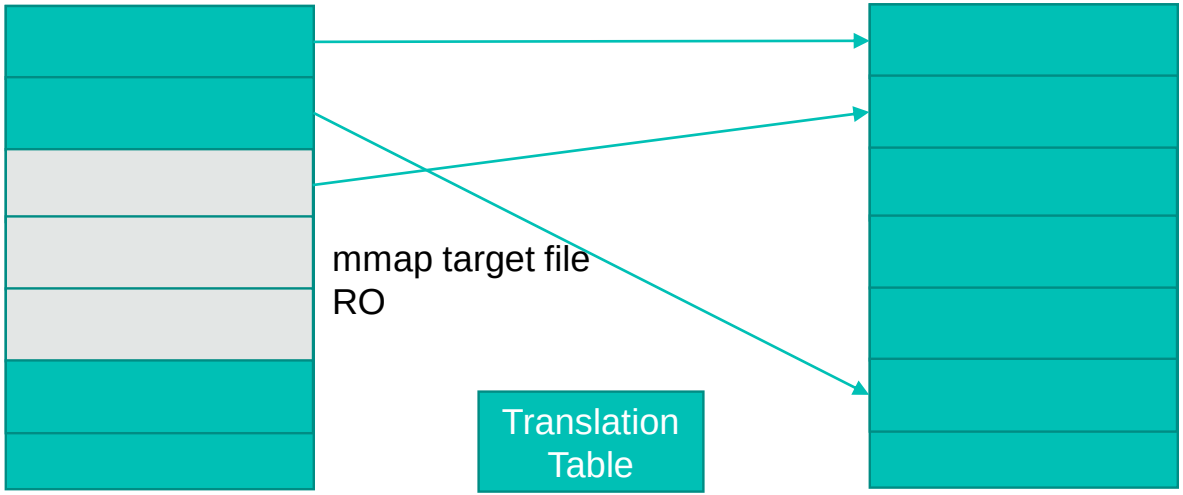


Thread 1
Do not need memory can page out

Thread 2
Try to write on mmaped memory

Normally fine!

Example 3: dirty cow



Thread 1
Do not need memory can page out

Thread 2
Try to write on mmaped memory

Sometimes race condition
kernel see change to mmaped file
Copy changes to underlying file
As it is paging out…
… but user did not have acces!
Can do this on…
passwd for example

Example 3: dirty cow

- https://github.com/dirtycow/dirtycow.github.io/blob/master/dirtyc0w.c

Example 3: dirty cow

Homework/exam question:
Explain the dirty cow vulnerability.

- https://github.com/dirtycow/dirtycow.github.io/blob/master/dirtyc0w.c

Plan

- Race condition
- Example of race condition vulnerabilities
  - access system call
  - How (not to) implement an OS reference monitor
  - dirty cow

Plan

Homework/exam question:
Give an example of race condition vulnerability.

- Race condition
- Example of race condition vulnerabilities
  - access system call
  - How (not to) implement an OS reference monitor
  - dirty cow

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Thank you, questions?

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