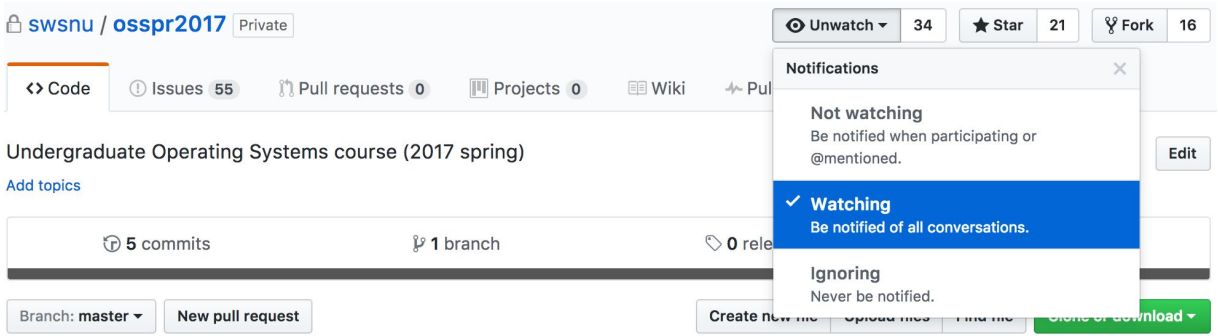
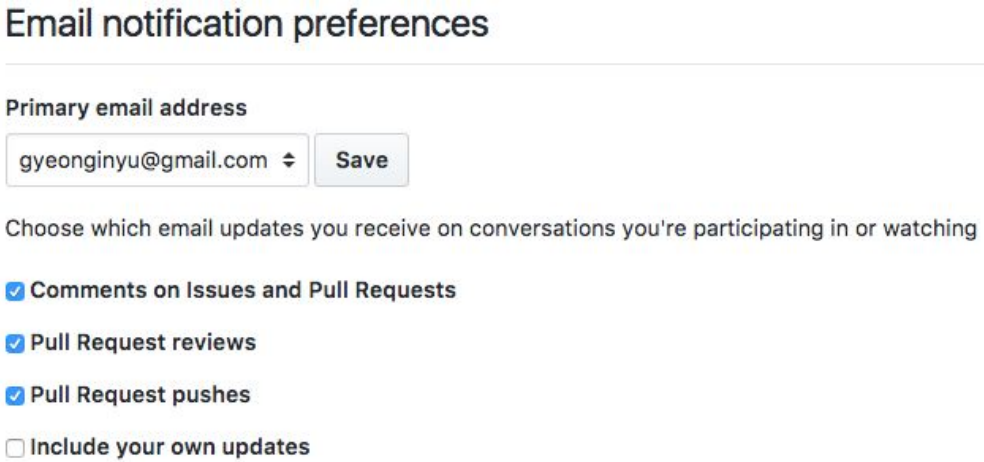
Project 2

CMSLab, SNU

Notification Settings

- https://github.com/swsnu/osspr2017
- https://github.com/settings/emails
- https://github.com/settings/notifications





Project 2 Overview

- Implement rotation-based read/write lock
- Each lock has a “rotation range”
  - Every lock can be acquired when the current rotation is in the rotation range
  - Or, it is blocked until the current rotation is located in the rotation range
- Read lock could be acquired when no acquired **write** lock range is overlapping with its range
- Write lock could be acquired when no acquired **read/write** lock range is overlapping with its range
  - Exclusive access

Rotation Range

- 1 axis: rotation
  - Actually, Tizen orientation has three axises! (Azimuth, Pitch, Roll)
- (degree - range) <= **range** <= (degree + range)
- Rotation ranges are **inclusive**
  - Ex) [30, 60], [60, 90] are overlapped
- Rotation ranges are **circular**
  - Ex) [330, 30] and [30, 330]
  - [330 … 0 … 30]
  - [30 … 180 … 330]

Range Example (1)

- Rotation 1
  - degree = 30
  - range = 30
- Rotation 2
  - degree = 45
  - range = 30

Are they overlapped?

Range Example (1)

- Rotation 1
  - degree = 30
  - range = 30
- Rotation 1
  - [0, 60]

- Rotation 2
  - degree = 45
  - range = 30
- Rotation 2
  - [15, 75]

Are they overlapped?

Yes!

Range Example (2)

- Rotation 1
  - degree = 30
  - range = 60
- Rotation 2
  - degree = 315
  - range = 30

Are they overlapped?

Range Example (2)

- Rotation 1
  - degree = 30
  - range = 60
- Rotation 1
  - [0, 90] + [330, 360)

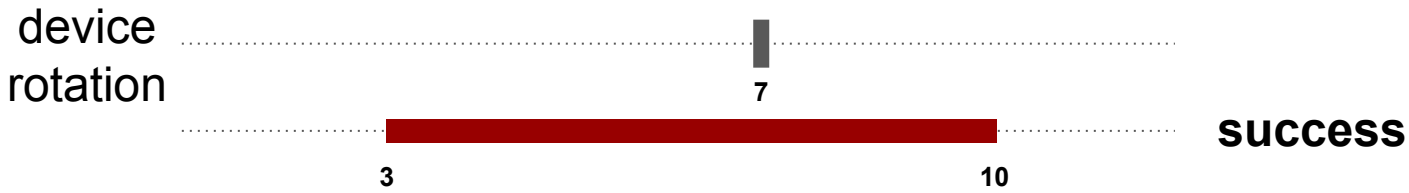
- Rotation 2
  - degree = 315
  - range = 30
- Rotation 2
  - [285, 345]

Are they overlapped?

Yes!

Rotation Lock Example

rotlock_write(3-10)

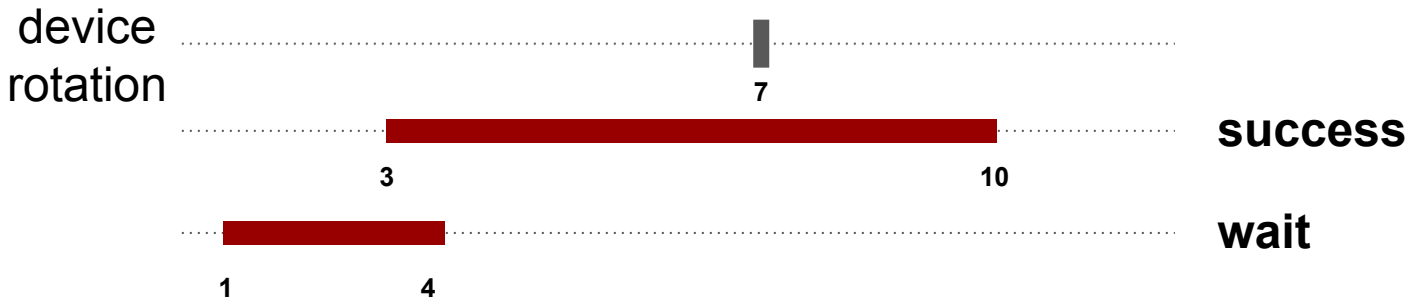


writer

reader

Rotation Lock Example

rotlock_write(1-4)

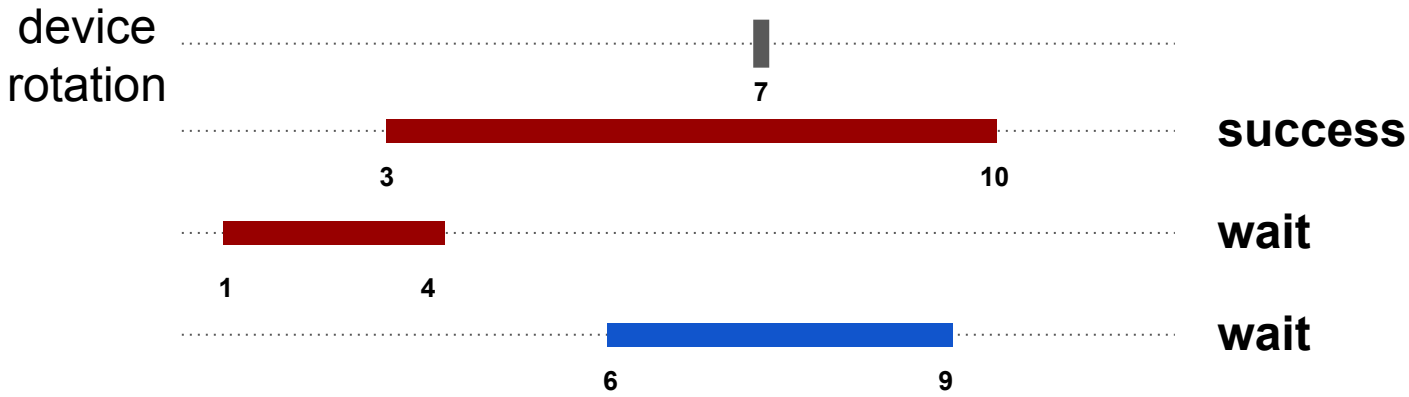


writer

reader

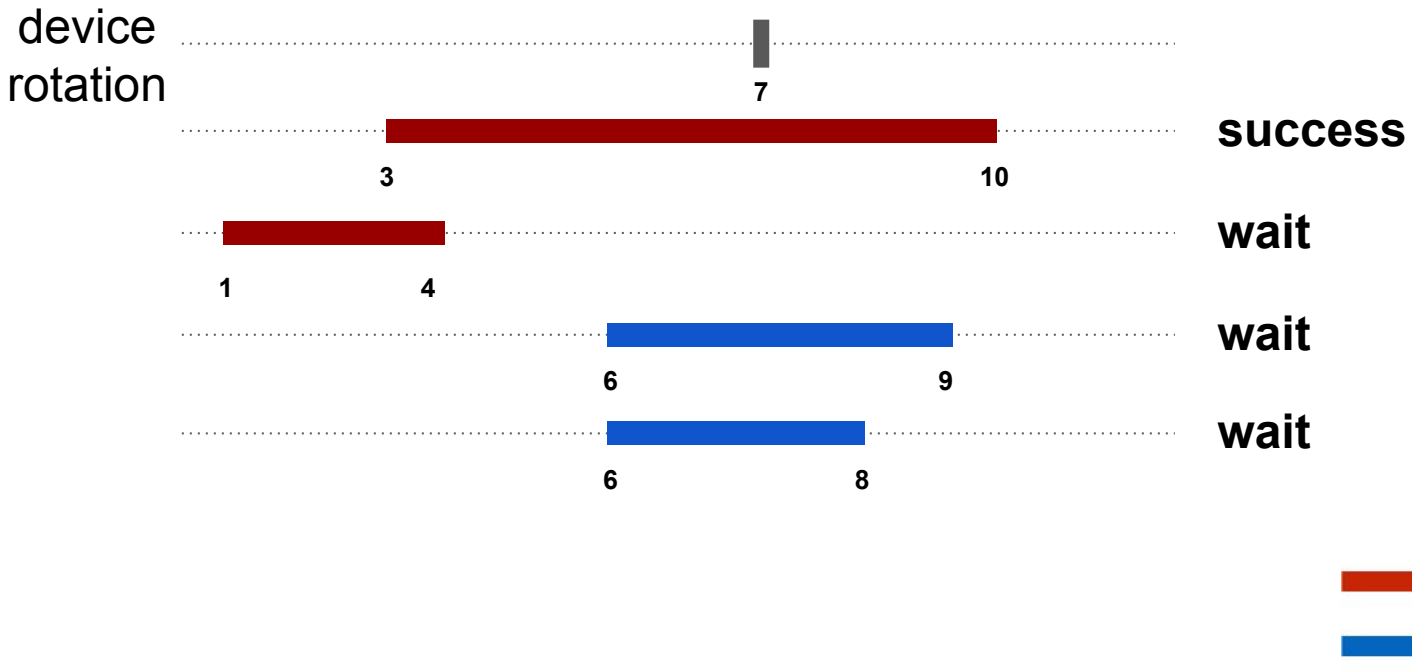
Rotation Lock Example

rotlock_read(6-9)



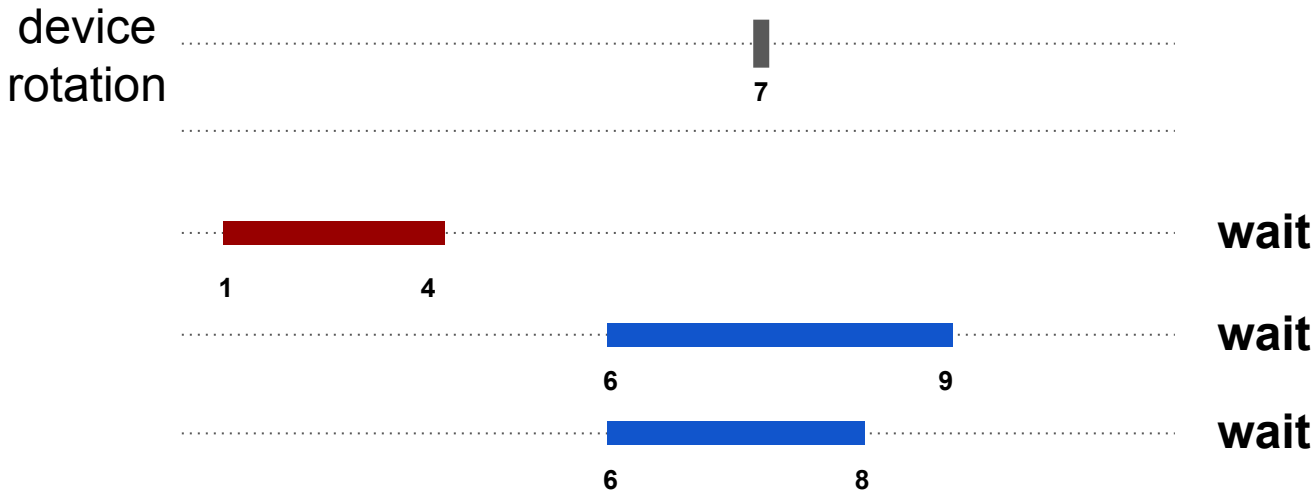
Rotation Lock Example

rotlock_read(6-8)



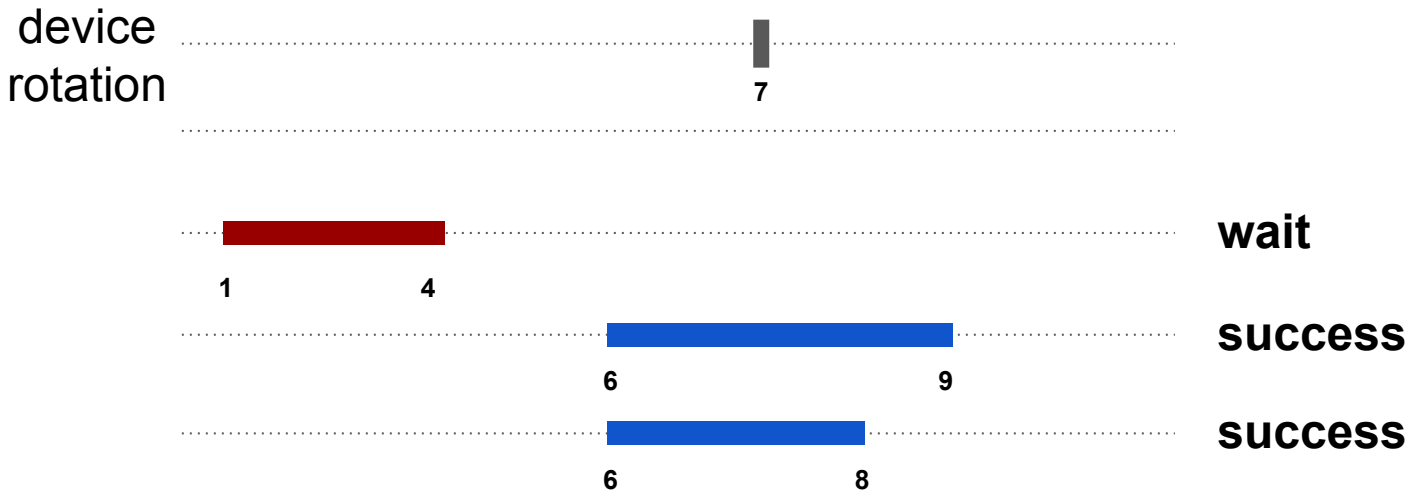
Rotation Lock Example

rotunlock_write(3-10)



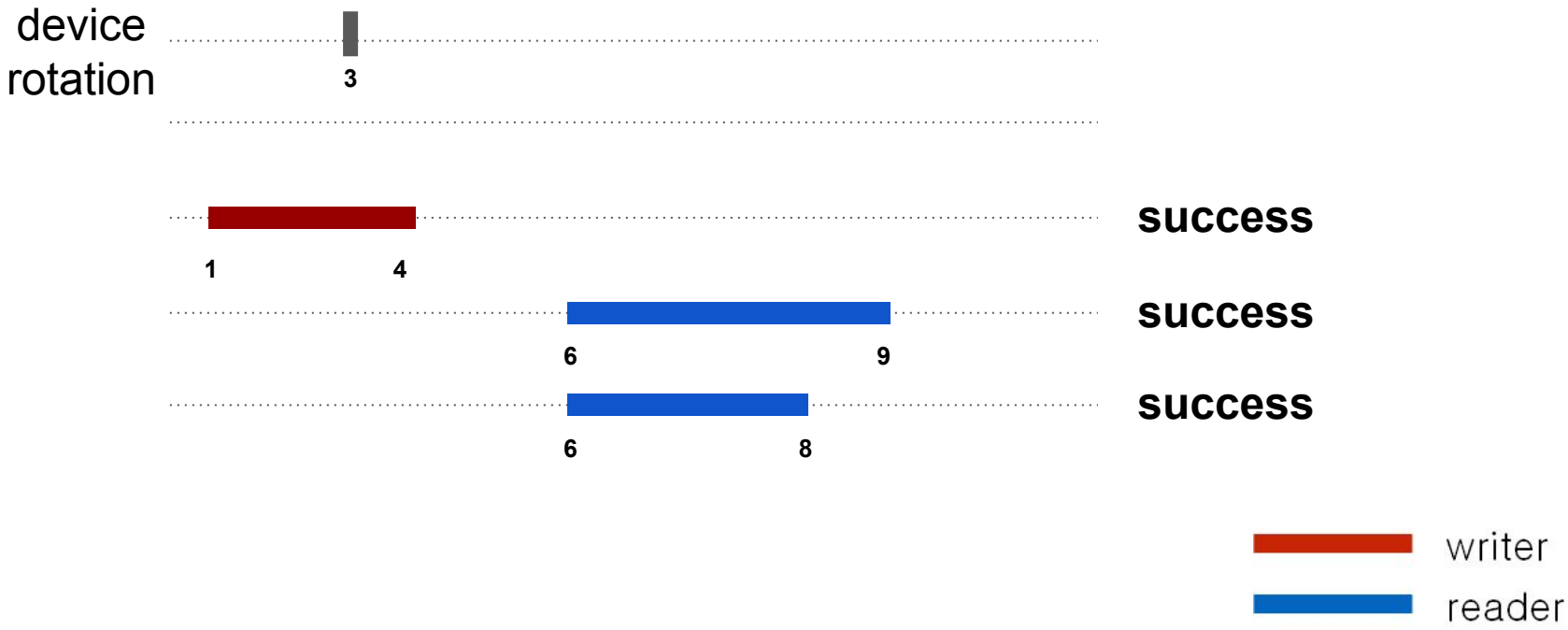
Rotation Lock Example

rotunlock_write(3-10)



Rotation Lock Example

Device rotation changed to 3

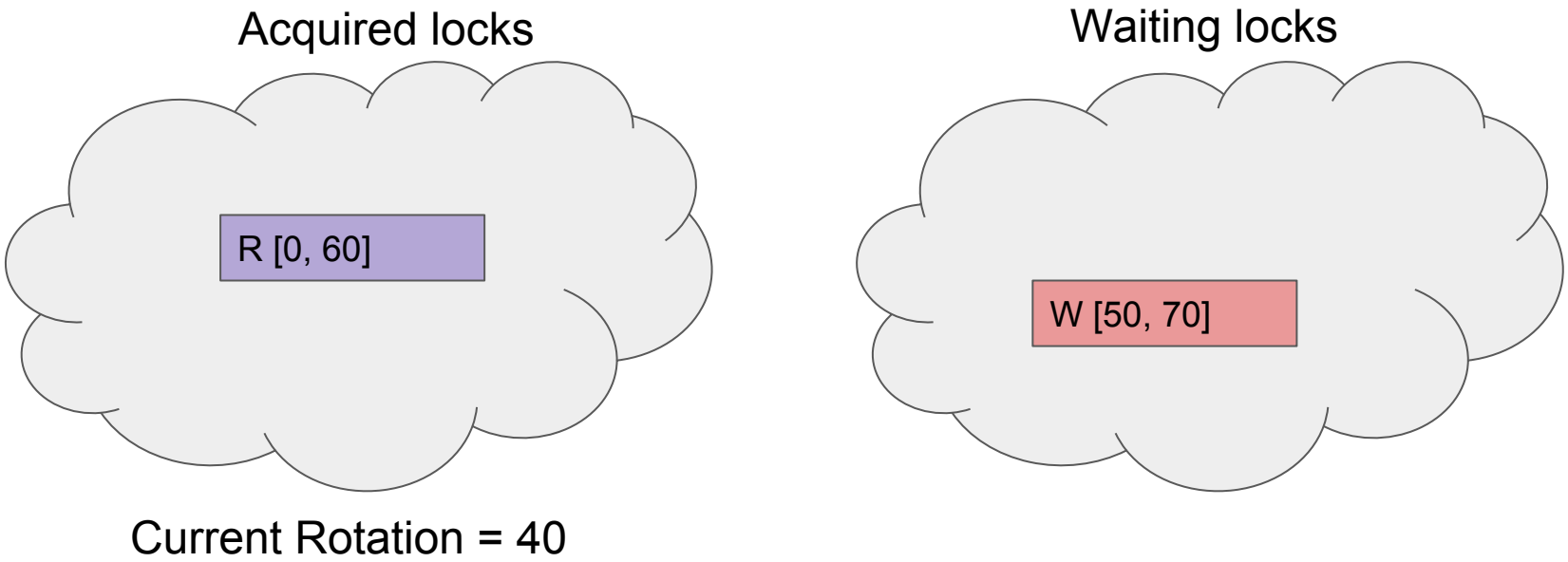


Preventing writer starvation

- You should implement a policy for preventing starvation of writers
  - Why? If reader comes in infinitely, a writer could wait forever!
- **If a reader holds a lock and a writer wants to take the lock, no more readers can take the lock**
- If you design your own *additional* policy, explain that in your README.md file, report, and slides!

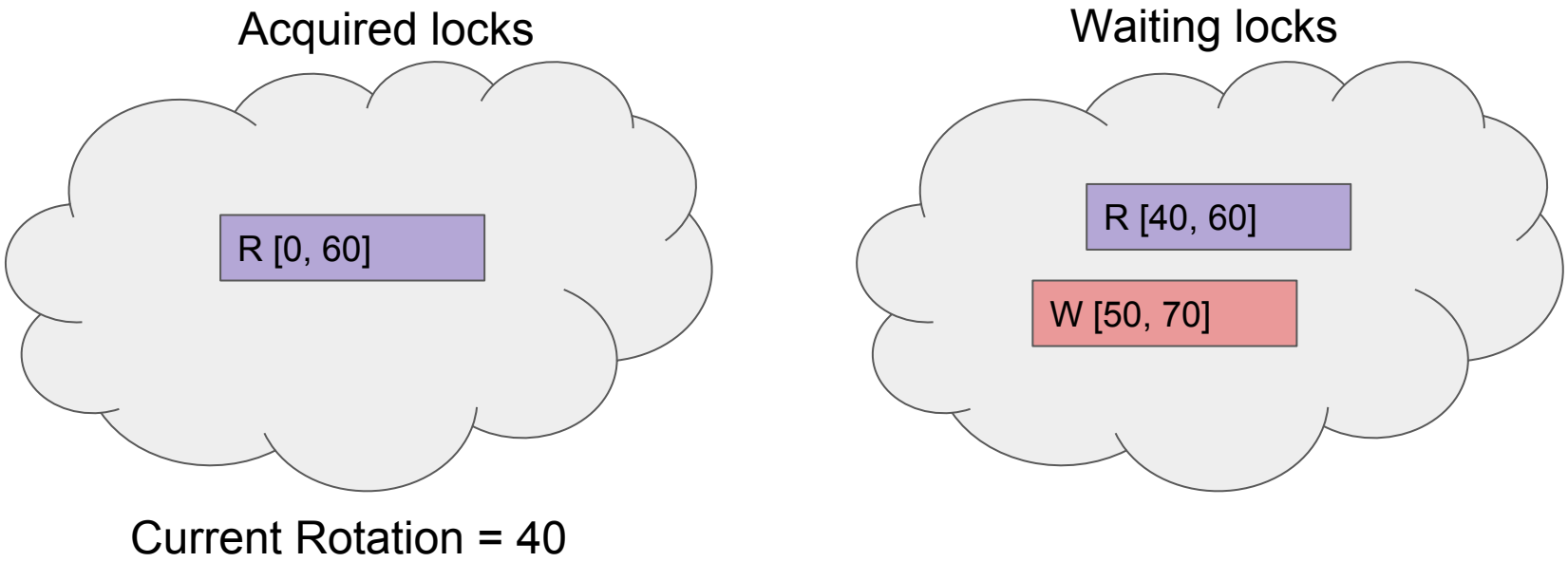
How to prevent writer starvation?

- A write lock is waiting for the rotation changes & the reader to release its lock



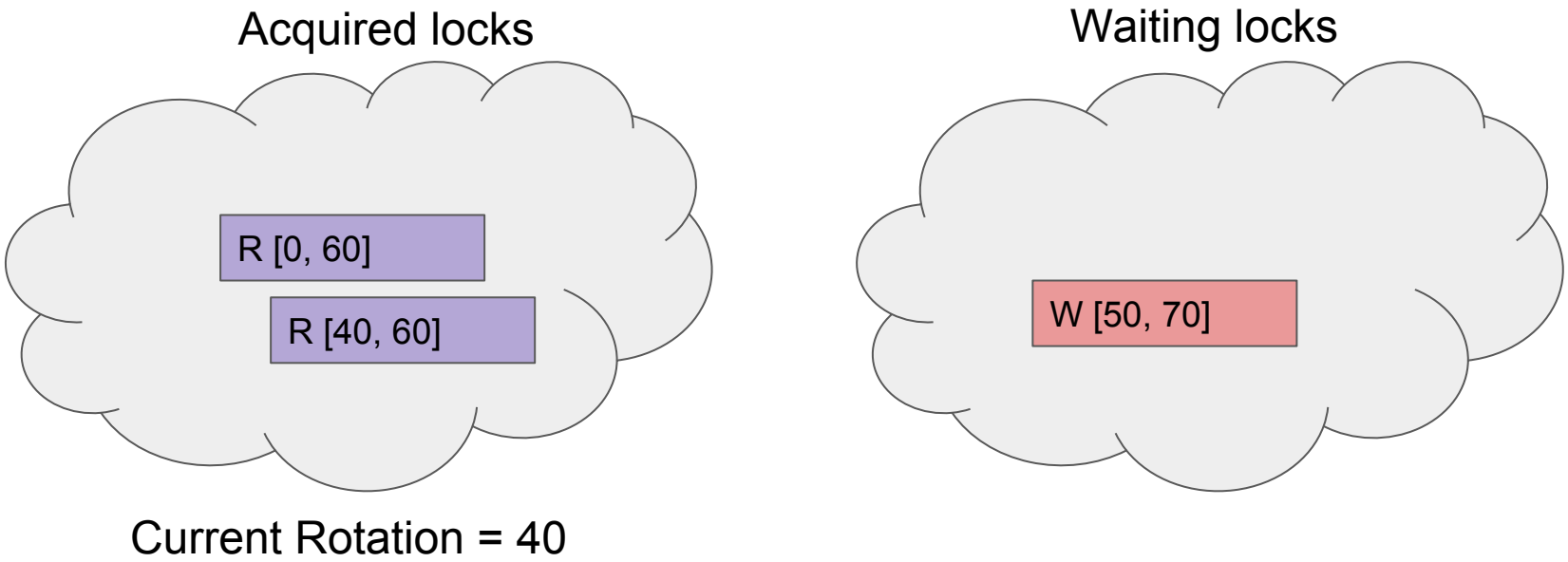
How to prevent writer starvation?

- A read lock [40, 60] came



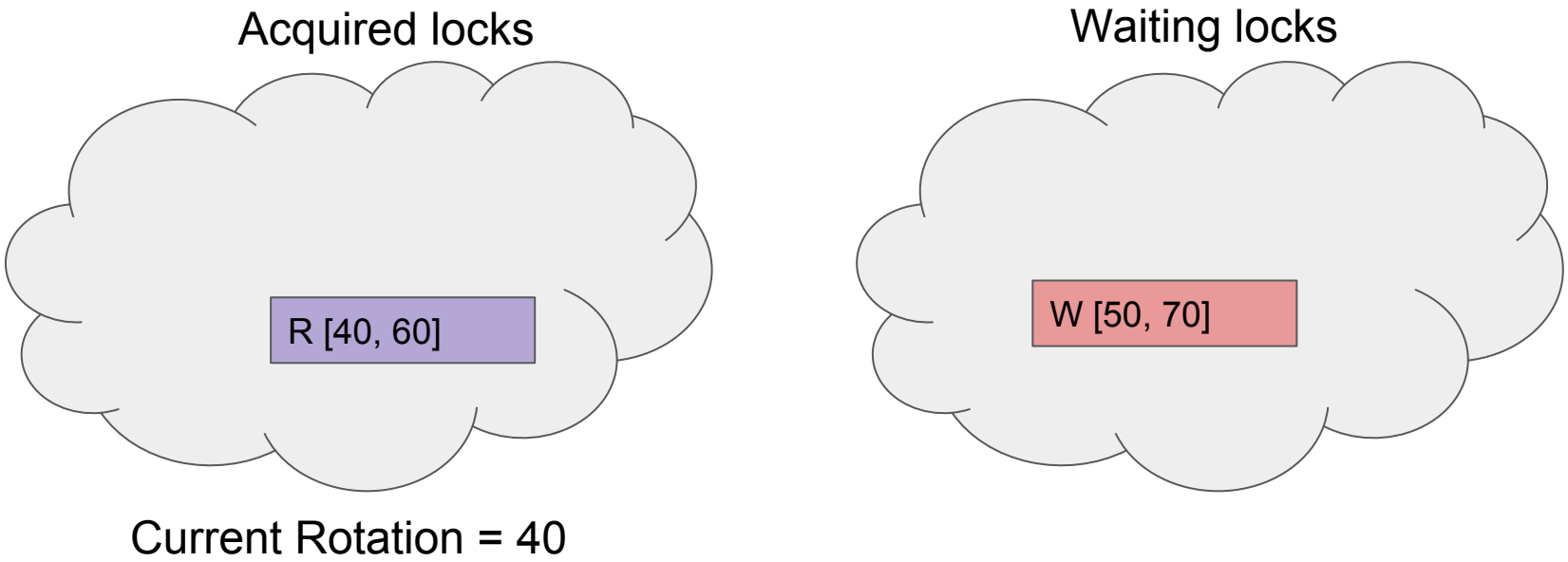
How to prevent writer starvation?

- $40 \in [40, 60] \rightarrow$ Acquires its lock immediately



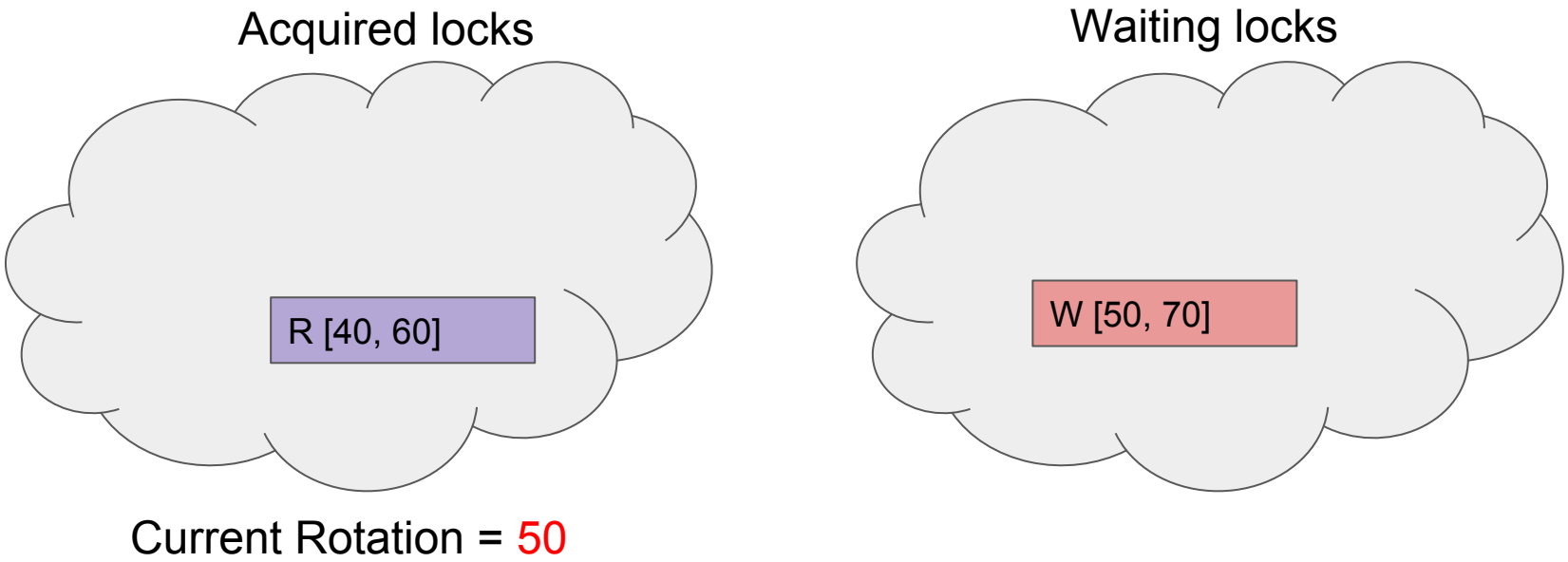
How to prevent writer starvation?

- R [0, 60] releases its lock



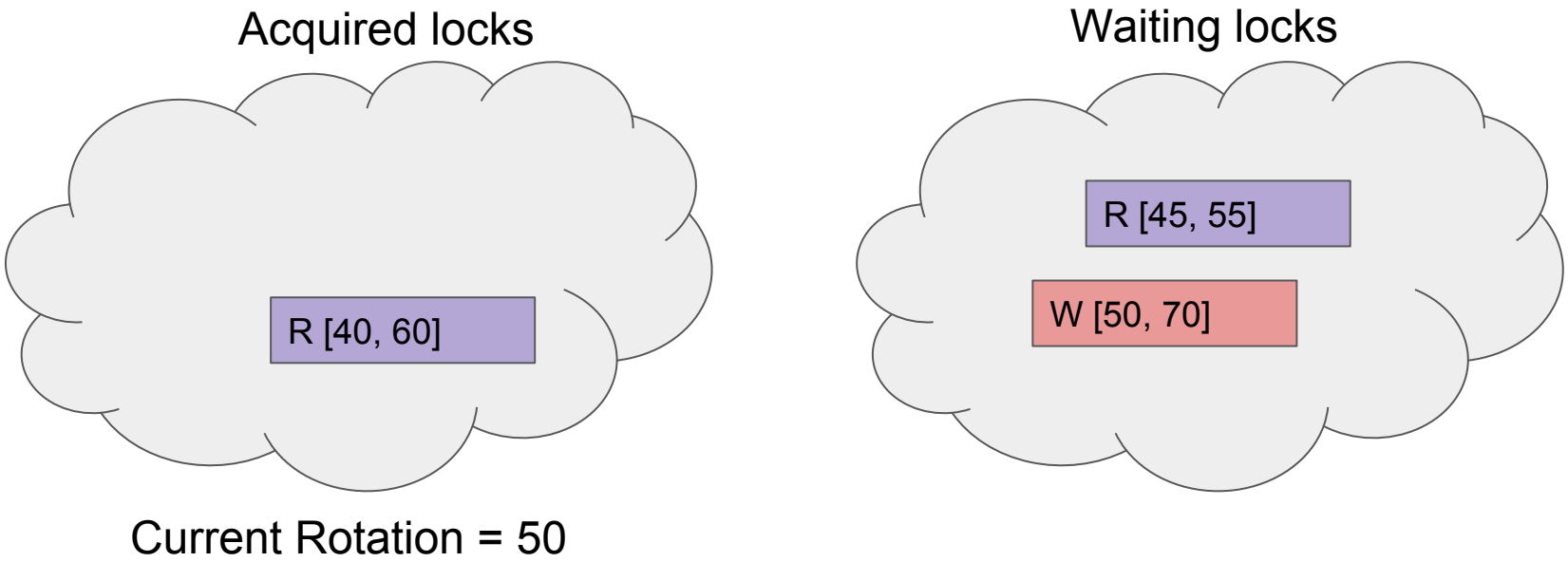
How to prevent writer starvation?

- Rotation changes 40 → 50



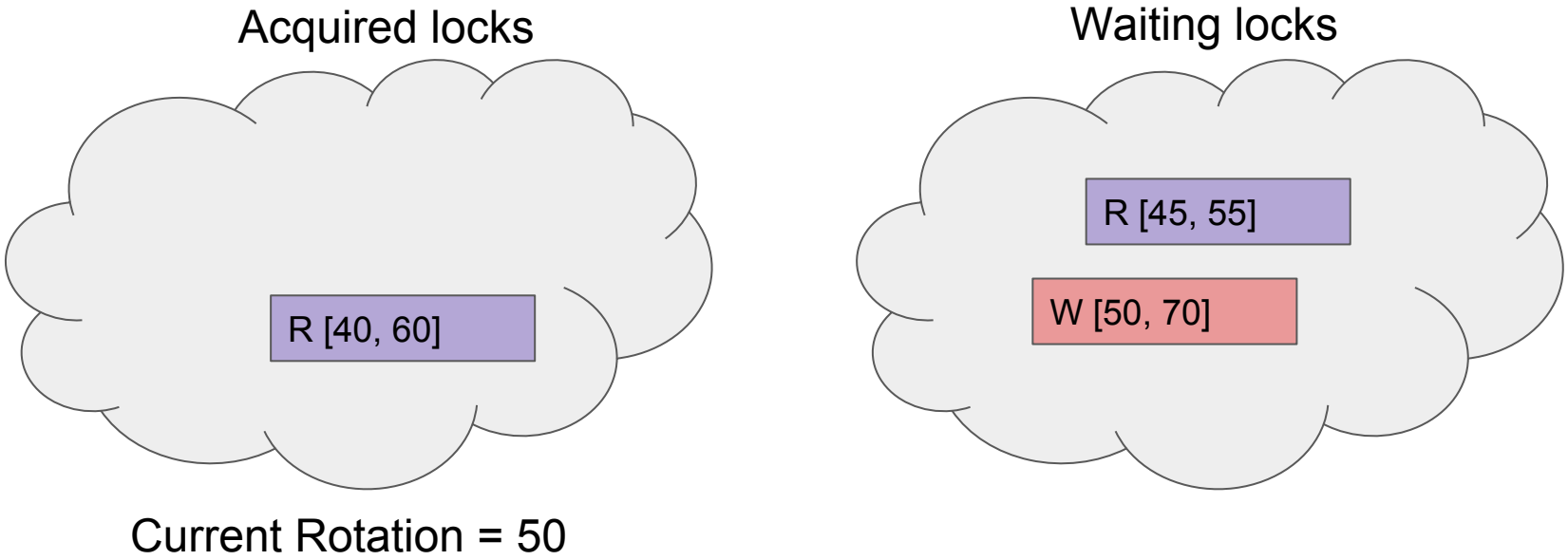
How to prevent writer starvation?

- A read lock [45, 55] came
- 50 ∈ [45, 55] but cannot acquire its lock, because ...



How to prevent writer starvation?

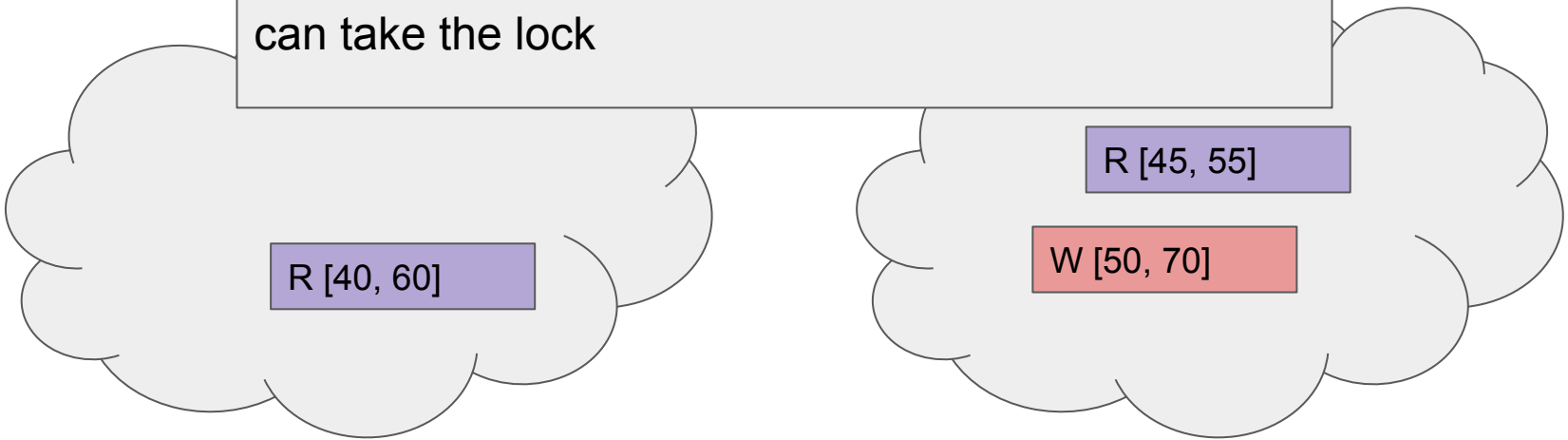
- W [50, 70] is waiting and 50 ∈ [50, 70]
- W [50, 70] is waiting for R [40, 60] to release its lock
- [45, 55] overlaps with [50, 70]



How to prevent writer starvation?

- W [50, 70
- W [50, 70
- [45, 55] o

If a reader holds a lock
and a writer wants to take
the lock,
no more readers
can take the lock

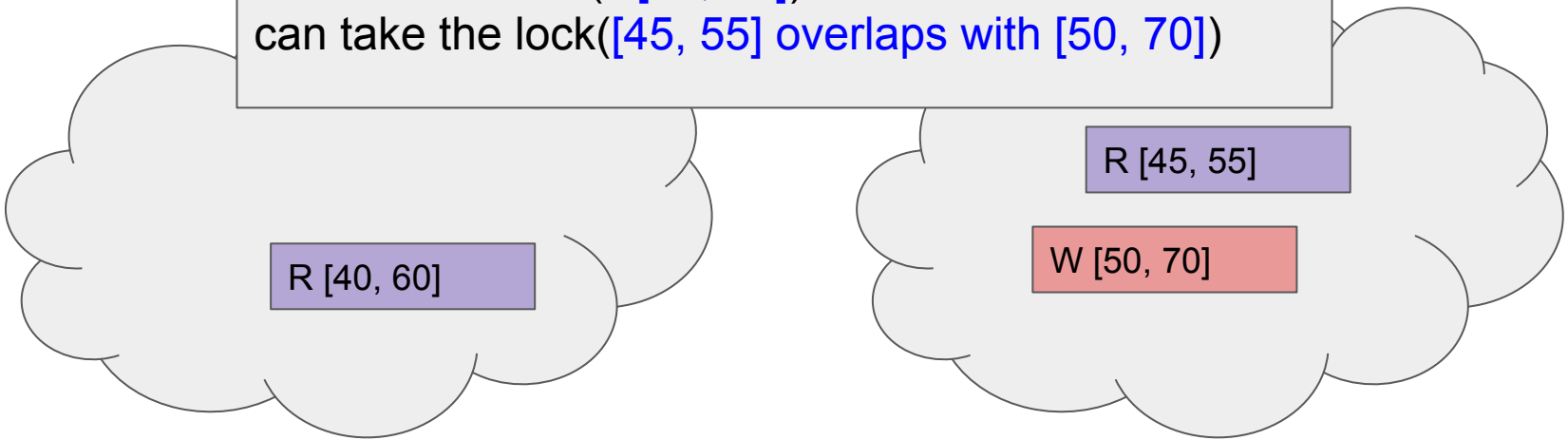


Current Rotation = 50

How to prevent writer starvation?

- W [50, 70
- W [50, 70
- [45, 55] o

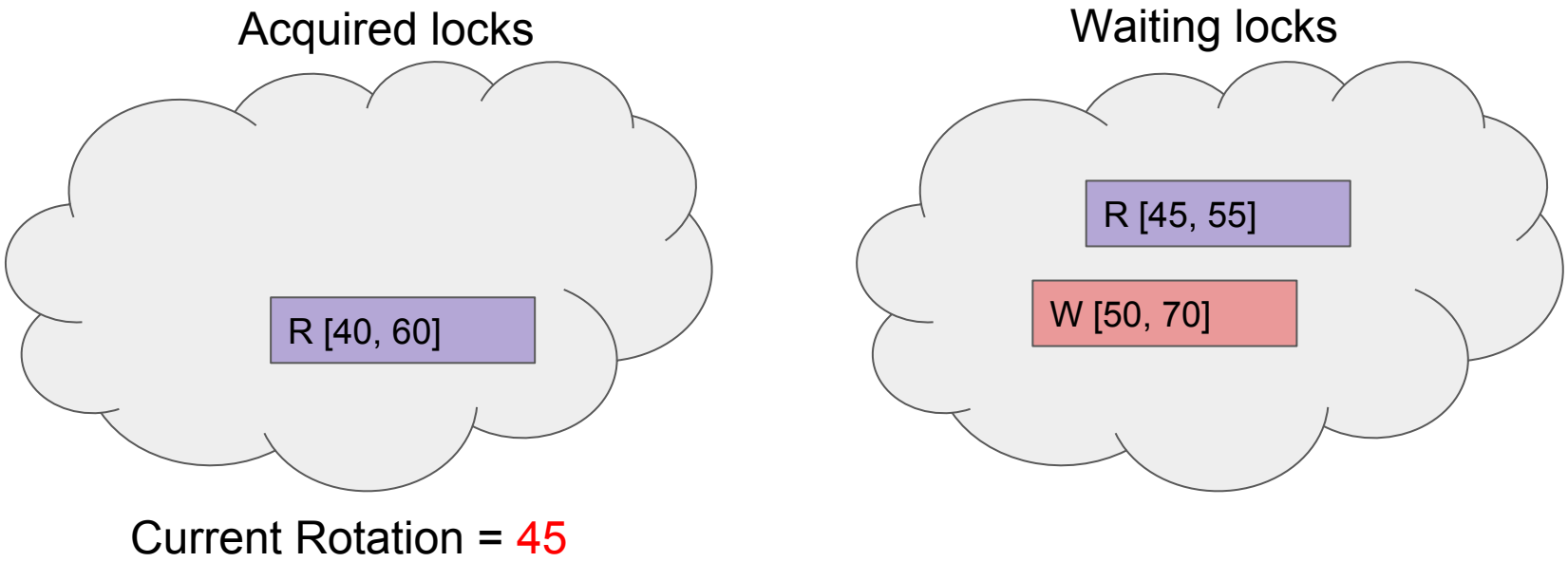
If a reader(R[40, 60]) holds a lock
and a writer(W[50, 70]) wants to take(50 ∈ [50, 70])
the lock([40, 60] overlaps with [50, 70], waiting),
no more readers(R[45, 55])
can take the lock([45, 55] overlaps with [50, 70])



Current Rotation = 50

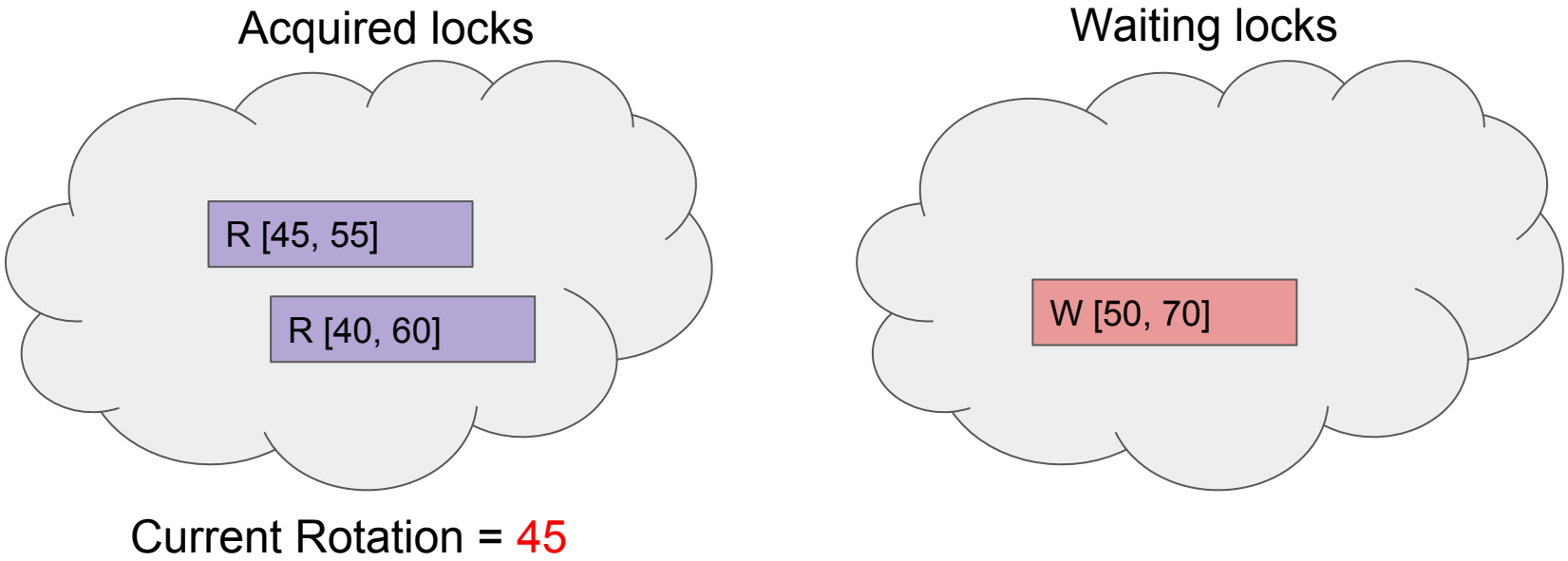
How to prevent writer starvation?

- Rotation changes 50 → 45



How to prevent writer starvation?

- W [50, 70] cannot grab its lock anymore ($\because 45 \notin [50, 70]$)
- Starvation prevention policy is no more applied → R [45, 55] acquires its lock

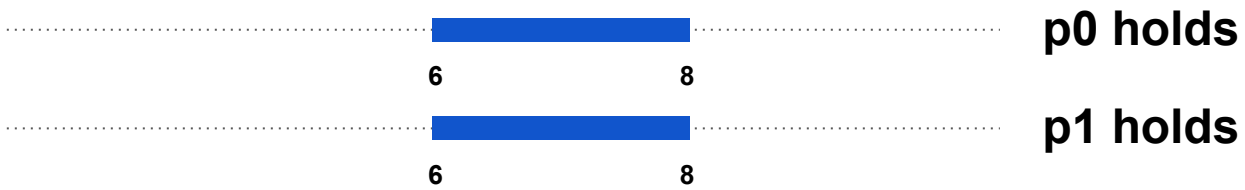


Terminating routine

- When a thread that has some holding or waiting locks is terminating, the remaining locks should be released (holding) or removed (waiting).
- Hints
  - exit_rotlock() in kernel/rotation.c
    - Release holding locks
    - Remove waiting locks
  - Inject exit_rotlock() to do_exit() in kernel/exit.c

Isolation

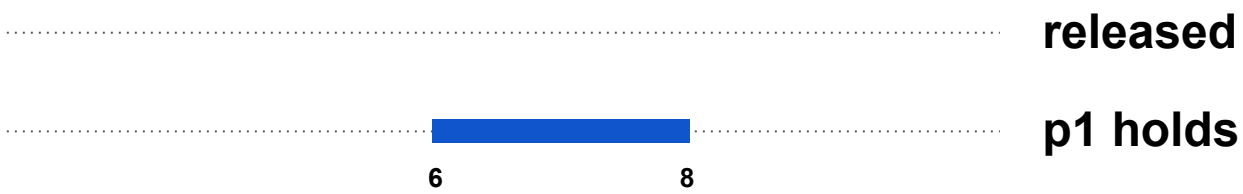
- Multiple processes shares same rotation lock system.
  - You have to identify which process (thread) the lock belongs to.
- A process can’t release locks that other processes hold.



Isolation

- A process can’t release locks that other processes hold.

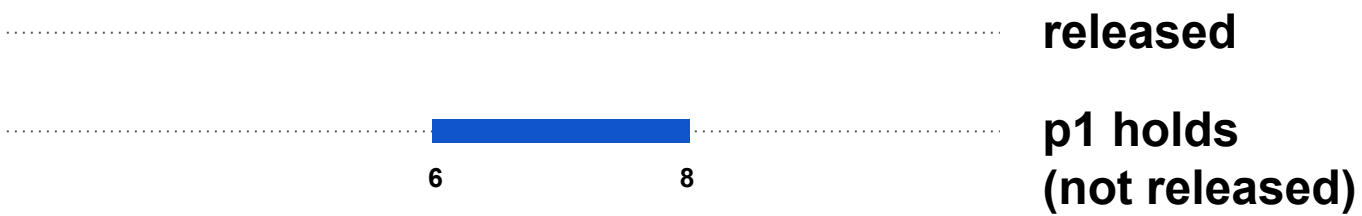
p0 calls unlock(6-8)



Isolation

- A process can’t release locks that other processes hold.

p0 calls unlock(6-8) **again**



Some hints for doing your project

- You will create things like acquired lock list and waiting lock list
  - Different approaches are also possible :)
  - Ex) Bitmap, linked list, ...
- Accessing those lists could result in race conditions
  - Remind: ARTIK has 4 cores
  - You should carefully design your code to prevent possible race conditions
    - Ex) One thread is removing a lock from waiting list, but another thread can access to the waiting list at the same time

Some hints for doing your project

- Possible approaches
  - Global
    - Ex) Manage acquired lock list and waiting lock list using a same lock
  - Fine-grained
    - Ex) Manage acquired lock list and waiting lock list using separated locks
    - Better concurrency, more complicated :)
- Synchronization mechanism
  - Spin Lock
    - Eligible for short sleep (e.g. short list iteration)
  - RCU (Read-Copy-Update)
  - …

Some hints for doing your project

- How to block processes
  - set_current_state(TASK_INTERRUPTIBLE)
  - Wait queue
    - prepare_to_wait() and finish_wait()
    - wait event
    - Maybe it’s necessary to modify existing kernel code :) or poor performance…
  - condition variable, mutex
  - ...
- **You should call “schedule()” right after set_current_state(), prepare_to_wait(), ...**

Some hints for doing your project

- How to wake up blocked processes?
  - PID or task_struct
    - wake_up_process(task_struct *t)
      - You can get “task_struct” value of the blocked process using pid. pid_task(), find_vpid(), …
  - wait queue
    - wake_up_interruptible()
    - ...
  - ...

Some hints for doing your project

- Lists could be changed during iteration
  - list_for_each_entry_safe could be useful to you
- Please remember that …
  - The rotation range is **circular!**
    - You should implement a logic for determining two circular ranges are overlapping or not
  - Be aware of deadlocks!

Wait queue

- Blocking
  - Declaring a new wait queue
    - DECLARE_WAIT_QUEUE_HEAD()
  - Create wait queue entry.
    - DEFINE_WAIT(), DECLARE_WAITQUEUE(), DEFINE_WAIT_FUNC()
  - Register a function that wakes up with the entry.
    - The function can contain condition check code.
    - DEFINE_WAIT() registers autoremove_wake_function automatically.
  - Then, prepare_to_wait() and schedule().

Wait queue

- Wake up
  - Other processes call __wake_up.
  - __wake_up calls the function registered with the entry.
  - If the function doesn’t remove the entry from the wait queue, the woken process handles it.
  - finish_wait()

Wait queue

- wait_event
  - DEFINE_WAIT()
  - while(true) {
    prepare_to_wait()
    if (condition)
    break;
    schedule();
    }
  - finish_wait()

Condition variable vs Wait queue

- Condition variable can be implemented with wait queue.
  - wait()
    - Register a function that check condition with the wait queue entry.
      - DEFINE_WAIT_FUNC(name, your_function)
    - Or use wait_event.
  - signal(): __wake_up(..., nr_exclusive=1, ...)
  - broadcast() : __wake_up(..., nr_exclusive=0, ...)

Selector & Trial

- Selector & Trial require a same lock (**0 <= range <= 180)**
  - If current rotation is 240, both selector & trial wait.
- When the device rotation is out of that range, both Selector & Trial stop working
- When the device rotation gets inside that range, Selector & Trial start to work

Selector & Trial

Selector	Trial
write_lock	
	read_lock & wait
10	
write_unlock	acquire lock
write_lock & wait	
	10 = 2 * 5
acquire lock	read_unlock

Q & A