CS 1550

Week 5 – Synchronization with xv6

Teaching Assistant

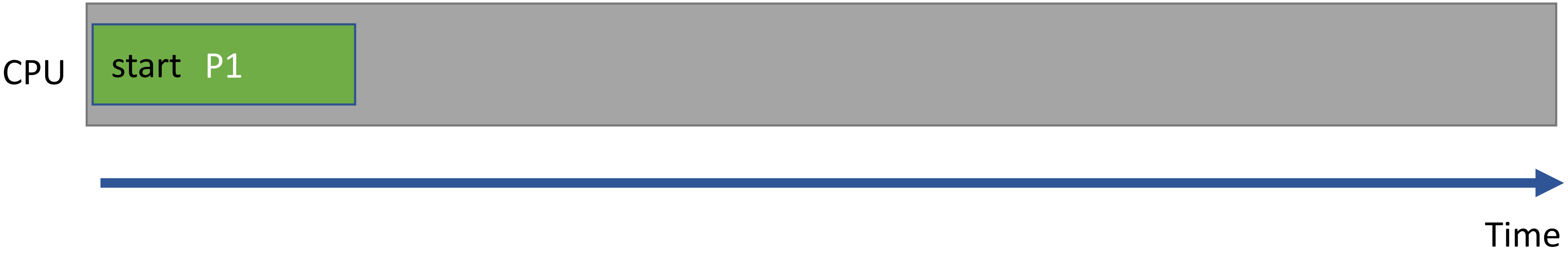
Maher Khan

(Slides credited to Henrique Potter)

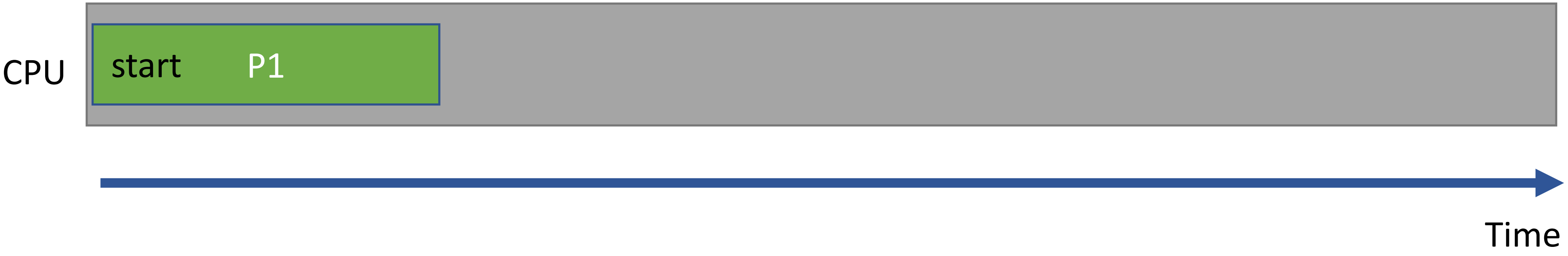
Keep in mind the different qemu

- qemu with xv6 (Labs) - Refer to Lab 1 if needed!
- qemu-x86 i386 (Project 1 and 2)

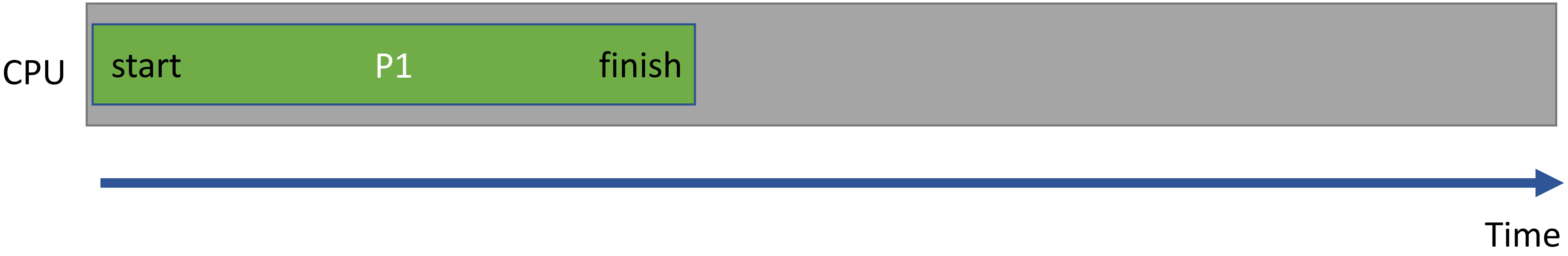
Locks – Processes without sharing CPU



Locks – Processes without sharing CPU

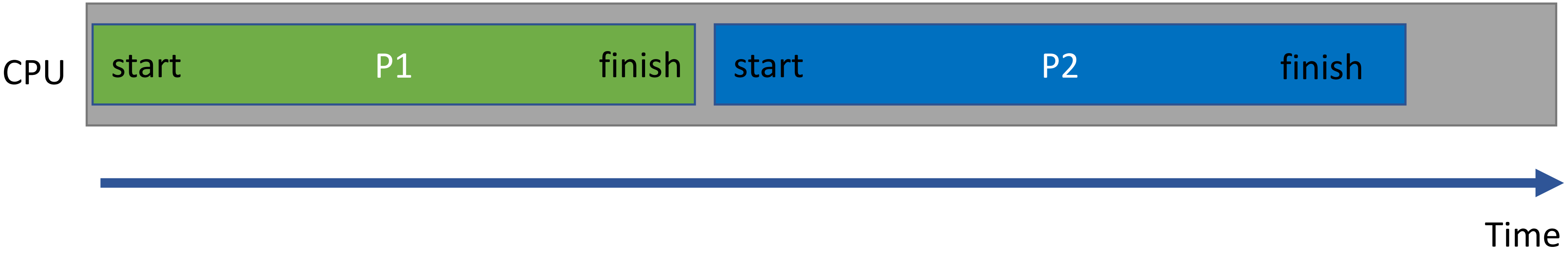


Locks – Processes without sharing CPU



Locks – Processes without sharing CPU

- **OS** chooses another processes to execute once the first finishes



Locks – Processes without sharing CPU

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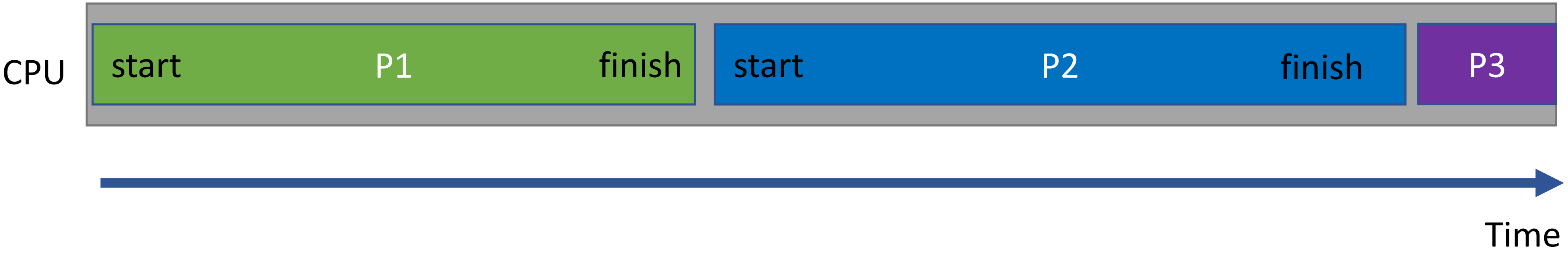
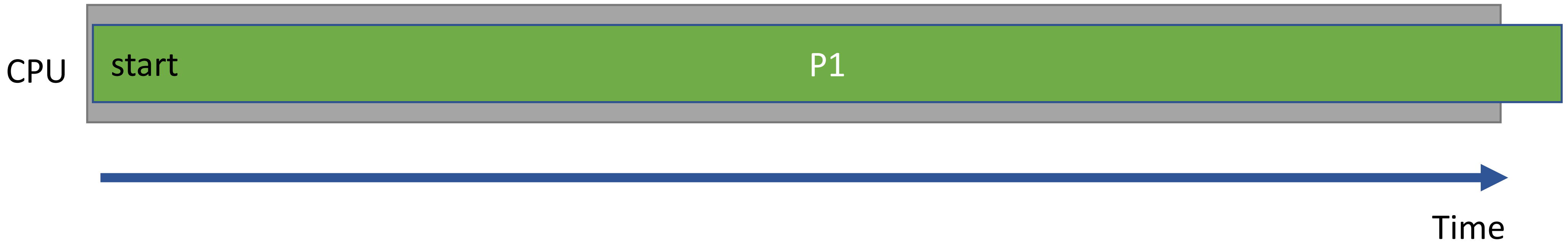


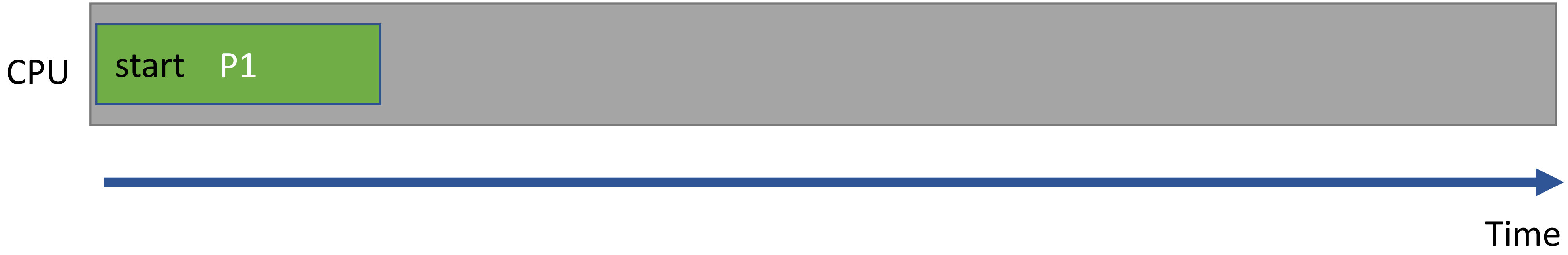
Locks – Processes without sharing CPU

- What if P1 is a big process?



Locks – Processes sharing CPU

- Solution switch processes during their execution.



Locks – Processes sharing CPU

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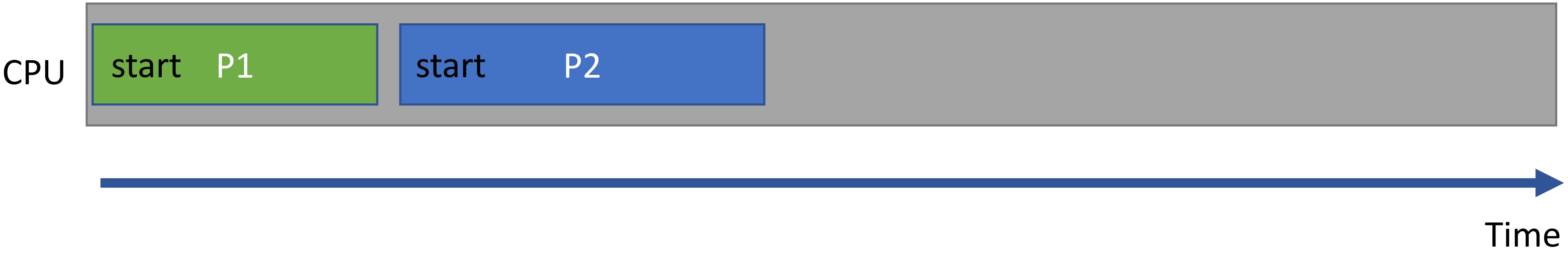

Locks – Processes sharing CPU

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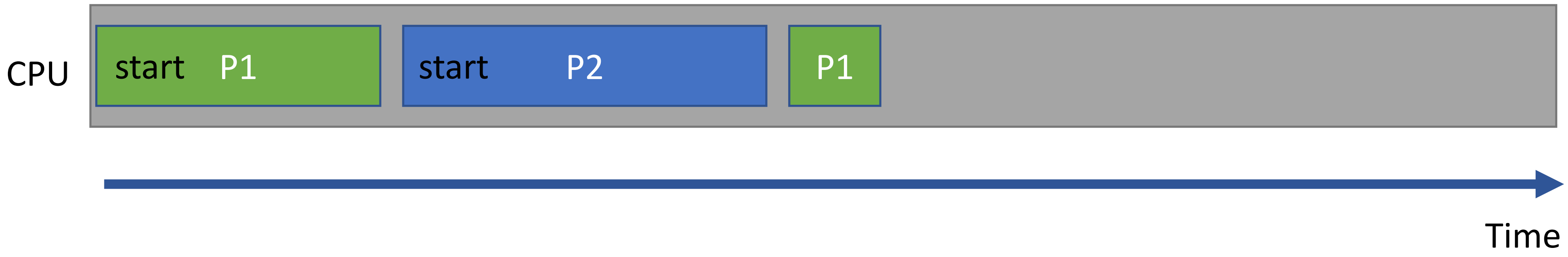
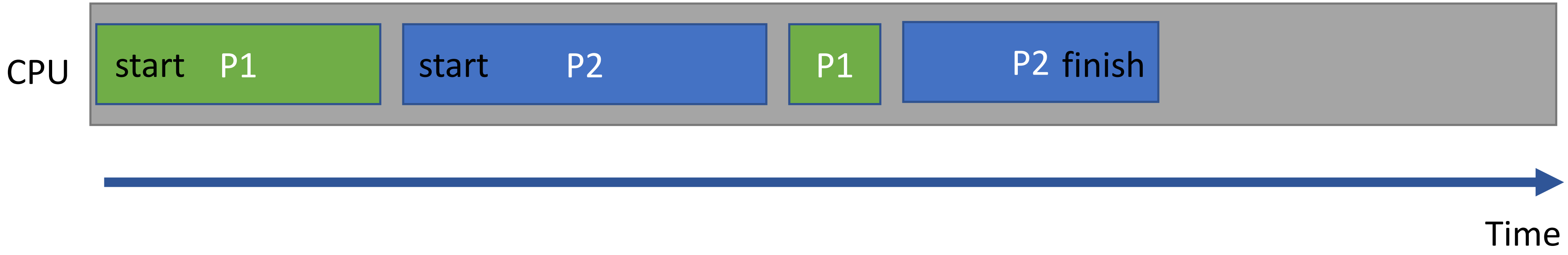


Locks – Processes sharing CPU

- Solution switch processes during their execution.



Locks – Processes sharing CPU

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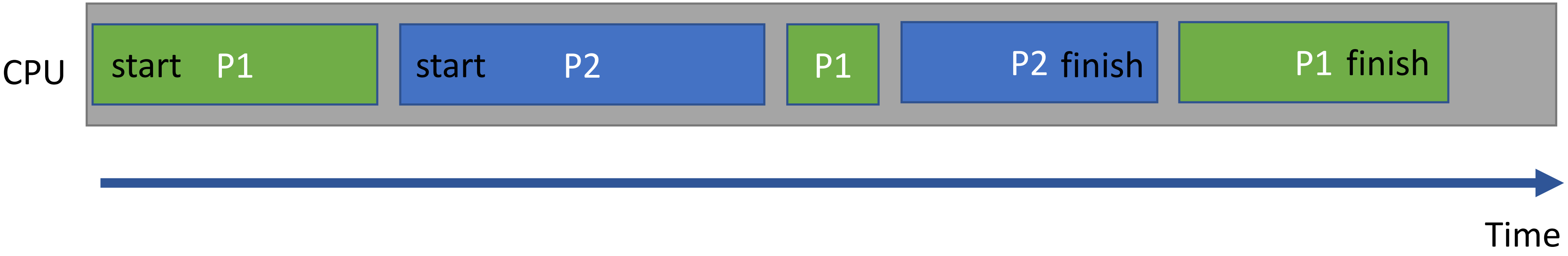
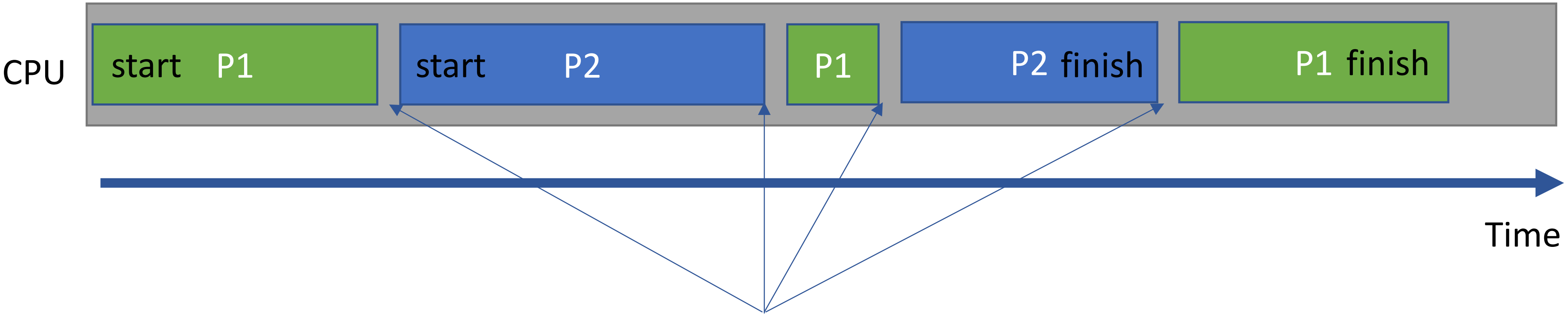


Locks – Processes sharing CPU

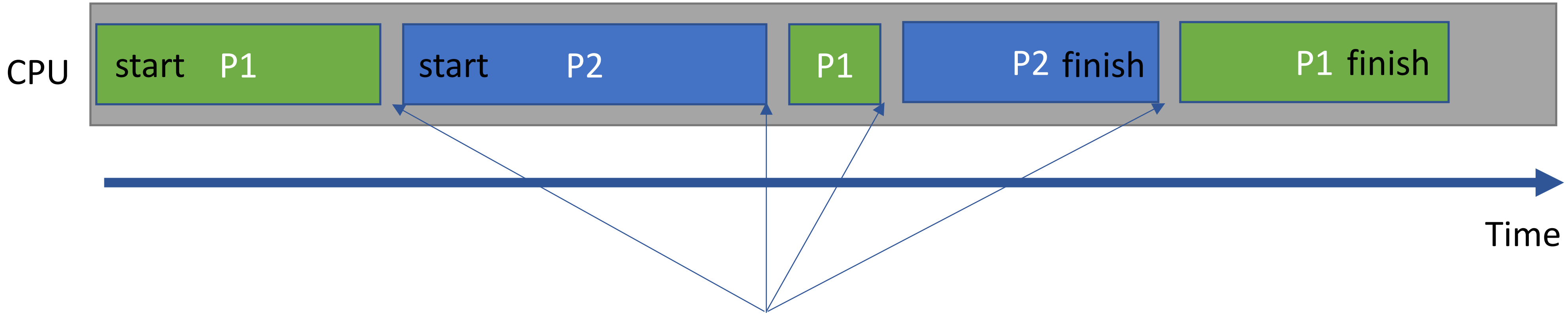
- Solution switch processes during their execution.



What is the little gap?

Locks – Processes sharing CPU

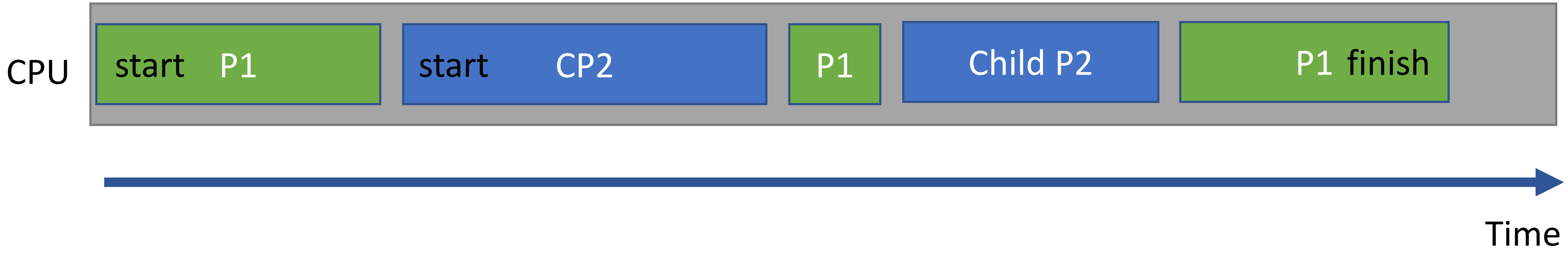
- Solution switch processes during their execution.



What is the little gap?
The OS **Scheduler**

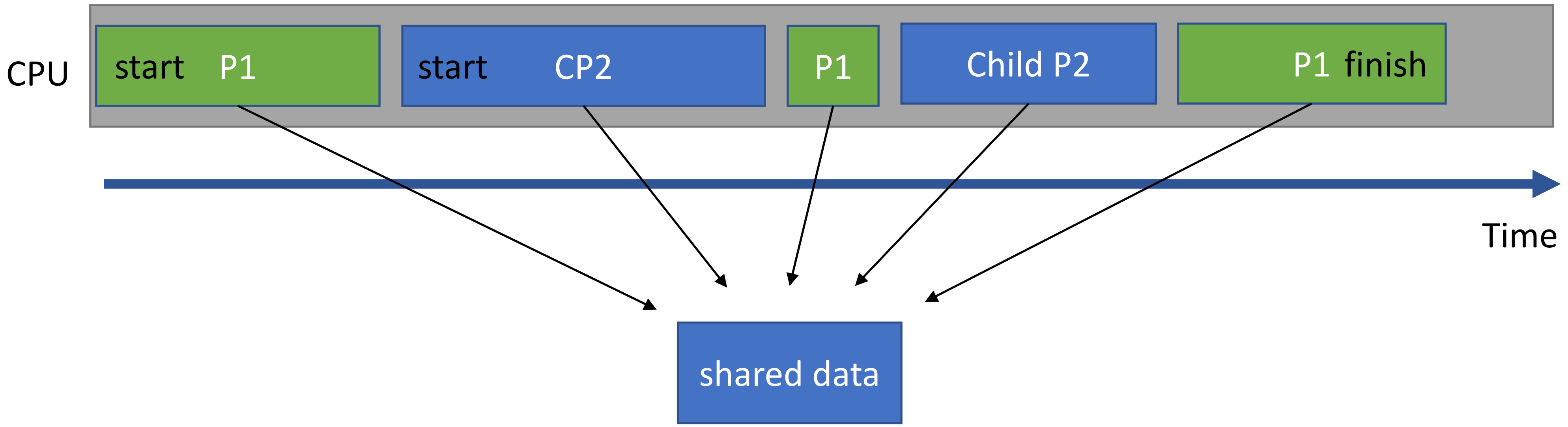
Locks – Processes sharing CPU

- What happens in Parent-Child Process scenario?



Locks – Processes sharing CPU

- What happens in Parent-Child Process scenario?
- How to keep integrity/correctness on race conditions?



Locks – Processes sharing CPU

```
struct list {
  int data;
  struct list *next;
};
```

Locks – Processes sharing CPU

```
struct list {
  int data;
  struct list *next;
};

struct list *list = 0;
```

Locks – Processes sharing CPU

```
struct list {
  int data;
  struct list *next;
};

struct list *list = 0;

void
insert(int data) {
      struct list *l;
      l = malloc(sizeof *l);
      l->data = data;
      l->next = list;
      list = l;
}
```

Locks – Processes sharing CPU

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struct list {
  int data;
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struct list *list = 0;

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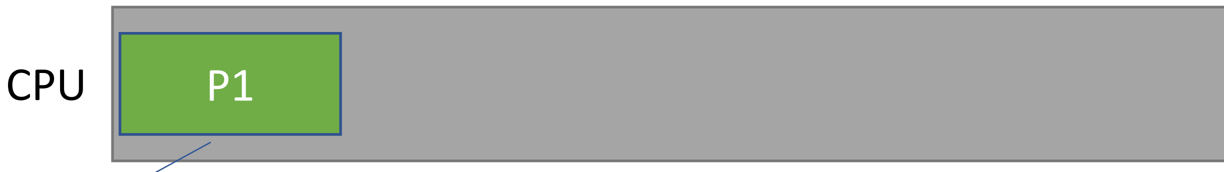


P1 stops here the
OS switches to P2

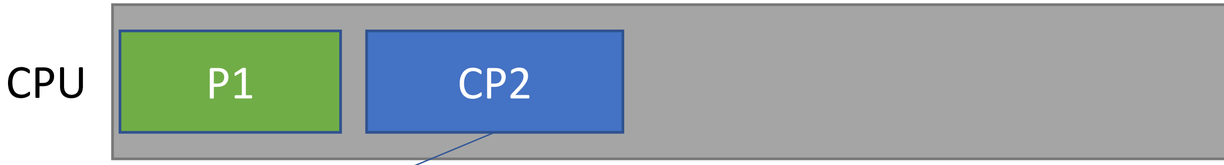
Locks – Processes sharing CPU

```
struct list {
  int data;
  struct list *next;
};

struct list *list = 0;

void
insert(int data) {
      struct list *l;
      l = malloc(sizeof *l);
      l->data = data;
      l->next = list;
      list = l;
}
```

P1 stopped



P2 gets the same reference to the same block of data of list and overwrites it

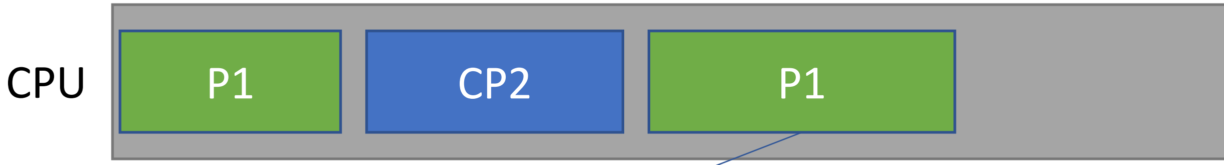
Locks – Processes sharing CPU

```
struct list {
  int data;
  struct list *next;
};

struct list *list = 0;

void
insert(int data) {
      struct list *l;
      l = malloc(sizeof *l);
      l->data = data;
      l->next = list;
      list = l;
}
```

CP2 stopped



When P1 comes back it will have written the wrong data

Locks – Processes sharing CPU

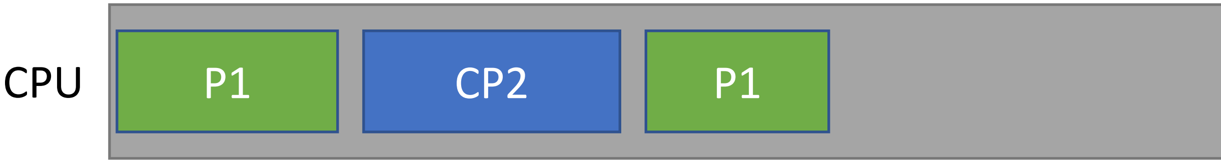
- Sharing CPU among processes
- Ensuring data integrity/correctness
- Ensure that a **critical section** of your code is only executed by one process

Locks – Processes sharing CPU

```
struct list *list = 0;
struct lock listlock;

void
insert(int data)
{
      struct list *l;

      acquire(&listlock);
      l = malloc(sizeof *l);
      l->data = data;
      l->next = list;
      list = l;
      release(&listlock);
}
```



Locks – Processes sharing CPU

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}
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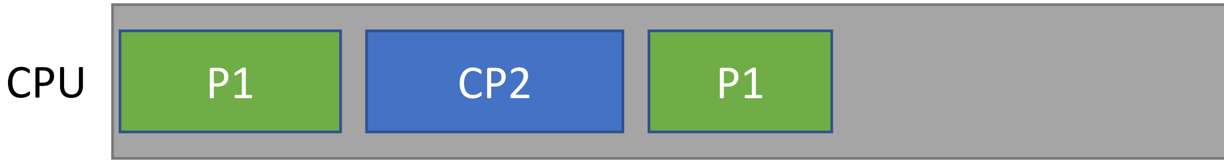

Locks – Processes sharing CPU

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struct list *list = 0;
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insert(int data)
{
        struct list *l;

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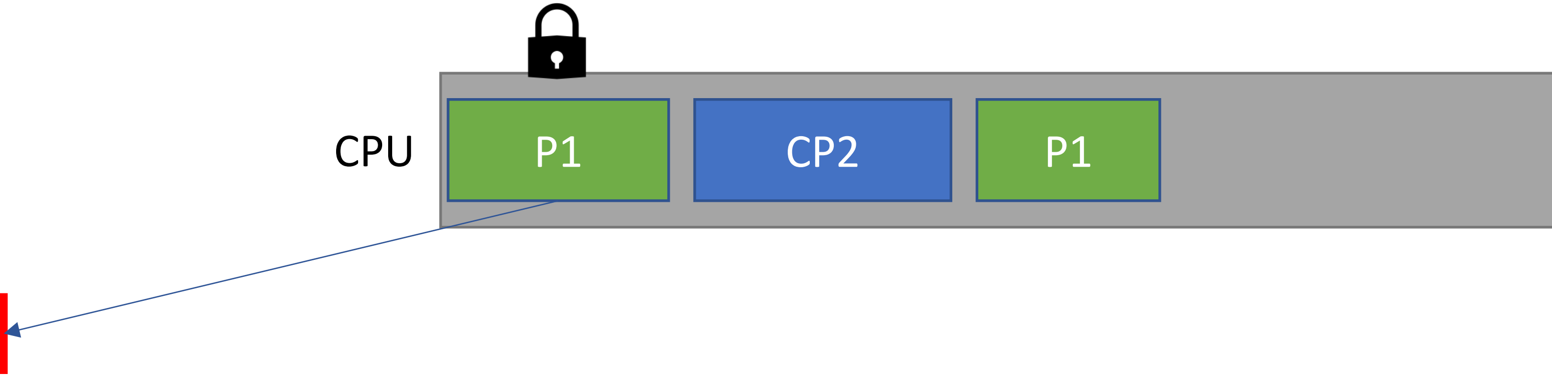
}
```



P1 gets locks the lock

Locks – Processes sharing CPU

```
struct list *list = 0;
struct lock listlock;

void
insert(int data)
{
        struct list *l;

        acquire(&listlock);
        l = malloc(sizeof *l);
        l->data = data;
        l->next = list;
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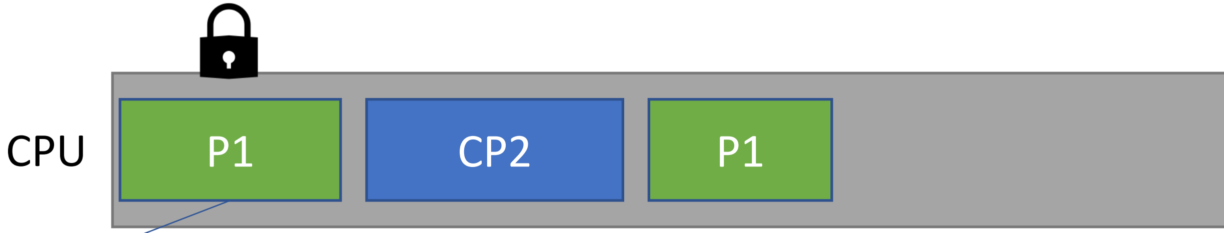
        release(&listlock);
}
```



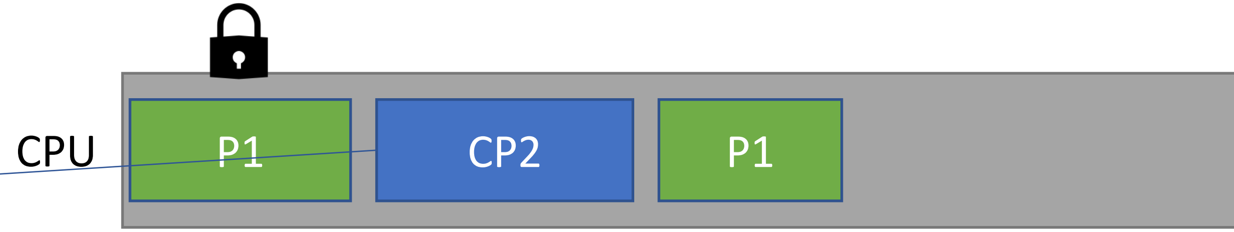
P1 gets locks the lock

Locks – Processes sharing CPU

```
struct list *list = 0;
struct lock listlock;

void
insert(int data)
{
        struct list *l;

        acquire(&listlock);
        l = malloc(sizeof *l);
P1 stopped      l->data = data;
        l->next = list;
        list = l;
        release(&listlock);
}
```



When the OS schedule CP2

Locks – Processes sharing CPU

```
struct list *list = 0;
struct lock listlock;

void
insert(int data)
{
        struct list *l;

        acquire(&listlock);
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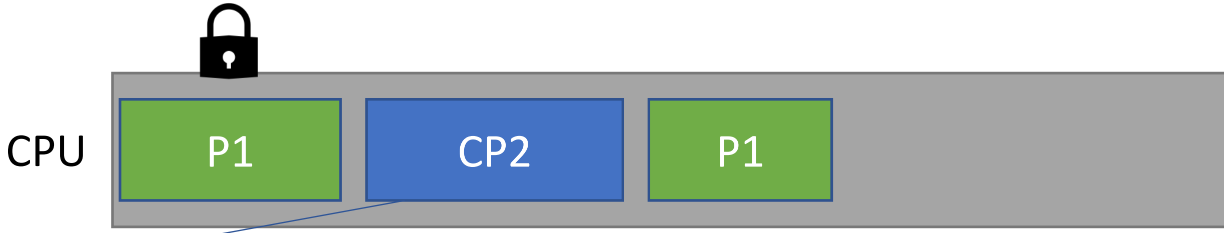
P1 stopped  l->data = data;
        l->next = list;
        list = l;
        release(&listlock);
}
```



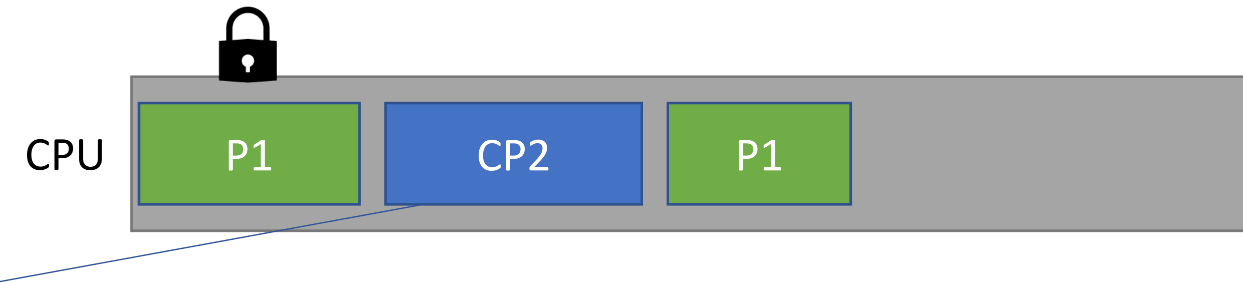
It will try to get the lock but won't.

Locks – Processes sharing CPU

```
    struct list *list = 0;
    struct lock listlock;

    void
    insert(int data)
    {
            struct list *l;

            acquire(&listlock);
            l = malloc(sizeof *l);
P1 stopped  l->data = data;
            l->next = list;
            list = l;
            release(&listlock);
    }
```



It will try to get the lock but won’t.

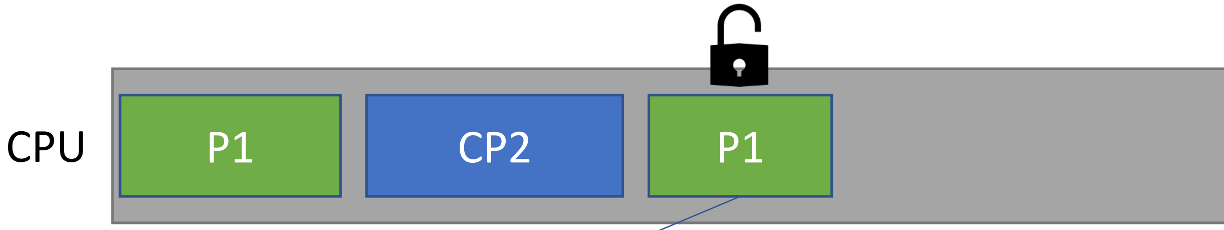
It will be constantly try to get it (in a loop).
Until the OS switches back to P1

Locks – Processes sharing CPU

```
struct list *list = 0;
struct lock listlock;

void
insert(int data)
{
        struct list *l;

CP2 stopped   acquire(&listlock);
        l = malloc(sizeof *l);
        l->data = data;
        l->next = list;
        list = l;
        release(&listlock);
}
```



P1 release the lock P2 will finally be able to execute, once scheduled

Locks – Processes sharing CPU

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struct list *list = 0;
struct lock listlock;

void
insert(int data)
{
        struct list *l;

        acquire(&listlock);
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        l->next = list;
        list = l;
        release(&listlock);
}
```
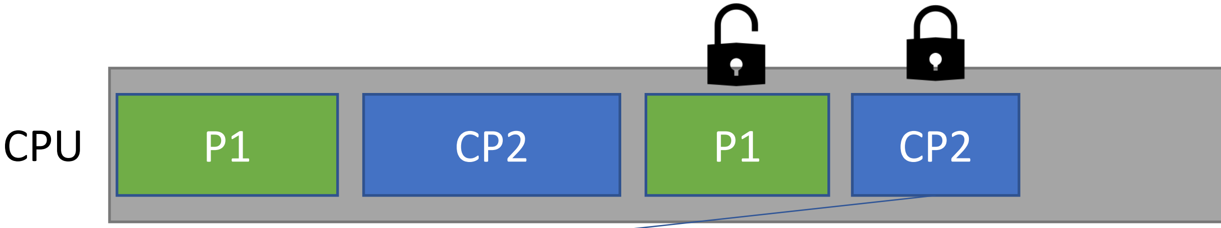

CP2 proceeds



P1 release the lock P2 will finally be able to execute, once scheduled

Locks – Processes sharing CPU

- SpinLock

```
Void
acquire(struct spinlock *lk)
{
    for(;;) {
        if(!lk->locked) {
            lk->locked = 1;
            break;
        }
    }
}
```

- Keep spinning until find lock is released

- But we can have the same issue as before

- We need to check and lock atomically

Locks – Processes sharing CPU

- Atomically check and change a register value
  - **`xchg(&lk->locked, 1)`**

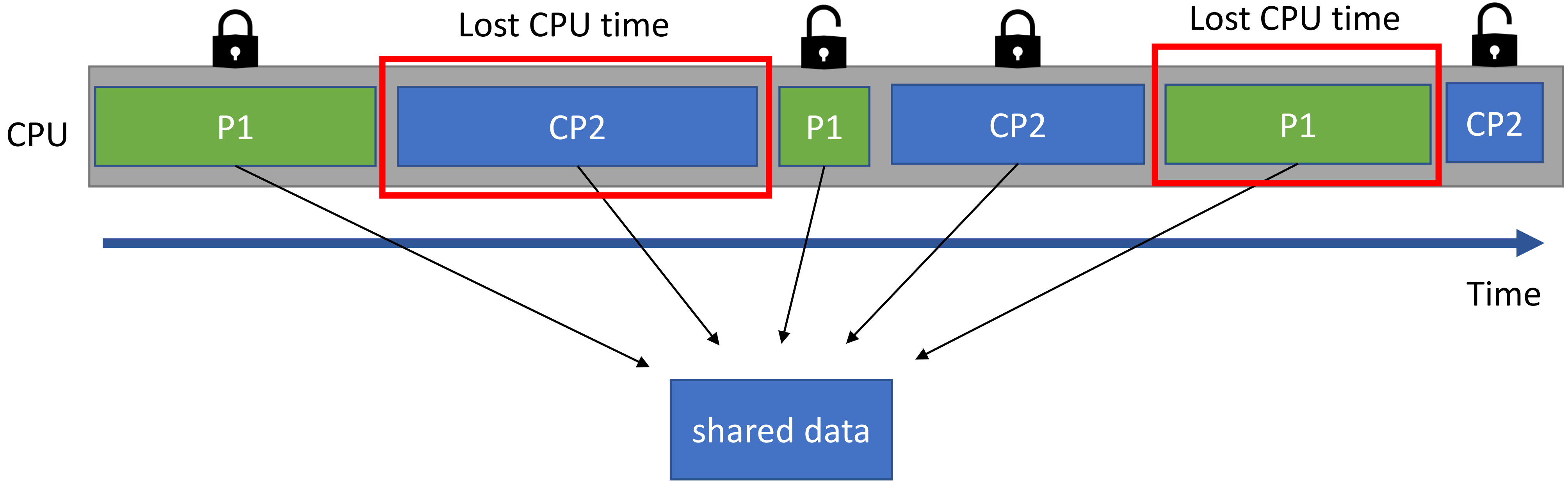
Locks – Processes sharing CPU

- Swap a word in memory with the contents of a register
- In acquire function:
  - loop xchg instruction
  - Each round atomically read lock and set the lock to 1

```
void
acquire(struct spinlock *lk)
{
    pushcli(); // disable interrupts to
avoid deadlock.
          …

// The xchg is atomic.
    while(xchg(&lk->locked, 1) != 0);

          …

// Record info about lock acquisition for
debugging.
    lk->cpu = mycpu();
    getcallerpcs(&lk, lk->pcs);
}
```

Locks – Processes sharing CPU

- But the we have another issue
  - Busy waiting



Locks – Processes sharing CPU

- Sleep Locks
  - For code need to hold a lock for a long time (read/write to disk)
- Avoids the schedule of “spin locked” processes

Locks – Processes sharing CPU

- Sleep Locks
    - For code need to hold a lock for a long time (read/write to disk)
- Avoids the schedule of “spin locked” processes

```
void
acquiresleep(struct sleeplock *lk)
{
    acquire(&lk->lk);
    while (lk->locked) {
        sleep(lk, &lk->lk);
    }
    lk->locked = 1;
    lk->pid = myproc()->pid;
    release(&lk->lk);
}
```

```
void
releasesleep(struct sleeplock *lk)
{
    acquire(&lk->lk);
    lk->locked = 0;
    lk->pid = 0;
    wakeup(lk);
    release(&lk->lk);
}
```

Locks – Processes sharing CPU

- Sleep Locks
  - For code need to hold a lock for a long time (read/write to disk)
- Avoids the schedule of “spin locked” processes

```
void
acquiresleep(struct sleeplock *lk)
{
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    while (lk->locked) {
        sleep(lk, &lk->lk);
    }
    lk->locked = 1;
    lk->pid = myproc()->pid;
    release(&lk->lk);
}
```

```
void
releasesleep(struct sleeplock *lk)
{
    acquire(&lk->lk);
    lk->locked = 0;
    lk->pid = 0;
    wakeup(lk);
    release(&lk->lk);
}
```

Locks – Processes sharing CPU

- Put one process to sleep waiting for event

- Mark current process as sleeping

- Call **sched()** to release the processor

```
void
sleep(void *chan, struct spinlock *lk)
{
  struct proc *p = myproc();
    …
  p->state = SLEEPING;

  sched();
    …
}
```

- Put one process to sleep waiting for event

- Mark current process as sleeping

- Call **sched()** to release the processor

```
void
sleep(void *chan, struct spinlock *lk)
{
  struct proc *p = myproc();

  if(p == 0)
    panic("sleep");

  if(lk == 0)
    panic("sleep without lk");
  if(lk != &ptable.lock){
    acquire(&ptable.lock);
    release(lk);
  }
  p->chan = chan;
  p->state = SLEEPING;

  sched();
  p->chan = 0
  if(lk != &ptable.lock){
    release(&ptable.lock);
    acquire(lk);
  }
}
```

Locks – Processes sharing CPU

- Wake up process when event happened
- Mark a waiting process as runnable

```
static void
wakeup(void *chan)
{
    struct proc *p;
    for(p = ptable.proc; p < &ptable.proc[NPROC]; p++)
        if(p->state == SLEEPING && p->chan == chan)
            p->state = RUNNABLE;
}
```

Locks – Processes sharing CPU

- Who needs to be a syscall?
  - SpinLocks
  - SleepLocks

CS 1550 – Lab exercise 2

- **PROCESS SYNCHRONIZATION IN XV6**
    - **Due**: Friday, February 22, 2019 @11:59pm
    - Part 2 - step 5: user.h
        - Add declaration for init_lock()
            - void init_lock(struct spinlock *);
        - struct condvar;
        - struct spinlock;
    - Part 3 - step 8: defs.h
        - Add declaration for sleep1()

CS 1550

Week 5 – Synchronization with xv6

Teaching Assistant

Maher Khan

(Slides credited to Henrique Potter)