

Operating Systems

Locks

Nipun Batra

Locks

Thread 1

```
cc7: mov  0x20135f,%eax
```

```
ccd: add  $0x1,%eax
```

```
cd0: mov  %eax,0x20135f
```

Thread 2

```
cc7: mov  0x20135f,%eax
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Locks

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- Thread 1 checks if lock is free

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- Thread 1 checks if lock is free
- Lock is free, Thread 1 acquires the lock
- Thread 2 checks if lock is free
- Is not free; does not execute till lock free

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- Thread 1 executes

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- Thread 2 checks (keeps on doing so) for lock being free

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- Thread 1 executes
- Thread 1 Unlocks
- Thread 2 checks (keeps on doing so) for lock being free
- Thread 2 executes and unlocks

Goals of a Lock

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- Mutual exclusion: Only a single thread can run the critical section at a time

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 - Multiple threads, multiple CPU

Building a Lock - Disable Interrupts

```
Void lock()  
{ Disable Interrupts}
```

Critical Section

```
Void unlock()  
{ Enable Interrupts}
```

Building a Lock - Disable Interrupts

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Pros

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3. Loss of interrupts

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 1. Call lock() at starting of program and run infinitely
2. Does not work on multiprocessors
 1. Each processor will have own interrupts?!
3. Loss of interrupts
4. Inefficient - Interrupt routines can be slow

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 - set flag, execute critical section

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- Thread calls lock before entering critical section
 - Is flag set? (some other thread has critical section control)
 - Yes - Spin waiting
 - No
 - set flag, execute critical section
 - After completion of critical section, unset flag

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void init(lock_t *mutex)
{ // 0 -> lock is available, 1 -> held
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void init(lock_t *mutex)
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void lock(lock_t *mutex) {
  while (mutex->flag == 1);
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  mutex->flag = 1; // now SET it!
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  while (mutex->flag == 1);
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```
void unlock(lock_t *mutex) { mutex->flag = 0; }
```

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Thread 2

Building a Lock - Load/Store or Flag

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Call Lock()

Building a Lock - Load/Store or Flag

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while(flag == 1) // Busy spinning

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Context Switch

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Need Hardware Support!

Atomic Instructions - Test & Set

```
1 int TestAndSet(int *ptr, int new) {  
2   int old = *ptr; // fetch old value at ptr  
3   *ptr = new; // store 'new' into ptr  
4   return old; // return the old value  
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- Return old value pointed by ptr
- Simultaneously update to new
- Performed Atomically and by Hardware!
 - The above is just a software depiction

Atomic Instructions - Test & Set

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5 void init(lock_t *lock) {
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8   lock->flag = 0;
9 }
10 void lock(lock_t *lock) {
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Define lock structure

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Init by setting flag
to 0

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Case 1: Lock not held
by any thread

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- Set flag to 1 and return 0 from test and set → Current thread acquires lock

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Case 1: Lock not held by any thread

- old value of flag = 0
- Set flag to 1 and return 0 from test and set —> Current thread acquires lock
- No spin waiting for current thread

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Case 2: Lock held by some other thread

- old value of flag = 1
- Set flag to 1 and return 1 from test and set
- Spin waiting for current thread since it goes in while loop

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Once out of
critical section,
unset flag

Test & Set Evaluation

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- Performance: Spin Waiting is bad!
 - Single core: Each thread spins away its allotted time slot, eating away the time for the thread holding the critical section
 - Multi core: If num threads \sim num cores
 - Each thread waiting to acquire lock can spin on its core, not eating up the time needed (quick) for the critical section to execute on other

Atomic Instructions - Compare & Swap

```
1 int CompareAndSwap(int *ptr, int expected, int new) {  
2   int actual = *ptr;  
3   if (actual == expected)  
4     *ptr = new;  
5   return actual;  
6 }
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- Test whether value at address (ptr) is equal to expected

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