sync-rwlocks

reader/writer problem

some shared data

only one thread modifying (read+write) at a time

read-only access *from multiple threads* is safe

could use lock — but doesn't allow multiple readers

reader/writer locks

abstraction: lock that distinguishes readers/writers

operations:

- read lock: wait until no writers
- read unlock: stop being registered as reader
- write lock: wait until no readers and no writers
- write unlock: stop being registered as writer

reader/writer locks

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operations:

- read lock: wait until no writers
- read unlock: stop being registered as reader
- write lock: wait until *no readers and no writers*
- write unlock: stop being registered as writer

pthread rwlocks

```
pthread_rwlock_t rwlock;
pthread_rwlock_init(&rwlock, NULL /* attributes */);
...
    pthread_rwlock_rdlock(&rwlock);
    ...  /* read shared data */
    pthread_rwlock_unlock(&rwlock);

    pthread_rwlock_wrlock(&rwlock);
    ...  /* read+write shared data */
    pthread_rwlock_unlock(&rwlock);

...
pthread_rwlock_destroy(&rwlock);
```

rwlock effects exercise

```
pthread_rwlock_t lock;
void ThreadA() {
  pthread_rwlock_rdlock(&lock);
  puts("a");
  ...
  puts("A");
  pthread_rwlock_unlock(&lock);
}
void ThreadB() {
  pthread_rwlock_rdlock(&lock);
  puts("b");
  ...
  puts("B");
  pthread_rwlock_unlock(&lock);
}
```

```
void ThreadC() {
  pthread_rwlock_wrlock(&lock);
  puts("c");
  ...
  puts("C");
  pthread_rwlock_unlock(&lock);
}
void ThreadD() {
  pthread_rwlock_wrlock(&lock);
  puts("d");
  ...
  puts("D");
  pthread_rwlock_unlock(&lock);
}
```

exercise: which of these outputs are possible?

1. aAbBcCdD 2. abABcdDC 3. cCabBAdD

4. cdCDaAbB 5. caACdDbB

Backup slides

rwlocks with monitors (attempt 1)

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mutex_t lock;
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/* condition, signal when writers becomes 0 */
cond_t ok_to_read_cv;
/* condition, signal when readers + writers becomes 0 */
cond_t ok_to_write_cv;
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cond_t ok_to_read_cv;
/* condition, signal when readers + writers becomes 0 */
cond_t ok_to_write_cv;
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```
ReadLock() {
mutex_lock(&lock);
  while (writers != 0) {
    cond_wait(&ok_to_read_cv, &lock);
  }
  ++readers;
  mutex_unlock(&lock);
}
ReadUnlock() {
  mutex_lock(&lock);
  --readers;
  if (readers == 0) {
    cond_signal(&ok_to_write_cv);
  }
  mutex_unlock(&lock);
}
```

```
WriteLock() {
  mutex_lock(&lock);
  while (readers + writers != 0) {
    cond_wait(&ok_to_write_cv);
  }
  ++writers;
  mutex_unlock(&lock);
}
WriteUnlock() {
  mutex_lock(&lock);
  --writers;
  [[cond_signal(&ok_to_write_cv);]{.fragment
fragment-index=5 .custom .myem-only}]{.fragment
fragment-index=6 .custom .myem-only}
  [[cond_broadcast(&ok_to_read_cv);]{.fragment
fragment-index=4 .custom .myem-only}]{.fragment
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  mutex_unlock(&lock);
}
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}
```

writer-priority (1)

```
mutex_t lock; cond_t ok_to_read_cv; cond_t ok_to_write_cv;
int readers = 0, writers = 0;
int waiting_writers = 0;

ReadLock() {
  mutex_lock(&lock);
  while (writers != 0
         || waiting_writers != 0) {
    cond_wait(&ok_to_read_cv, &lock);
  }
  ++readers;
  mutex_unlock(&lock);
}

ReadUnlock() {
  mutex_lock(&lock);
  --readers;
  if (readers == 0) {
    cond_signal(&ok_to_write_cv);
  }
  mutex_unlock(&lock);
}
```

```
WriteLock() {
  mutex_lock(&lock);
  ++waiting_writers;
  while (readers + writers != 0) {
    cond_wait(&ok_to_write_cv, &lock);
  }
  --waiting_writers;
  ++writers;
  mutex_unlock(&lock);
}

WriteUnlock() {
  mutex_lock(&lock);
  --writers;
  if (waiting_writers != 0) {
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  mutex_unlock(&lock);
}

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  mutex_lock(&lock);
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WriteLock() {
  mutex_lock(&lock);
  ++waiting_writers;
  while (readers + writers != 0) {
    cond_wait(&ok_to_write_cv, &lock);
  }
  --waiting_writers;
  ++writers;
  mutex_unlock(&lock);
}

WriteUnlock() {
  mutex_lock(&lock);
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  if (waiting_writers != 0) {
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reader-priority (1)

```
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  ++waiting_readers;
  while (writers != 0) {
    cond_wait(&ok_to_read_cv, &lock);
  }
  --waiting_readers;
  ++readers;
  mutex_unlock(&lock);
}

ReadUnlock() {
  ...
  if (waiting_readers == 0) {
    cond_signal(&ok_to_write_cv);
  }
}
```

```
WriteLock() {
  mutex_lock(&lock);
  while (waiting_readers +
          readers + writers != 0) {
    cond_wait(&ok_to_write_cv);
  }
  ++writers;
  mutex_unlock(&lock);
}
WriteUnlock() {
  mutex_lock(&lock);
  --writers;
  if (readers == 0 && waiting_readers == 0) {
    cond_signal(&ok_to_write_cv);
  } else {
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reader-priority (1)

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WriteLock() {
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  while (waiting_readers +
          readers + writers != 0) {
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WriteUnlock() {
  mutex_lock(&lock);
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}
```

choosing orderings?

can use monitors to implement lots of lock policies

want X to go first/last — add extra variables

(number of waiters, even lists of items, etc.)

need way to write condition "you can go now"

e.g. writer-priority: readers can go if no writer waiting