CS 202, Spring 2015
Handout 4 (Class 5)

The previous handout demonstrated the use of mutexes and condition variables. This handout demonstrates the use of monitors (which combine mutexes and condition variables).

1. The bounded buffer as a monitor

```
    // This is pseudocode that is inspired by C++.
    // Don’t take it literally.

    class MyBuffer {
      public:
        MyBuffer();
        ~MyBuffer();
        void Enqueue(Item);
        Item = Dequeue();
      private:
        int count;
        int in;
        int out;
        Item buffer[BUFFER_SIZE];
        Mutex* mutex;
        Cond* nonempty;
        Cond* nonfull;
    }

    void
    MyBuffer::MyBuffer()
    {
        in = out = count = 0;
        mutex = new Mutex;
        nonempty = new Cond;
        nonfull = new Cond;
    }

    void
    MyBuffer::Enqueue(Item item)
    {
        mutex.acquire();
        while (count == BUFFER_SIZE)
            cond_wait(&nonfull, &mutex);

        buffer[in] = item;
        in = (in + 1) % BUFFER_SIZE;
        ++count;
        cond_signal(&nonempty, &mutex);
        mutex.release();
    }

    Item
    MyBuffer::Dequeue()
    {
        mutex.acquire();
        while (count == 0)
            cond_wait(&nonempty, &mutex);

        Item ret = buffer[out];
        out = (out + 1) % BUFFER_SIZE;
        --count;
        cond_signal(&nonfull, &mutex);
        mutex.release();
        return ret;
    }
```



```
    int main(int, char**)
    {
        MyBuffer buf;
        int dummy;
        tid1 = thread_create(producer, &buf);
        tid2 = thread_create(consumer, &buf);

        // never reach this point
        thread_join(tid1);
        thread_join(tid2);
        return -1;
    }

    void producer(void* buf)
    {
        MyBuffer* sharedbuf = reinterpret_cast<MyBuffer*>(buf);
        for (;;) {
            /* next line produces an item and puts it in nextProduced */
            Item nextProduced = means_of_production();
            sharedbuf->Enqueue(nextProduced);
        }
    }

    void consumer(void* buf)
    {
        MyBuffer* sharedbuf = reinterpret_cast<MyBuffer*>(buf);
        for (;;) {
            Item nextConsumed = sharedbuf->Dequeue();

            /* next line abstractly consumes the item */
            consume_item(nextConsumed);
        }
    }
```

Key point: *Threads* (the producer and consumer) are separate from *shared object* (MyBuffer). The synchronization happens in the shared object.

```
2. This monitor is a model of a database with multiple readers and
writers. The high-level goal here is (a) to give a writer exclusive
access (a single active writer means there should be no other writers
and no readers) while (b) allowing multiple readers. Like the previous
example, this one is expressed in pseudocode.

    // assume that these variables are initialized in a constructor
    state variables:
        AR = 0;  // # active readers
        AW = 0;  // # active writers
        WR = 0;  // # waiting readers
        WW = 0;  // # waiting writers

        Condition okToRead = NIL;
        Condition okToWrite = NIL;
        Mutex mutex = FREE;

    Database::read() {
        startRead();  // first, check self into the system
        Access Data
        doneRead();   // check self out of system
    }

    Database::startRead() {
        acquire(&mutex);
        while((AW + WW) > 0){
            WR++;
            wait(&okToRead, &mutex);
            WR--;
        }
        AR++;
        release(&mutex);
    }

   Database::doneRead() {
        acquire(&mutex);
        AR--;
        if (AR == 0 && WW > 0) { // if no other readers still
          signal(&okToWrite, &mutex);   // active, wake up writer
        }
        release(&mutex);
    }

    Database::write(){  // symmetrical
        startWrite();  // check in
        Access Data
        doneWrite();  // check out
    }

    Database::startWrite() {
        acquire(&mutex);
        while ((AW + AR) > 0) { // check if safe to write.
                                // if any readers or writers, wait
            WW++;
            wait(&okToWrite, &mutex);
            WW--;
        }
        AW++;
        release(&mutex);
    }

    Database::doneWrite() {
        acquire(&mutex);
        AW--;
        if (WW > 0) {
            signal(&okToWrite, &mutex); // give priority to writers
        } else if (WR > 0) {
            broadcast(&okToRead, &mutex);
        }
        release(&mutex);
    }

    NOTE: what is the starvation problem here?
```



```

3. Shared locks

    struct sharedlock {
      int i;
      Mutex mutex;
      Cond c;
    };

    void AcquireExclusive (sharedlock *sl) {
      acquire(&sl->mutex);
      while (sl->i) {
        wait (&sl->c, &sl->mutex);
      }
      sl->i = -1;
      release(&sl->mutex);
    }

    void AcquireShared (sharedlock *sl) {
      acquire(&sl->mutex);
      while (sl->i < 0) {
        wait (&sl->c, &sl->mutex);
      }
      sl->i++;
      release(&sl->mutex);
    }

    void ReleaseShared (sharedlock *sl) {
      acquire(&sl->mutex);
      if (!--sl->i)
        signal (&sl->c, &sl->mutex);
      release(&sl->mutex);
    }

    void ReleaseExclusive (sharedlock *sl) {
      acquire(&sl->mutex);
      sl->i = 0;
      broadcast (&sl->c, &sl->mutex);
      release(&sl->mutex);
    }

    QUESTIONS:
    A. There is a starvation problem here. What is it? (Readers can keep
       writers out if there is a steady stream of readers.)
    B. How could you use these shared locks to write a cleaner version
       of the code in item 2., above? (Though note that the starvation
       properties would be different.)
```