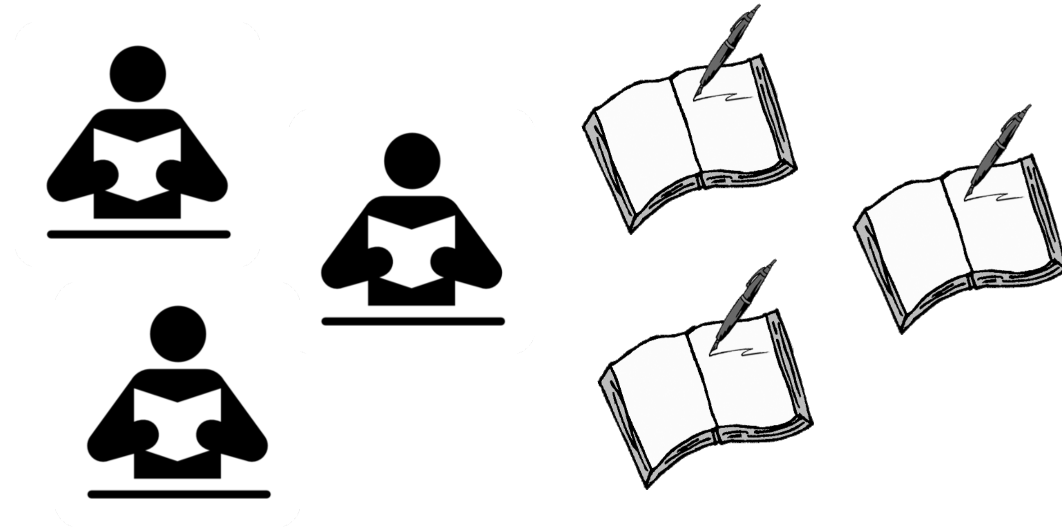
Readers/Writers Problem



Readers/Writers with Semaphores

```
class ReadWrite {
   public:
      void Read();
      void Write();
   private:
      Semaphore wrt = 1;
      Semaphore mutex = 1;
      int readers = 0;
}

ReadWrite::Write() {
   wrt.Wait();
   <perform write>
   wrt.Signal();
}
```

```
ReadWrite::Read() {
   mutex.Wait();
   readers++;
   if (readers == 1)
       wrt.Wait();
   mutex.Signal();
   <perform read>
   mutex.Wait();
   readers--;
   if (readers == 0)
       wrt.Signal();
   mutex.Signal();
}
```

Readers/Writers with Monitors

```
private int numReaders = 0;
private int numWriters = 0;

private synchronized void prepareRead() {
  while (numWriters > 0) wait();
  numReaders++;
}

private synchronized void doneRead() {
  numReaders--;
  if (numReaders == 0) notify();
}

public ... doRead() {
  // reads NOT synchronized
  prepareRead();
  <do the reading>
  doneRead();
}
```


Readers/Writers with Monitors

```
private int numReaders = 0;
private int numWriters = 0;

private synchronized void prepareRead() {
  while (numWriters > 0) wait();
  numReaders++;
}

private synchronized void doneRead() {
  numReaders--;
  if (numReaders == 0) notify();
}

public ... doRead() {
  // reads NOT synchronized
  prepareRead();
  <do the reading>
  doneRead();
}
```

```
private void prepareWrite() {
    numWriters++;
    while (numReaders > 0) wait();
}

private void doneWrite() {
    numWriters--;
    notify();
}

public synchronized void doWrite(...) {
    // writes synchronized
    prepareWrite();
    <do the writing>
    doneWrite();
}
```

The Dining Philosophers

Dining Philosophers

```
Lock chopsticks[5];

void philosopher(int i) {
  while (true) {

    think();

    chopsticks[i].acquire(); // left chopstick
    chopsticks[(i+1)%5].acquire(); // right chopstick

    eat();

    chopsticks[i].release();
    chopsticks[(i+1)%5].release();
  }
}
```

Deadlock!

Dining Philosophers with Monitors

```
monitor DiningPhilosophers  {
   enum {THINK, HUNGRY, EAT}
      state[5];
   condition self[5];
}

void synchronized pickup(int i) {
   state[i] = HUNGRY;
   tryEat(i);
   if (state[i] != EAT)
      self[i].wait();
}

void synchronized putdown(int i) {
   state[i] = THINK;
   // test left and right neighbors
   tryEat((i+4)%5);
   tryEat((i+1)%5);
}
```

```
void tryEat(int n) {
  // check left and right of n
  if (state[(n+4)%5] != EAT &&
      state[n] == HUNGRY &&
      state[(n+1)%5] != EAT) {
    state[n] = EAT;
    self[n].signal();
  }
}


void philosopher(int i) {
  state[i] = THINK;
  while (true) {
    think();
    pickup(i);
    eat();
    putdown(i);
  }
}
```


Deadlock

Thread A:

```
lock1.acquire();
lock2.acquire();

// do something

lock1.release();
lock2.release();
```

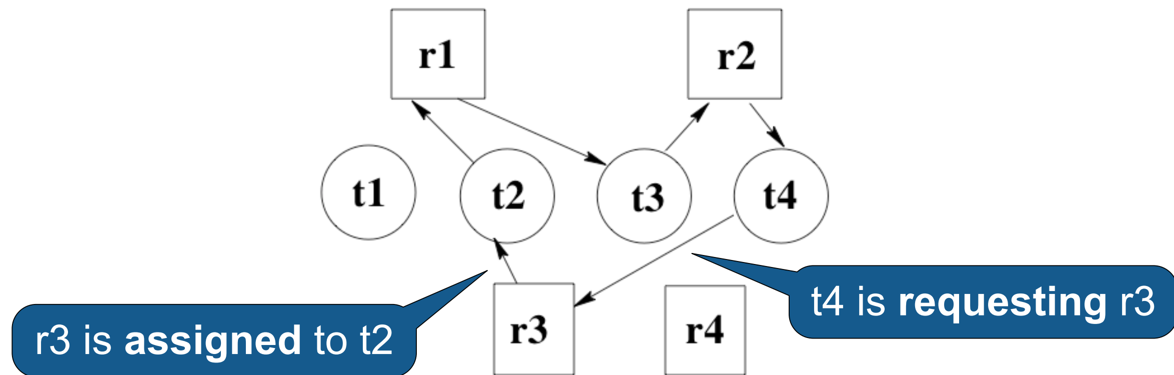
Thread B:

```
lock2.acquire();
lock1.acquire();

// do something

lock1.release();
lock2.release();
```

Resource Allocation Graph



Multiple Copies of Resources