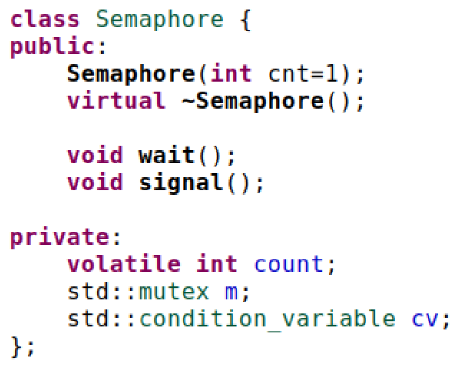
Semaphores

Semaphores

- Think of semaphores as bouncers at a nightclub. Fire codes limit the number of people that are allowed in the club at a time. If the club is full the bouncer makes people wait at the door, but as soon as someone leaves one of these waiting people can enter.
- It's simply a way to limit the number of consumers for a specific resource. For example, to limit the number of simultaneous calls to a database in an application.

Semaphores

- Must initialize count. It corresponds to how many at once.



```
class Semaphore {
public:
    Semaphore(int cnt=1);
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    void wait();
    void signal();

private:
    volatile int count;
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    std::condition_variable cv;
};
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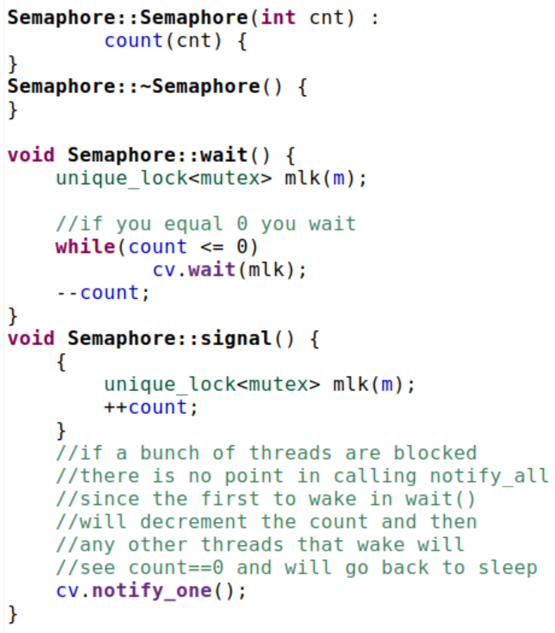

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Semaphore::Semaphore(int cnt) :
        count(cnt) {
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Semaphore::~Semaphore() {
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void Semaphore::wait() {
    unique_lock<mutex> mlk(m);

    //if you equal 0 you wait
    while(count <= 0)
            cv.wait(mlk);
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void Semaphore::signal() {
    {
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    //if a bunch of threads are blocked
    //there is no point in calling notify_all
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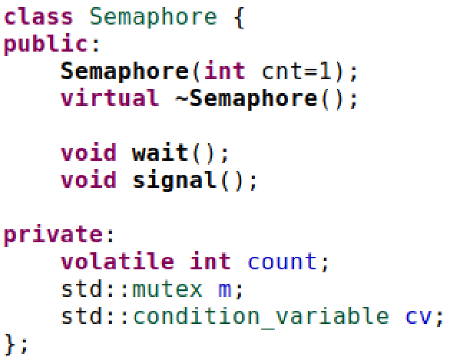

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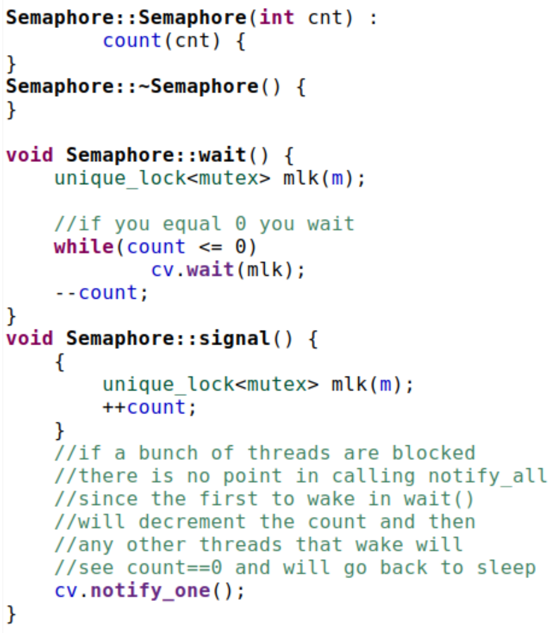

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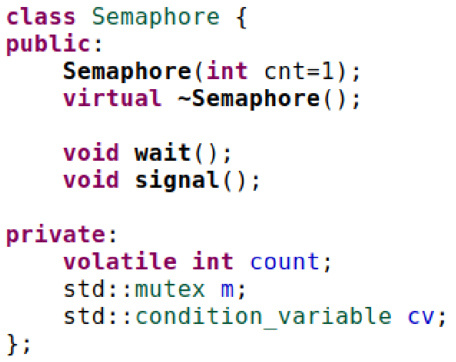
- wait(): if count==0 then thread is blocked, otherwise thread decrements count and proceeds

Semaphores



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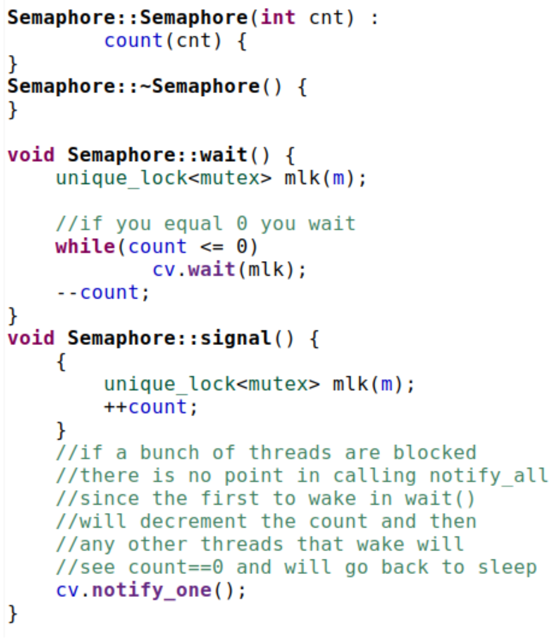

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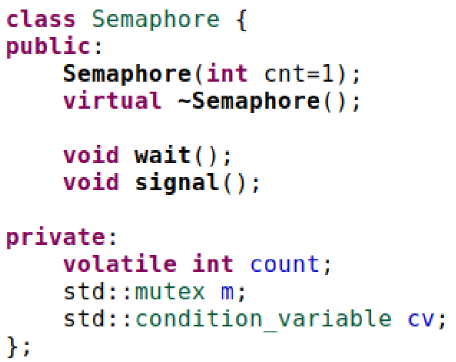

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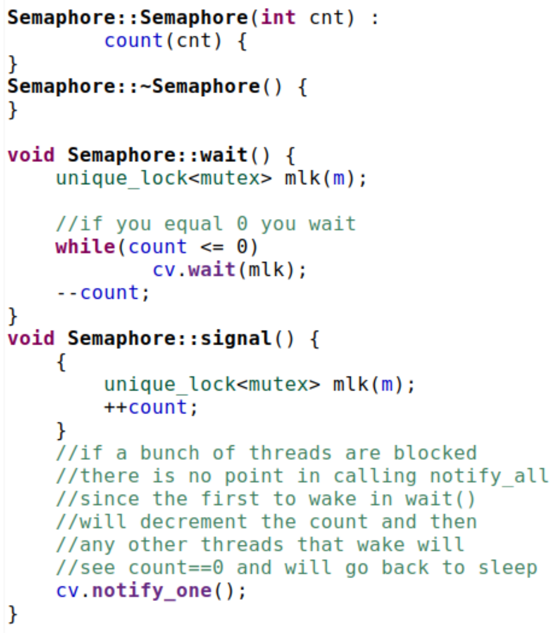

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- wait(): if count==0 then thread is blocked, otherwise thread decrements count and proceeds
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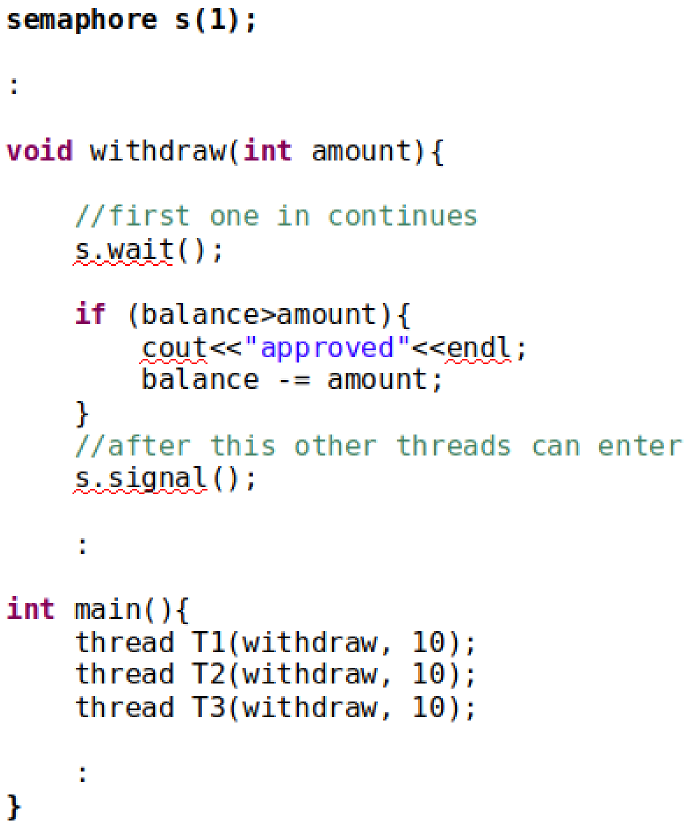
Also, you Can signal and wait on different threads!
BTW for mutexes you must lock and unlock on the SAME thread.

Semaphores

An Example

Semaphores



```
semaphore s(1);

:

void withdraw(int amount){

    //first one in continues
    s.wait();

    if (balance>amount){
        cout<<"approved"<<endl;
        balance -= amount;
    }
    //after this other threads can enter
    s.signal();

    :

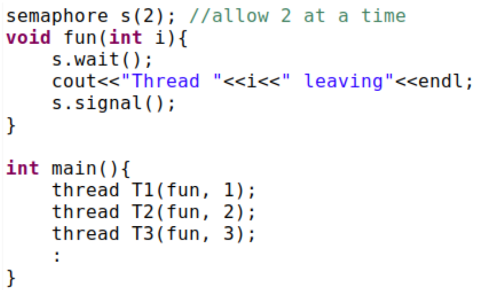
int main(){
    thread T1(withdraw, 10);
    thread T2(withdraw, 10);
    thread T3(withdraw, 10);

    :
}
```

- An Example:
- Semaphore initialized to 1
- This is known as a binary semaphore
- It acts like a mutex.

Semaphores

Another Example



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semaphore s(2); //allow 2 at a time
void fun(int i){
    s.wait();
    cout<<"Thread "<<i<<" leaving"<<endl;
    s.signal();
}

int main(){
    thread T1(fun, 1);
    thread T2(fun, 2);
    thread T3(fun, 3);
    :
}
```

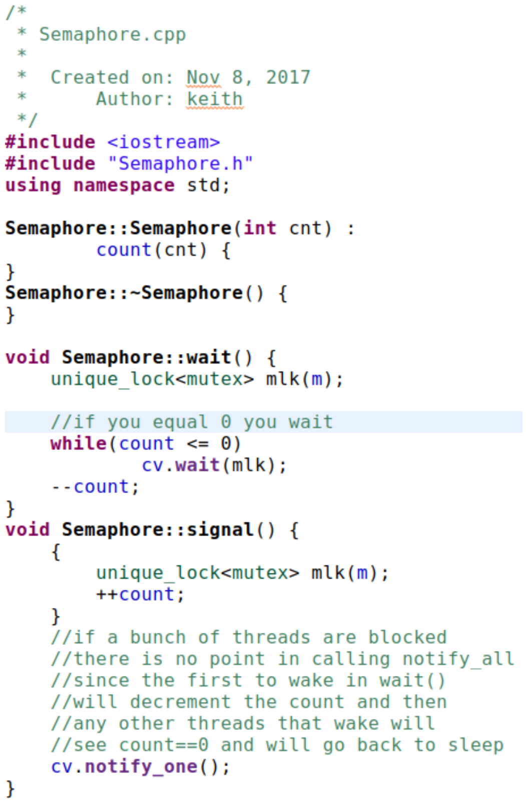

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 * Semaphore.cpp
 *
 *  Created on: Nov 8, 2017
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 */
#include <iostream>
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using namespace std;

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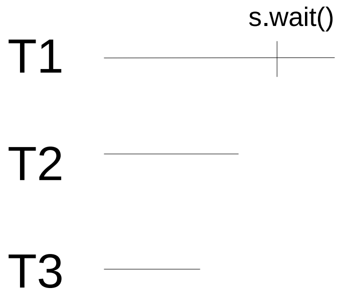
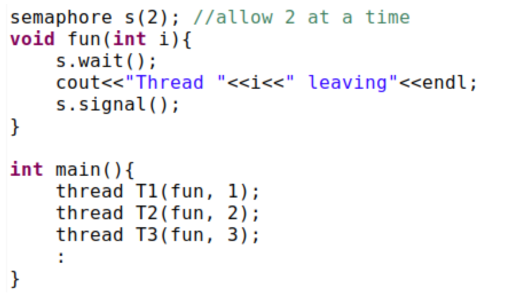
Assumming the order that threads start is (T1,T2,T3). Here is what happens:

T1 calls s.wait()





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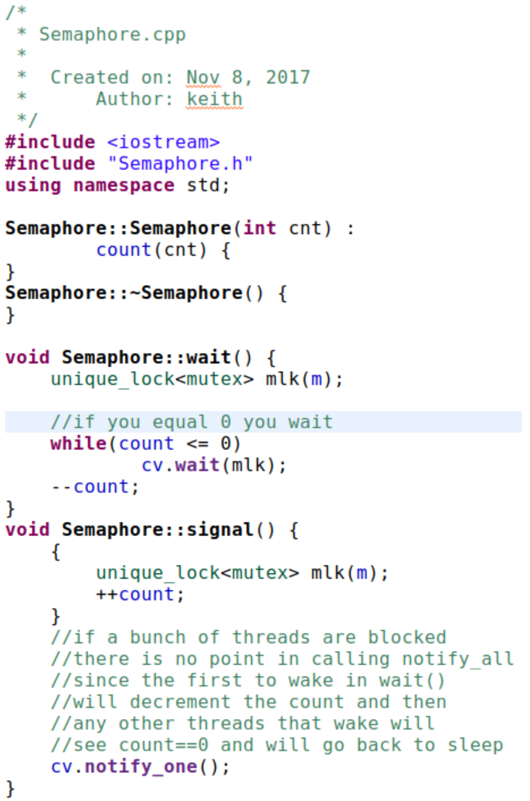

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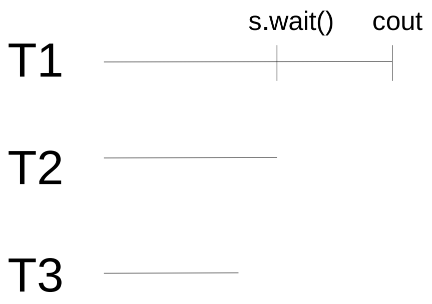
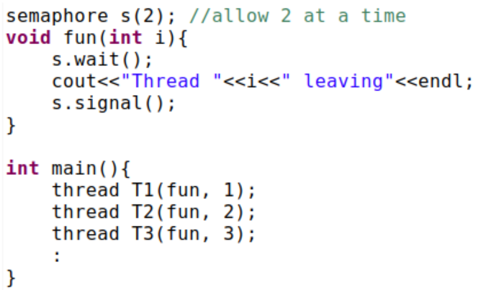
T1 calls s.wait() after which s.count==1, T1 Then couts…





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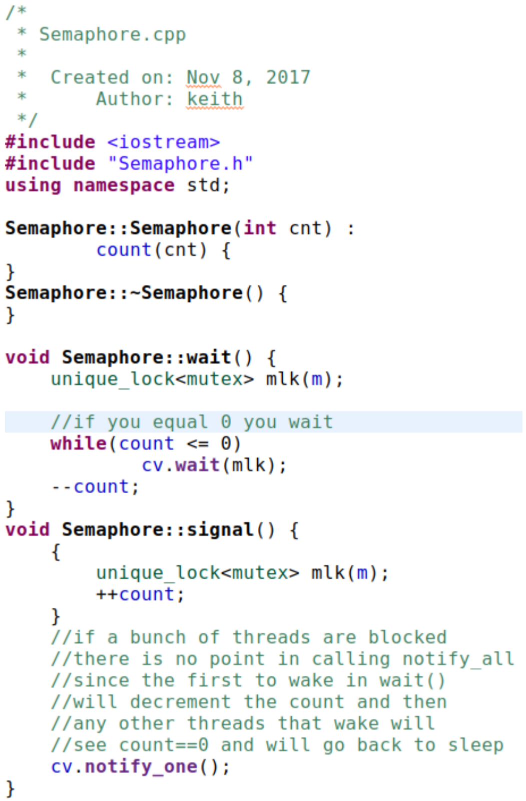

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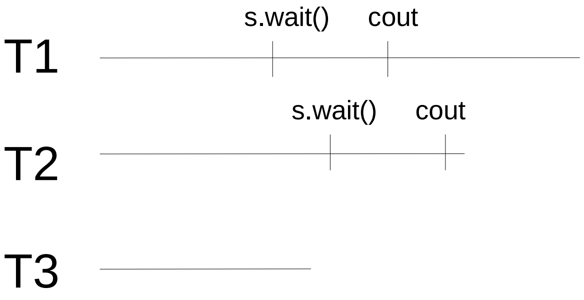
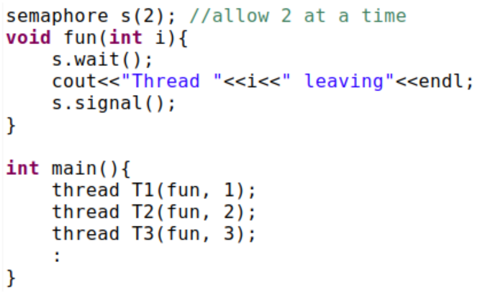
T1 calls s.wait() after which s.count==1, T1 Then couts its leaving

T2 calls s.wait() after which s.count==0, T2 Then couts its leaving





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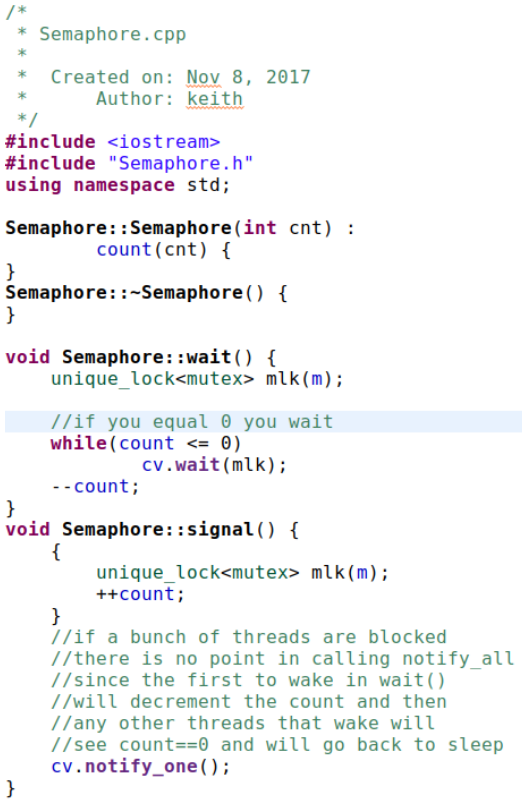

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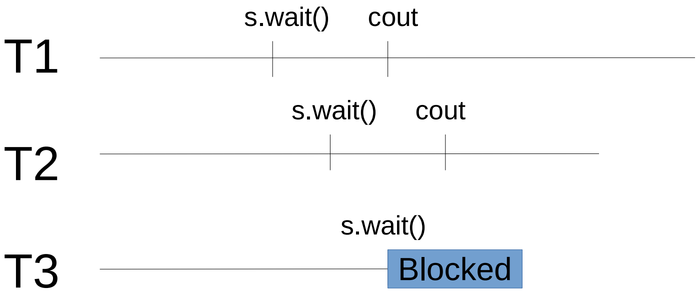
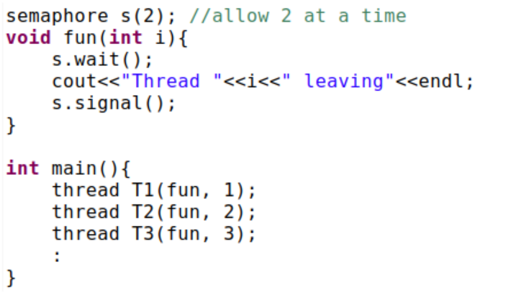
T3 calls s.wait() and Blocks...





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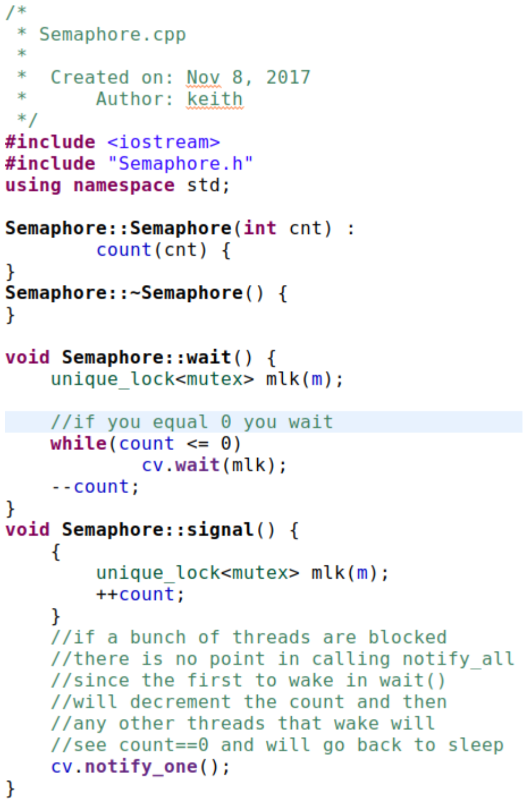

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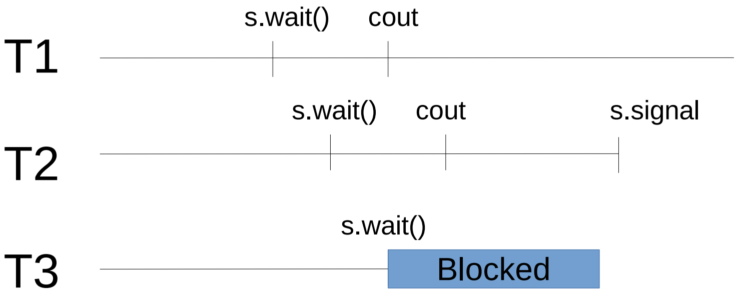

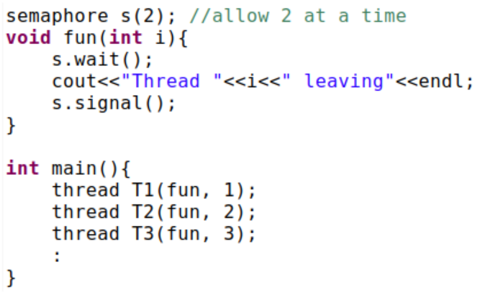

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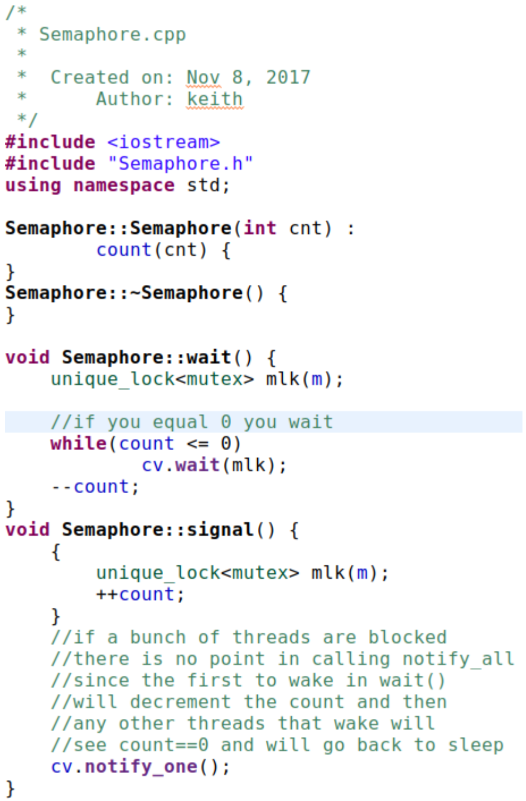

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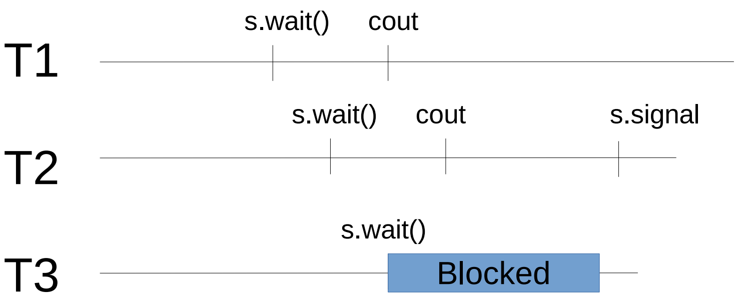
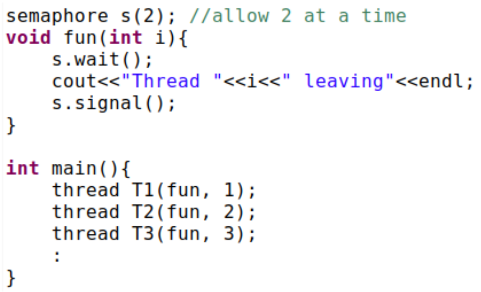
T3 awakes as soon as T2 signals, decrements count (count==0), works...





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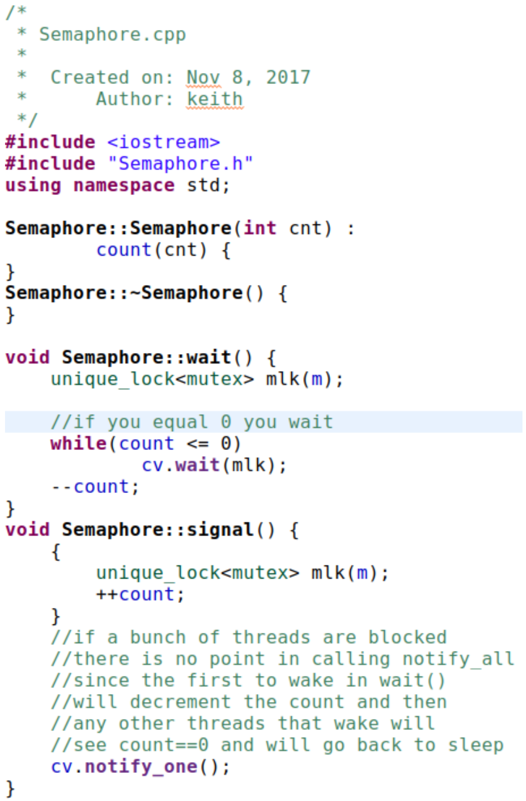

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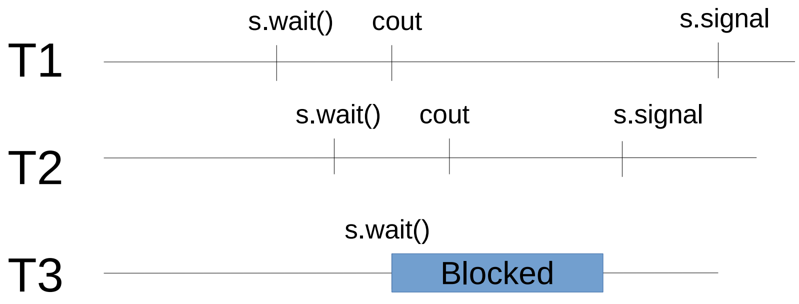
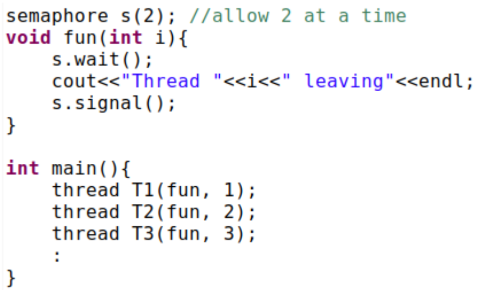
T2 (or T1) calls s.signal after which s.count==1
T3 awakes as soon as T2 signals, decrements count (s.count==0), works…
T1 calls s.signal after which s.count==1





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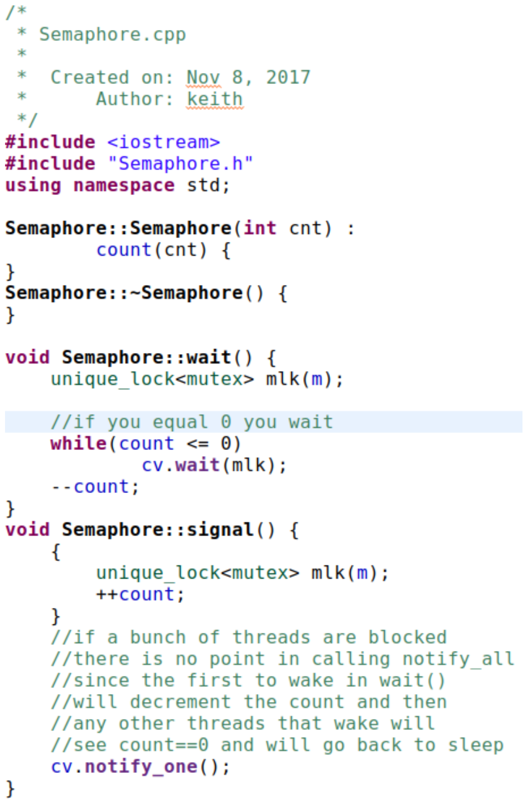
semaphore s(2); //allow 2 at a time
void fun(int i){
    s.wait();
    cout<<"Thread "<<i<<" leaving"<<endl;
    s.signal();
}

int main(){
    thread T1(fun, 1);
    thread T2(fun, 2);
    thread T3(fun, 3);
    :
}
```



```
/*
 * Semaphore.cpp
 *
 *  Created on: Nov 8, 2017
 *      Author: keith
 */
#include <iostream>
#include "Semaphore.h"
using namespace std;

Semaphore::Semaphore(int cnt) :
        count(cnt) {
}
Semaphore::~Semaphore() {
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void Semaphore::wait() {
    unique_lock<mutex> mlk(m);

    //if you equal 0 you wait
    while(count <= 0)
            cv.wait(mlk);
    --count;
}
void Semaphore::signal() {
    {
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        ++count;
    }
    //if a bunch of threads are blocked
    //there is no point in calling notify_all
    //since the first to wake in wait()
    //will decrement the count and then
    //any other threads that wake will
    //see count==0 and will go back to sleep
    cv.notify_one();
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Assumming the order that threads start is (T1,T2,T3). Here is what happens:

T1 calls s.wait() after which s.count==1, T1 Then couts its leaving
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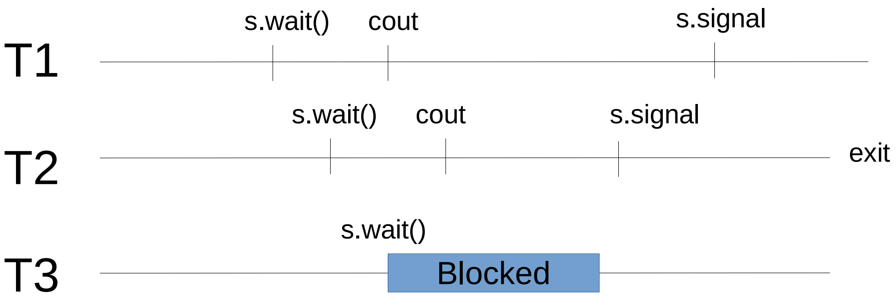
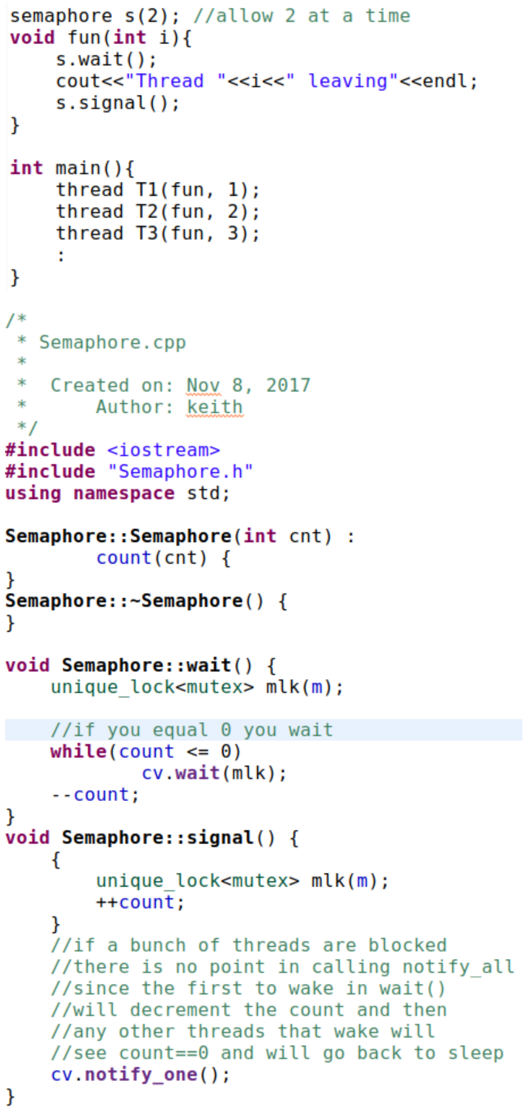
T3 awakes as soon as T2 signals, decrements count (s.count==0), works…
T1 calls s.signal after which s.count==1
T2 exits





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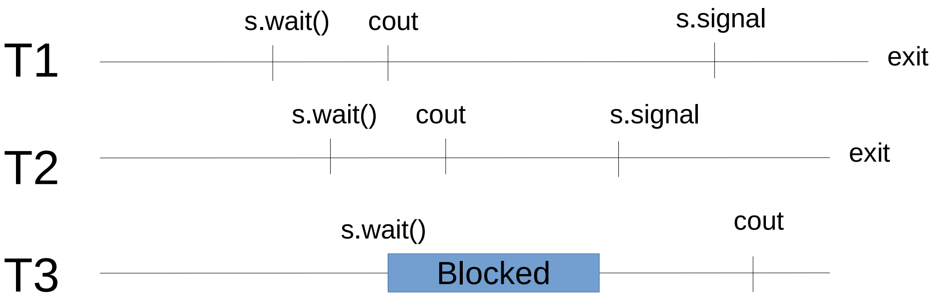
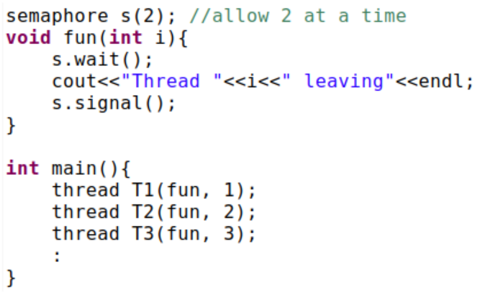
T1 exits, T3 couts





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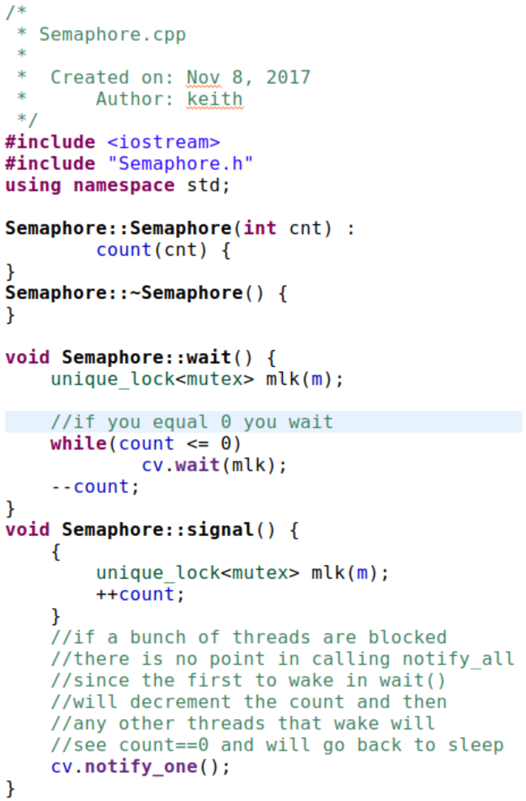

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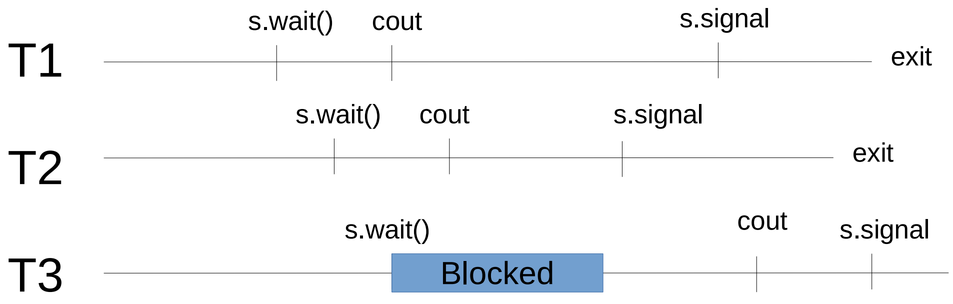
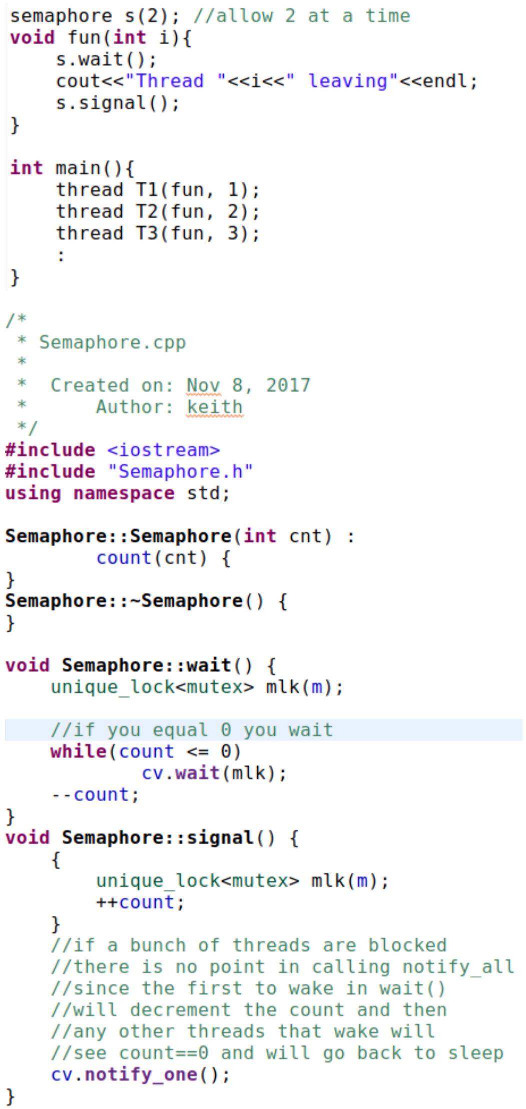
T3 awakes as soon as T2 signals, decrements count (s.count==0), works…
T1 calls s.signal after which s.count==1
T2 exits
T1 exits, T3 couts
T3 calls s.signal after which s.count==2





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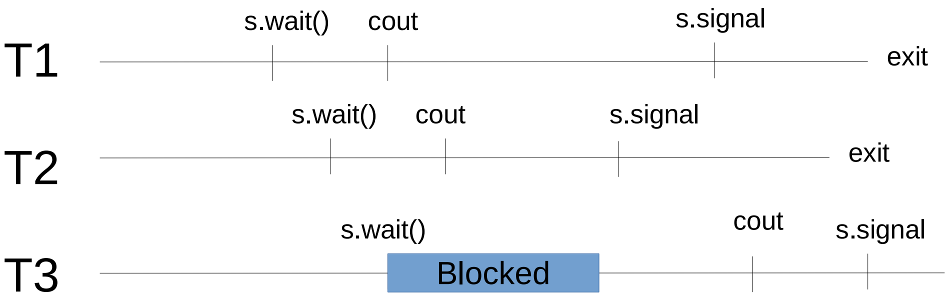
T3 awakes as soon as T2 signals, decrements count (s.count==0), works…
T1 calls s.signal after which s.count==1
T2 exits
T1 exits, T3 couts
T3 calls s.signal after which s.count==2
T3 exits

Notice that the Semaphores count is once again 2



Semaphores

Go to project
410_Semaphore_ConditionVar_Mutex_Thread_Producer_Consumer