

# Mutual Exclusion (Mutex)

Protects critical sections that are longer than 1 line

# Mutual Exclusion (Mutex)

- Enforcement
  - Only **1** thread in a critical section at a time
- Availability
  - If **no** thread in critical section, then **any** thread can enter
- Minimal Stay
  - Threads stay in critical section for minimal time
- Consistency
  - If resource must be protected anywhere, then it must be protected everywhere

# Mutex – what it does

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**We want to ensure this never happens!**

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Only 1 thread can be executing code between lines 63 and 68 at a time.

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Assume t1 is executing line 65

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t2 is likely blocked at line 63, waiting for t1 to finish executing line 68.

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t2 is blocked at line 63, waiting for t1 to finish executing line 68.

Once t1 executes line 68, t2 is free to acquire the mutex and proceed

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  - Cannot switch to other, non-related, processes
  - Will not work on multi-core system unless you disable interrupts on all cores (big performance hit)
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  - Kills performance on core
- So... Cannot use disabled interrupts solution



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Easily verified

Multiprocessor/multiprocess as long as can share memory



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### Bad

Busy wait (line 19) must keep checking until available, CPU usage spikes)

Starvation and Deadlock both possible

Compare\_and\_swap has to be atomic, this C++ code is not

# Mutex – Using implementation in C++ 11

- Mutexes are thread based in C++ 11, not process based!

```
#include <mutex>
```

```
std::mutex g_mutex;          //generally a global value
```

```
:
```

```
g_mutex.lock();              //if available then proceed, otherwise thread blocks
```

```
g_mutex.unlock(); //unlocks the mutex, other waiting threads can acquire
```

## General rules

Unlock a mutex when you are done (else waiting threads will wait forever)

Do not lock() a mutex twice from same thread without intermediate unlock(). Otherwise thread will block waiting to acquire a mutex that it has.

# Mutex – Solve withdrawal problem

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std::mutex mymutex;  
void withdraw(int amt){  
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- You will never unlock the mutex.
- All threads waiting to enter the critical section will be blocked forever
- Process will never join() those threads
- Process will be blocked forever
- Have to kill and restart process

# Mutex – A better idea

- Use a self unlocking mutex- As soon as the mutex goes out of scope it unlocks.

```
std::mutex mymutex;  
void withdraw(int amt){  
    lock_guard<std::mutex> lock(mymutex); //locks mymutex here  
    if(balance > amt){  
        cout<<"approved"<<endl;  
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But wait! What if you throw an exception here?

- No worries, the lock\_guard will unlock as soon as it goes out of scope

# Summary

- Mutexes function as a traffic cop, they allow 1 thread in a critical section at a time, other threads are blocked.
- Prefer a `lock_guard` over a raw mutex since it automatically unlocks when it goes out of scope
- To use: Identify minimal critical sections, then wrap critical section with an auto unlocking `lock_guard`
- Mutexes are going to be global variables, they will NOT be local variables