Concurrency Swift & Objective-C

The *Main* Problem

- The main issue of concurrency arises when we try to do long running tasks on the main thread, which blocks any user interaction.
- What we want is to be able to run long running tasks off of the main thread so it isn't blocked.

Some Concepts/Terminology

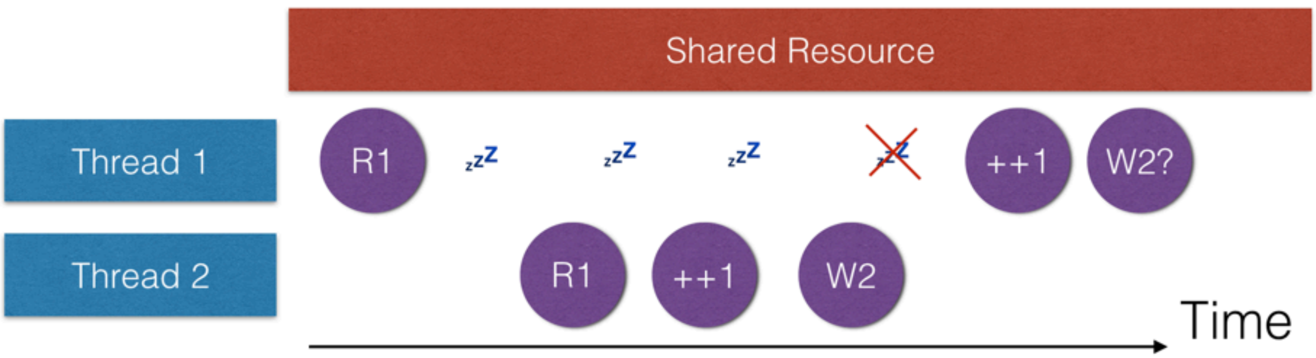
- When code executes the path of execution is singular. (What does this mean?)
- **Threads** allows the OS and our apps to have multiple separate paths of execution.
- This means we can run tasks at the same time.
- Every line of code runs on *some thread*.
- You will almost never want to deal *directly* with threads in iOS because dealing with threads directly is incredibly complex.
- Instead you will use either the C API *GCD* (Grand Central Dispatch) or (NS)OperationQueue to interact *indirectly* with threads by using queues.

3 Threading Problems

- There are 3 infamous problems that can arise when dealing directly with threads.
- These can also arise when dealing with Queues.

1) Race Conditions

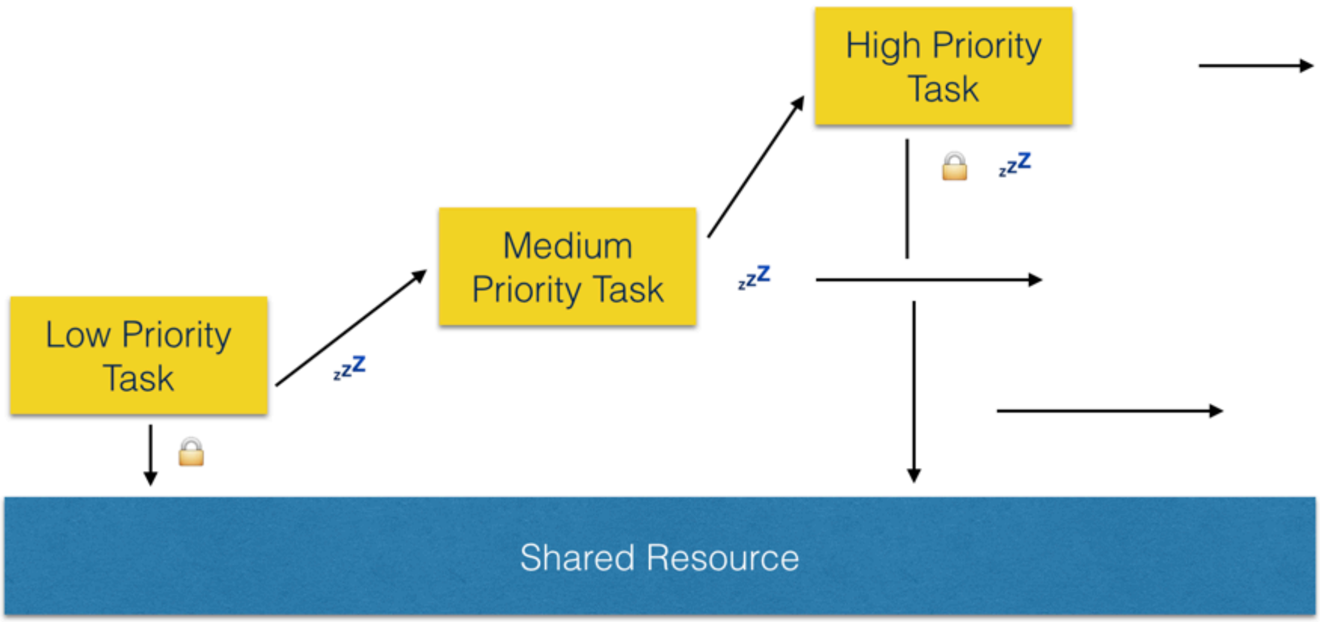
- Can happen when 2 or more threads try to *modify* a shared resource



- Hard to debug because probabilistic
- Traditional solution is to *lock* the shared resource while it is being mutated to prevent another process from writing to it. (atomic)
- Serial Q's are actually a much better solution than locks when you have different threads writing to the same resource (more on serial vs concurrent Q's below)

2) Priority Inversion

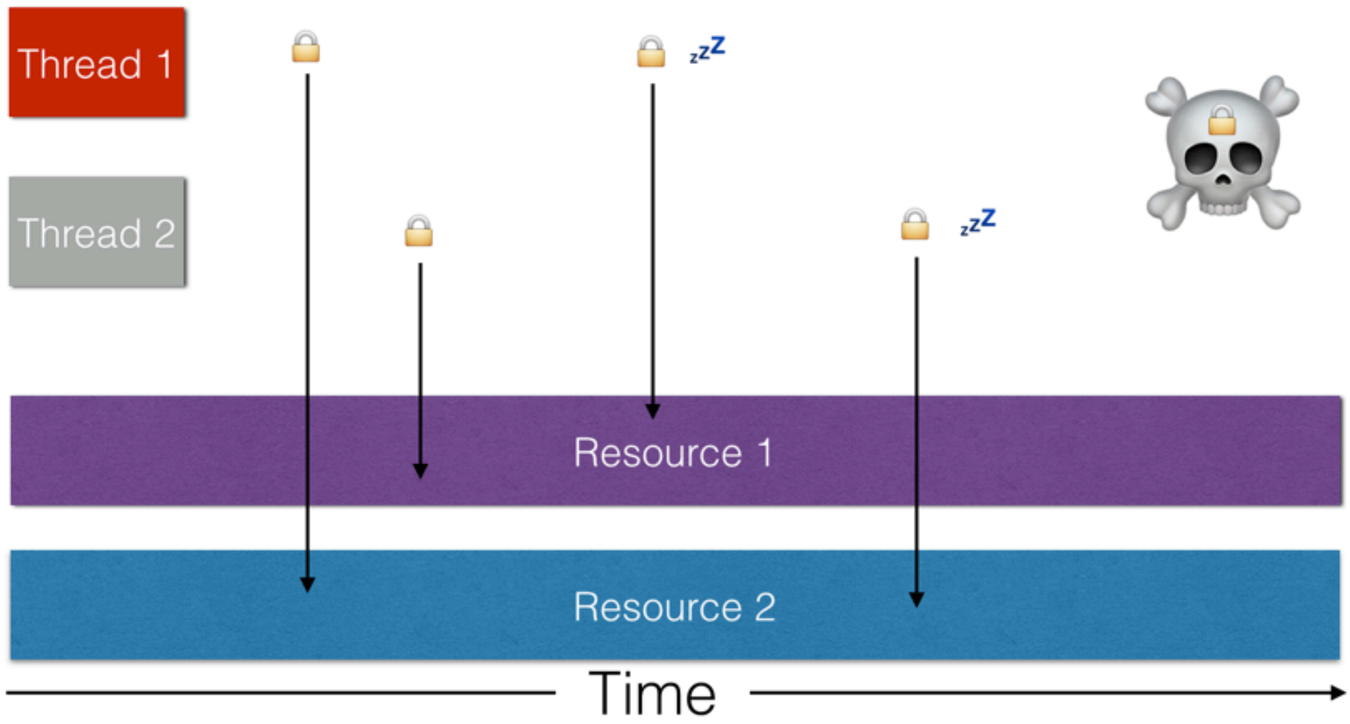
- priority inversion is when a lower priority task preempts a higher priority task



- GCD solves this by boosting the priority of lower priority tasks to speed them up.

3) Dead Lock

- When two threads never execute because they are both waiting for the other to release a shared resource.



- This is why solving race conditions using locks can be problematic.
- Better to use Serial Q's when writing to shared resources from different Q's.

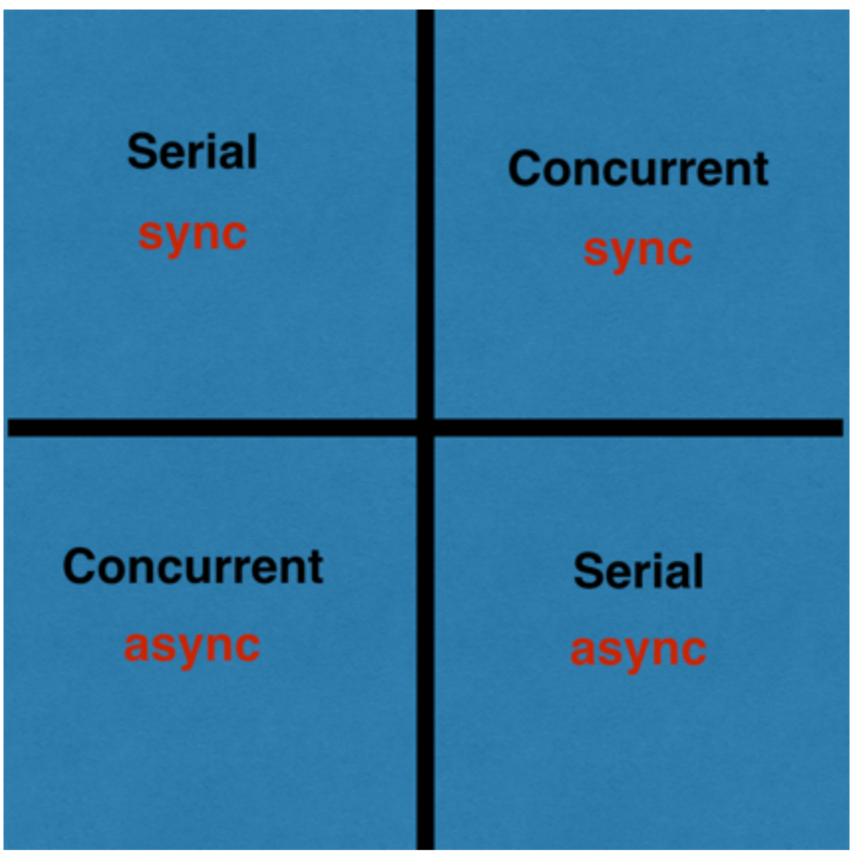
More Terminology

- Concurrency allows us to run multiple paths of execution at the same time.
- Single core devices do this by task switching very quickly.
- Since 2011 iPad and iPhone have been multicore which allows true concurrency.
- Here's a table of CPU's found on iOS devices.
- Instead of dealing directly with threads

GCD/(NS)OperationQueue use queues.
- Queues are not the same thing as threads.
- Queues are abstractions that employ/use threads.
- Queues are used to execute *blocks/closures.*
- Queues can be *serial* or *concurrent*.
- A *serial queue* **executes** blocks FIFO.
- Serial queues wait until the currently executed block completes before the next block is executed.
- A *concurrent queue* **dequeues** (starts) blocks in a FIFO manner.
- The execution of blocks on a concurrent queue happen on different underlying threads concurrently (depending on “resources”).
- Concurrent queues do not wait for the currently dequeued block to return before executing the next one. They dequeue in order, but immediately.
- This means the completion of blocks on a concurrent queue is essentially random. Never rely on the order of completion.
- **Main Queue:**
    - The main queue is the interface queue.
    - The main queue uses the applications *main thread*.
    - The main queue is where all interface interaction events are received (like touch events).
    - **When your app interacts with the view it *must* do so on the main queue.**
    - This is because the main queue is ***not thread safe***. (What does it mean to be “thread safe”?)
    - Example of tapping a button
        - Touch event arrives on main thread.

        - Button's action runs on the main thread.
        - No other interface events can be handled while this is happening.
        - Once the code finishes running, the main thread is again ready to receive events or run code.
    - The main thread is ***blocked*** while your code runs on it, and this can make the interface unresponsive if your code is a time hog.
    - You need to worry about creating background queues in at least 2 situations
        - 1. Your code does something that ***might*** take a long time. (Even if you have a fast network and you're not doing an expensive request, why should you ***never ever*** do a network request on the main Q?)
        - 2. Some framework/library you're using calls you back on a background queue. E.g. (NS)URLSession calls you back on a background queue.
            - So, you must get a reference to the main queue in order to update the view.
            - Note: only come back to the main queue at the moment you need to update the interface, never before.
            - Coming back before you actually need to update the view may result in intermittent weirdness.
- We have 2 types of queues: concurrent and serial queues.
- We also have 2 types of execution: sync and async.
- You can run an async task on a concurrent or serial Q.

- sync/async tells you whether the current Q you're calling from needs to wait for the task to complete before continuing.
- serial/concurrent tells you whether a Q has 1 or many threads (whether it can run only 1 or many tasks simultaneously).
- sync/async is about what happens to the execution of code at the source of the task (does it wait or keep moving).
- concurrent/serial is about the execution of the task (does it execute serially ie, on 1 thread, or concurrently on multiple threads).



(NS)OperationQueue Vs GCD

- Apple offers three different (!) API's for concurrency: C GCD, Swift GCD wrapper and (NS)OperationQueue.

- (NS)OperationQueue is an OO wrapper around GCD available in Swift and Objc.
- Swift 3 now adds another related API that is a struct based wrapper around GCD.
- For simple concurrency you will most likely use GCD (called DispatchQueue in Swift >= 3).
- Use (NS)OperationQueue if:
  - you need to do more complex concurrency, like communicating between tasks, and monitoring execution.
  - You need your concurrent operations to be objects (Objc). (Why might you need to do this?)
  - You need to cancel operations, or you need other kinds of control, like scheduling.
    - You need to be notified about the state of operations. ((NS)OperationQueue uses KVO).
- I will focus on GCD (C API in Objc, DispatchQueue Swift 3). You will mostly use GCD in day to day iOS coding.
- I will also look at a couple of simple examples of (NS)OperationQueue.

Creating Or Getting Queues in GCD:

- Note: To see everything GCD can do a search in **Dash** with “*dispatch_*” with ObjC selected as the language.
- 2 ways to get a queue:
  - 1) User created (named).

    - 2) System created (global).
- You are rarely going to use the first option in Objc (can’t control the priority), but Swift 3+ has made user created Q's a much more useful option.
- User created background queues look like this:

```

// C Definition of User Created Q's
dispatch_queue_t dispatch_queue_create( const char *label, dispatch_queue_attr_t attr);

// Creation Objc
dispatch_queue_t userCreatedBackgroundQ1 = dispatch_queue_create("com.lighthouse.threading.1", DISPATCH_QUEUE_CONCURRENT);

dispatch_queue_t userCreatedBackgroundQ2 = dispatch_queue_create("com.lighthouse.threading.2", DISPATCH_QUEUE_SERIAL);

// Creation Swift 1.x + 2.x

let userCreatedBackgroundQ1: dispatch_queue_t  = dispatch_queue_create("com.lighthouse.threading.1", DISPATCH_QUEUE_CONCURRENT);

let userCreatedBackgroundQ2: dispatch_queue_t = dispatch_queue_create("com.lighthouse.threading.2", DISPATCH_QUEUE_SERIAL);

```

```
// Creation Swift 3

let bgQ1 = DispatchQueue(label: "com.steve.queue") // serial by default
let bgQ2 = DispatchQueue(label: "com.steve.queue", qos: .userInitiated, attributes: .concurrent)

```

- Apple has added QOS to the GCD Swift 3 API.
- I will return to this below.

- **System created (vs user created)** queues are **the one you will mostly use**:

```

// Objc Definition
dispatch_queue_t dispatch_get_global_queue( long identifier, unsigned long flags);

// Objc Creation
dispatch_queue_t sysCreatedbackgroundQ1 = dispatch_get_global_queue(QOS_CLASS_USER_INTERACTIVE, 0);

// Swift 1.x + 2.x Creation
let sysCreatedbackgroundQ1: dispatch_queue_t = dispatch_get_global_queue(QOS_CLASS_USER_INTERACTIVE, 0);

```

```swift
// Swift 3
let userInitiatedQOS = DispatchQueue.global(qos:.userInitiated)
let userInteractiveQOS = DispatchQueue.global(qos:.userInteractive)
let defaultQOS = DispatchQueue.global() // qos is .default
let utilityQOS = DispatchQueue.global(qos:.utility)
let backgroundQOS = DispatchQueue.global(qos:.background)
let unspecifiedQOS = DispatchQueue.global(qos:.unspecified)

```

- dispatch_queue_t is the return type (_t is the way C indicates this is a type).
- dispatch_get_global_queue() takes 2 parameters.
- Always pass 0 for the second param (it’s reserved for future use)
- The first param is an enum value that specifies the relative priority, called *Quality Of Service (QOS).*
- There are 4 possible options in Objc:

```
QOS_CLASS_USER_INTERACTIVE // highest priority
QOS_CLASS_USER_INITIATED // high priority, used when user initiates an action
QOS_CLASS_UTILITY // used for long running tasks
QOS_CLASS_BACKGROUND // used when user doesn’t need result
```

- Swift 3 adds *unspecified* to the QOS.

You can get ahold of the main queue like this:

```
// Getting Ref To Main Queue Objc
dispatch_queue_t mainQ = dispatch_get_main_queue();

// Getting Ref To Main Queue Swift 1.x + 2.x
let mainQ2: dispatch_queue_t = dispatch_get_main_queue();

// Swift 3
let mainQ3 = DispatchQueue.main


```

Adding Tasks To Queues in GCD:

```
// C Definition
void dispatch_async( dispatch_queue_t queue, dispatch_block_t block);

// Objc Example
dispatch_queue_t backgroundQ1 = dispatch_get_global_queue(QOS_CLASS_USER_INTERACTIVE, 0);

dispatch_async(backgroundQ1, ^{
    printf("%d: 1\n", __LINE__);
});
```

```
printf("%d: 2\n", __LINE__);

// Swift 1.x + 2.x Example

let backgroundQ1: dispatch_queue_t = dispatch_get_global_queue(QOS_CLASS_USER_INTERACTIVE, 0);

dispatch_async(backgroundQ1){
    print(#line, "1")
}
print(#line, "2");

// Swift 3

DispatchQueue.global(qos:.userInteractive).async {
  print(#line, "3")
}

print(#line, "4")

```

- `dispatch_async` takes 2 paramaters: the queue and the block to dispatch
- `dispatch_async` returns *immediately*
- What does the above code print and why?
- `dispatch_sync` does not return until the block has run
- You will almost never use `dispatch_sync` except in very advanced situations. (Don't try to handle dependencies using `dispatch_sync`. (Use (NS)OperationQueue instead).

- `dispatch_once` is used to execute a block only once during the lifetime of the app.
- `dispatch_once` is used in the singleton pattern in Objc.

```

// C Definition
void dispatch_once( dispatch_once_t *predicate, dispatch_block_t block);

// Objc Creation
static dispatch_once_t onceToken = 0;

// This waits for completion
dispatch_once(&onceToken, {
    printf("this will only execute once")
});

dispatch_once(&onceToken, {
    printf("this will never execute!")
})

// Swift 1.x + 2.x Creation

var onceToken: dispatch_once_t = 0;

// This waits for completion
dispatch_once(&onceToken, {
    print("this will only execute once")
});
```

```

dispatch_once(&onceToken, {
    print("this will never execute!")
})

// NB. xCode includes a code snippet with this.

// Swift 3

???

```

Never Do This

- Never call sync on a background Q. Why?

```
// Swift 3
DispatchQueue.global().sync {
    print("💀")
}
```

- Never call sync on the mainQ since this will deadlock.

```
// Swift 3
DispatchQueue.main.sync {
    print("☠️")
}
```

```
// indicator is a reference to a
```

```
UIActivityIndicatorView

indicator.startAnimating()

// Runs after 1 second on the main queue.
DispatchQueue.main.asyncAfter(deadline: .now() + .seconds(1) ) {
    indicator.stopAnimating()
}

// For the time .seconds(Int), .microseconds(Int) and .nanoseconds(Int) may also be used.

```

Resources:

- objc.io whole edition: https://www.objc.io/issues/2-concurrency/
- Apple's guide: https://developer.apple.com/library/content/documentation/General/Conceptual/ConcurrencyProgrammingGuide/Introduction/Introduction.html