Swift 6

A Guide to Concurrency

INTRO

Kanagasabapathy Rajkumar
Senior iOS Developer
Apple Platforms Developer since 2014
Experienced in Swift, UIKit, SwiftUI, and Protocol-Oriented Programming
Specialized in Concurrency and Swift Package Management

Prepare to Say Goodbye to

- 🚫 Callback hell
- 🚫 Error-Handling Headaches
- 🚫 Thread-Safety Issues
- 🚫 Complicated Synchronization
- 🚫 Unreadable Asynchronous Code

Thanks to Swift 5.5 and Enhanced in Swift 6

Embrace...

✅ Async/Await

✅ Structured Concurrency

✅ Actors Isolation

✅ Tasks

✅ Cleaner Code

✅ Strict Concurrency

Thanks to Swift 5.5 and Enhanced in Swift 6

Evolution of Concurrency APIs

NSThread - Manual thread management

GCD - Task management with queues

Operation Queues - Task dependencies and ordering

Combine - Reactive programming model

✅ Swift 5 - Async/Await & Structured Concurrency

Swift 6 - Complete Currency by default and Data Race Safety

Concurrency Roadmap

✨ Features
📜 Version History
⚖️ Advantages and Disadvantages
💡 Practical Examples

Topics on the Agenda

⏳ Async/Await
🕸️ Structured Concurrency
📝 Tasks
🎭 Actors
🔒 Sendable

Async/Await

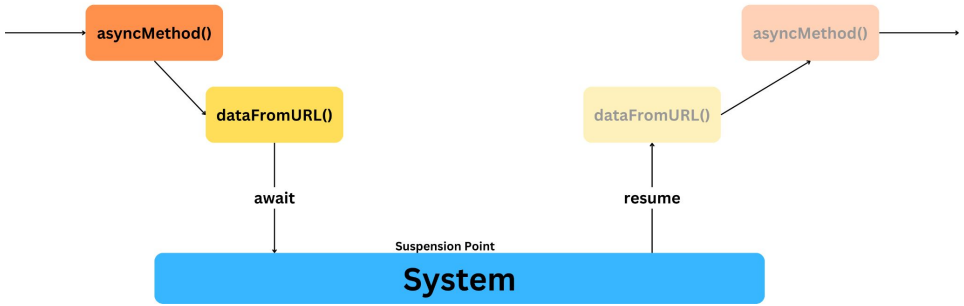
Basic Syntactic Building Block

📜 **Suspension Points:** Mark functions as ***async*** to enable the use of suspension points within the function.

⏳ **Awaiting Results:** The ***await*** keyword introduces a suspension point, where the function pauses until the asynchronous operation completes.

🔄 **Error Handling:** Integrates seamlessly with ***do-catch*** for handling errors in asynchronous functions.

Async/Await Flow



Async/Await Practical Examples

```swift
// Define a function that simulates an asynchronous task
func performTask(taskNumber: Int) async {
    print("Task \(taskNumber) started.")
    do {
        try await Task.sleep(nanoseconds: 1_000_000_000) // Simulate some asynchronous work (1 second)
        print("Task \(taskNumber) completed.")
    } catch {
        print(error)
    }
}
```

```swift
// Async-await Networking Example with Generics
func sendRequest<T>(urlStr: String) async throws -> T where T : Decodable {
        guard let urlStr = urlStr as String?, let url = URL(string: urlStr) as URL?else {
            throw NetworkError.invalidURL
        }
        let (data, response) = try await URLSession.shared.data(from: url)
        guard let response = response as? HTTPURLResponse, 200...299 ~= response.statusCode else {
            throw NetworkError.unexpectedStatusCode
        }
        guard let data = data as Data? else {
            throw NetworkError.unknown
        }
        guard let decodedResponse = try? JSONDecoder().decode(T.self, from: data) else {
            throw NetworkError.decode
        }
        return decodedResponse
    }
```

Pros & Cons

Simplifying Asynchronous Programming

Streamlining Concurrency and Alternative to Callback/Closures

- Introduced: iOS 15

Changes

- *Swift 5:* Not available
- *Swift 5.5:* Introduction of Async/Await - **Proposal SE-0296**
- Swift 6: Continued improvements and complementary use with GCD, OperationQueue, and Combine.

Advantages

- Readability, Error Handling and alternative to Completion Handler/Closures
- Reduces complexity associated with Callback Hell or nested closures
- Reduces chance of race conditions or deadlocks

Disadvantages

- Limited backward compatibility
- Complex Integrations when interacting with existing GCD or OperationQueue


CALLBACK
HELL
ASYNC/AWAIT
imgflip.com

Tasks

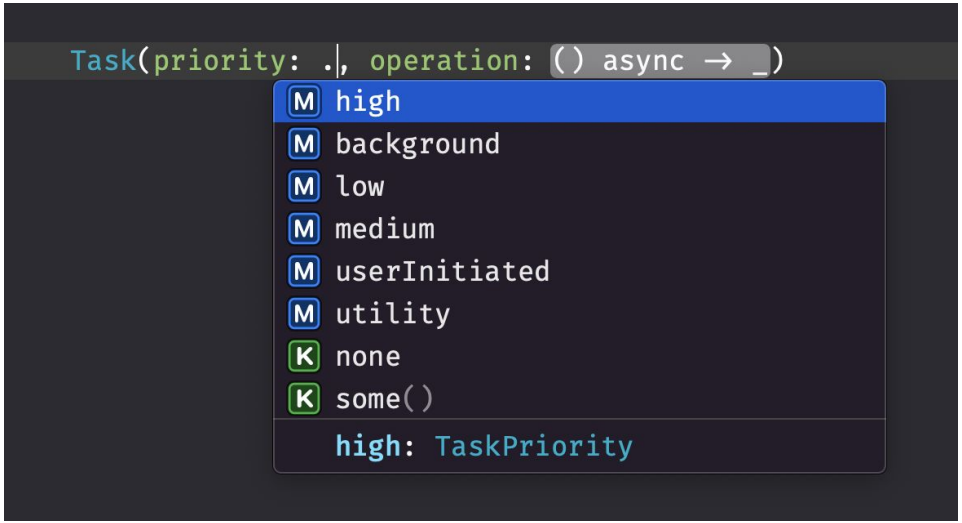
Fundamental Unit of Concurrent Work

📜 Sequential, Asynchronous and Self-contained

🔄 **Task Groups**: Use TaskGroup to manage collections of tasks that run concurrently and complete as a group.

🔍 **Task Prioritization**: Assign priorities to tasks (e.g., .userInitiated, .background) to optimize performance.

📅 **Task Cancellation**: Easily cancel tasks using the cancel() method, propagating cancellation to child tasks.


Task(priority: ., operation: () async → _)
high
background
low
medium
userInitiated
utility
none
some()
high: TaskPriority

Tasks

```
Task(priority: .high) {
    print("high Task Started")
    try? await Task.sleep(nanoseconds: 1_000_000_000)
    print("high Task Completed")
}
Task(priority: .userInitiated) {
    print("userInitiated Task Started")
    try? await Task.sleep(nanoseconds: 1_000_000_000)
    print("userInitiated Task Completed")
}
Task(priority: .medium) {
    print("medium Task Started")
    try? await Task.sleep(nanoseconds: 1_000_000_000)
    print("medium Task Completed")
}
Task(priority: .low) {
    print("low Task Started")
    try? await Task.sleep(nanoseconds: 1_000_000_000)
    print("low Task Completed")
}
Task(priority: .utility) {
    print("utility Task Started")
    try? await Task.sleep(nanoseconds: 1_000_000_000)
    print("utility Task Completed")
}
Task(priority: .background) {
    print("Background Task Started")
    try? await Task.sleep(nanoseconds: 1_000_000_000)
    print("Background Task Completed")
}
```

```
// Independent - Useful when you start the task that isn't tied to current context.
Task.detached {
    print("Detached Task started at \(Date())")
    try? await Task.sleep(nanoseconds: 2 * 1_000_000_000)
    print("Detached Task completed at \(Date())")
}
```

```
// Group Tasks
func stucturedConcurrencyWithTaskGroup() async {
    await withTaskGroup(of: String.self) { group in
        for i in 1...3 {
            group.addTask {
                try? await Task.sleep(nanoseconds: UInt64(i) * 1_000_000_000)
                return "Group Task \(i) completed"
            }
        }
        for await result in group {
            print(result)
        }
    }
}
Task {
    await stucturedConcurrencyWithTaskGroup()
}
```

```
// Task Cancellation
func taskWithCancellation() async {
    let task = Task {
        for i in 1...3 {
            try? await Task.sleep(nanoseconds: 1_000_000_000)
            try await Task.checkCancellation()
            print("Task iteration \(i) completed")
        }
        return "Task completed"
    }
    DispatchQueue.global().asyncAfter(deadline: .now() + 2) {
        task.cancel()
    }
    do {
        let result = try await task.value
        print(result)
    } catch {
        print("Task was canceled")
    }
}
Task {
    await taskWithCancellation()
}
Thread.sleep(forTimeInterval: 7)
```

Pros & Cons

The Building Block of Swift Concurrency

Fundamental Unit of Concurrent Work

- Introduced: iOS 15

Changes

- *Swift 5:* Not available
- *Swift 5.5:* Introduction of Tasks - **Proposal SE-0304**
- Swift 6: Improvements in Task Management and Task Isolation

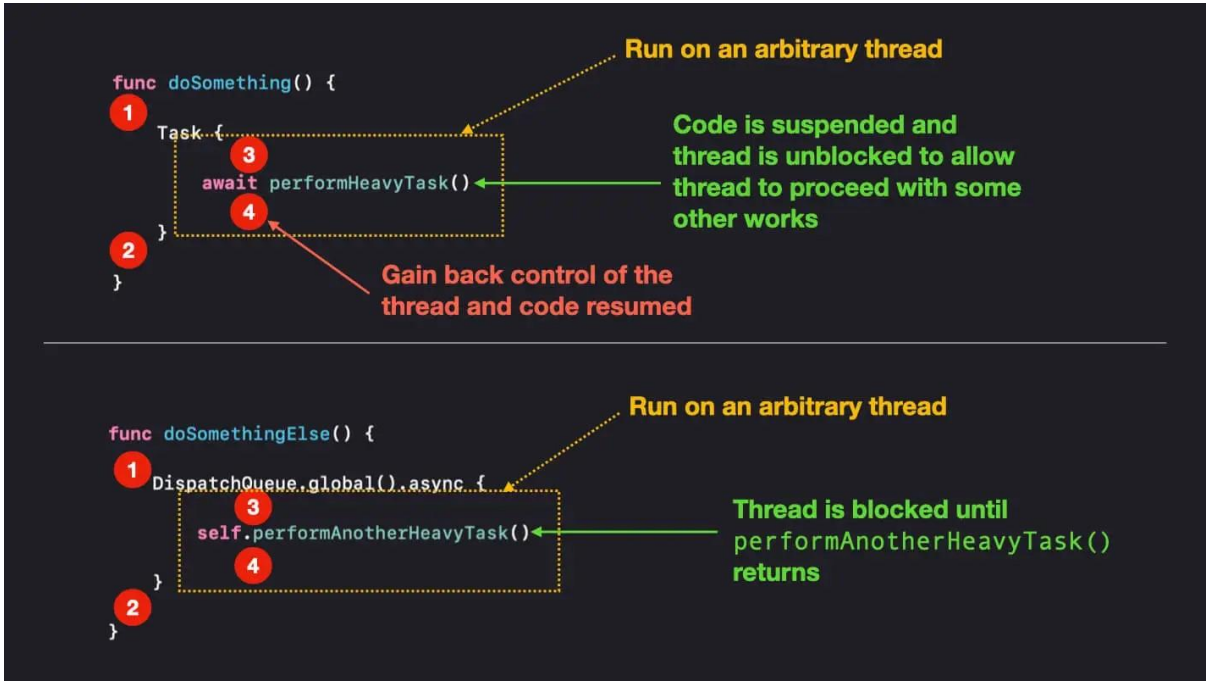
Advantages

- Built-in Cancellation
- Works well with async-await
- Reducing common concurrency issues such as Thread explosion and so on

Disadvantages

- Managing multiple tasks
- Limited backward compatibility
- Complex scenarios such as cancellation and task groups

Task vs DispatchQueue



Task vs DispatchQueue

Grand Central Dispatch

```
var isCancelled: Bool = false

DispatchQueue.global().async { [weak self] in
    Thread.sleep(forTimeInterval: 30)
    guard let self else { return }
    guard !self.isCancelled else { return }
    self.continueWithMyLogic()
}

isCancelled = true
```

Manual state management

Non-throwing suspension

No automatic cancellation support

Structured Concurrency

Organized and Efficient Task Management

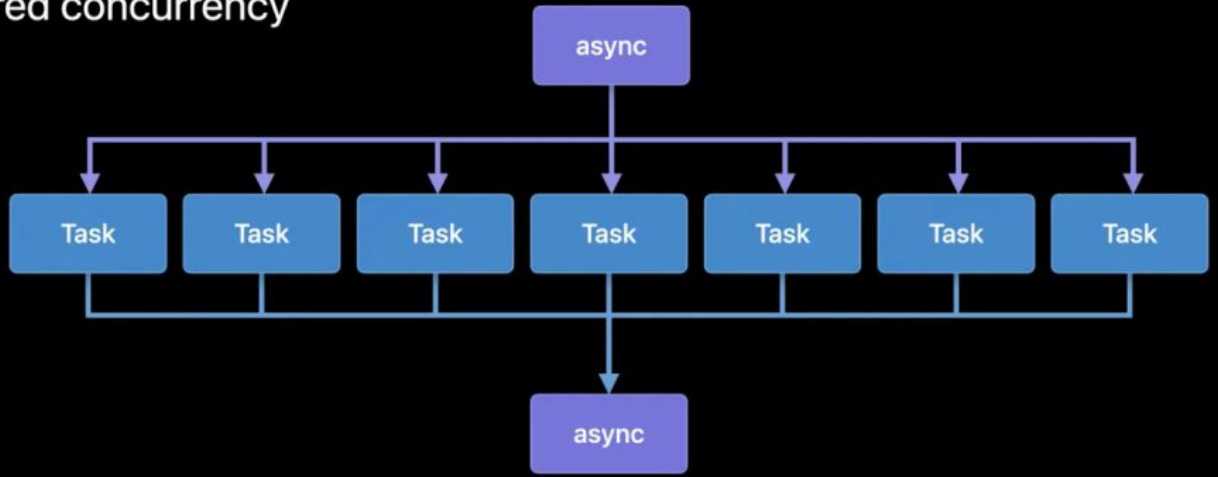
🧵 **Thread Safety**: Structured concurrency ensures that all spawned tasks are properly handled within their scope.

📏 **Task Lifespan Management**: Automatically handle the lifecycle of tasks, cleaning up resources when tasks complete.

📋 **Error Propagation**: Any error in child tasks is automatically propagated up to the parent task, ensuring robust error handling.

Swift Concurrency

Structured concurrency



Structured Concurrency

```
private let baseURL =  "https://picsum.photos/"
private(set) var images: [UIImage] = [UIImage]()
private func fetchImage(imageUrl: String) async throws ->  UIImage {
    do {
        guard let url = URL(string: baseURL + imageUrl) else {
            throw URLError(.badURL)
        }
        print("Val: \(imageUrl)")
        let (data, _) = try await URLSession.shared.data(from: url, delegate: nil)
        if let image = UIImage(data: data) {
            print(image)
            return image
        } else {
            throw URLError(.badURL)
        }
    } catch {
        if let error = error as? URLError, error.code == URLError.cancelled {
            print(error)
        } else {
            throw error
        }
    }
    return UIImage()
}
```

```
func fetchMultipleImagesArray() async throws  {
    async let image100 = fetchImage(imageUrl:"100")
    async let image101 = fetchImage(imageUrl:"101")
    async let image102 = fetchImage(imageUrl:"102")
    async let image103 = fetchImage(imageUrl:"103")
    async let image104 = fetchImage(imageUrl:"104")
    let asyncLetResult = try await
([image100,image101,image102,image103,image104])
    await MainActor.run {
        images.append(contentsOf: asyncLetResult)
    }
}
Task {
    do {
        try await fetchMultipleImagesArray()
    } catch {
        print("Failed to download images: \(error)")
    }
}
```

/// Output:

```
Val: 104
Val: 101
Val: 103
Val: 100
Val: 102
```

```
Image: <UIImage:0x6000030018c0 anonymous {104, 104} renderingMode=automatic(original)>
Image: <UIImage:0x600003001830 anonymous {101, 101} renderingMode=automatic(original)>
Image: <UIImage:0x600003009170 anonymous {102, 102} renderingMode=automatic(original)>
Image: <UIImage:0x600003009200 anonymous {100, 100} renderingMode=automatic(original)>
Image: <UIImage:0x6000030017a0 anonymous {103, 103} renderingMode=automatic(original)>
```

Pros & Cons

Organizing Concurrent Tasks

Ensuring Safe and Predictable Task Management

- Introduced: iOS 15

Changes

- *Swift 5:* Not Available
- *Swift 5.5:* Introduction of Structured Concurrency - **Proposal SE-0304**
- Swift 6: Enhanced support and refinements for structured concurrency.

Advantages

- Safety and Predictability
- Integration with Async/Await, Async-let - Proposal **SE-0317**
- Error Handling and Isolation of concurrent operations

Disadvantages

- Limited backward compatibility
- Complexity in Large codebases

Actors

Coordination and Safety in Concurrency

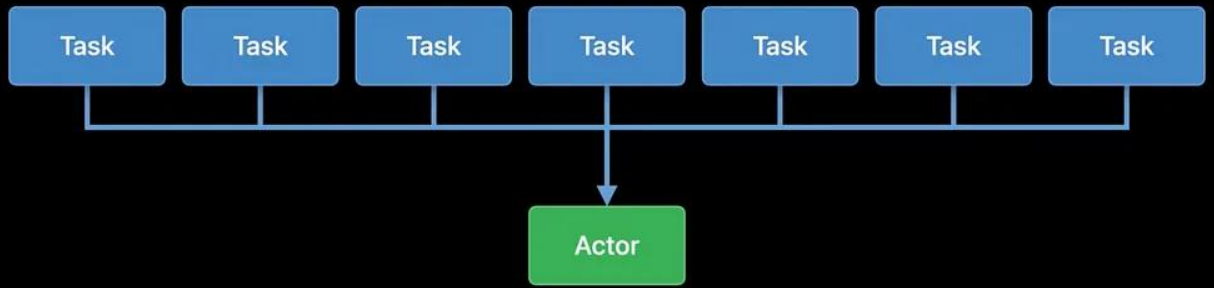
🧩 **Task Coordination**: Orchestrate/Coordinate multiple tasks with controlled access to shared data.

🔒 **Data Isolation**: Isolates internal state, allowing only one task at a time to modify it.

🛡️ **Concurrency Safety**: Prevents data races by managing concurrent mutations effectively.

Swift Concurrency

Actors



Class vs Actors

```
class Counter {
    var value = 0
    func increment() -> Int {
        let currentValue = value
        Thread.sleep(forTimeInterval: 0.1)
        value = currentValue + 1
        return value
    }
}
let counter = Counter()
Task.detached {
    print("Class 🎾 \(counter.increment())")
}
Task.detached {
    print("Class 🥎 \(counter.increment())")
}
```

```
actor SafeCounter {
    var value = 0
    func increment() -> Int {
        let currentValue = value
        Thread.sleep(forTimeInterval: 0.1)
        value = currentValue + 1
        return value
    }
}
let safeCounter = SafeCounter()
Task.detached {
    print("Actor ⚽ \(await safeCounter.increment())")
}
Task.detached {
    print("Actor 🏀 \(await safeCounter.increment())")
}
```

Pros & Cons

Safeguarding Shared State

Isolating State to Prevent Data Races

- Introduced: iOS 15

Changes

- *Swift 5:* Not available
- *Swift 5.5:* Introduction of Actors - **Proposal SE-0306**
- Swift 6: Actor Isolation

Advantages

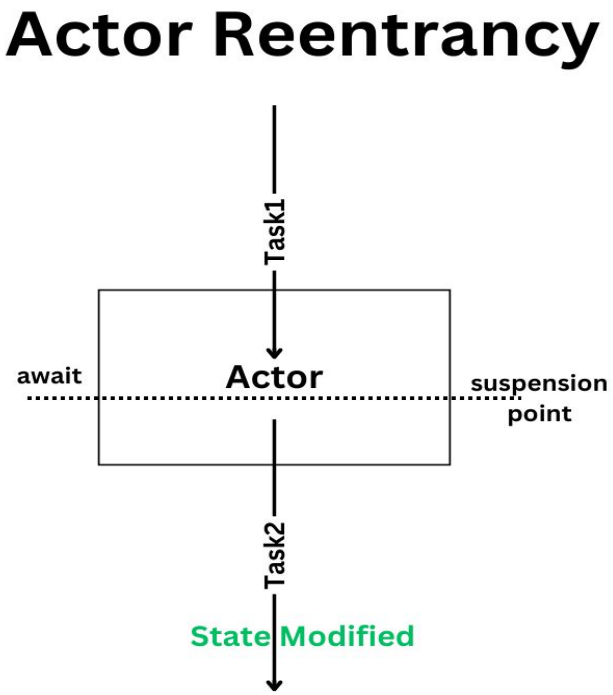
- Data safety and simplicity
- Reference type that helps in concurrency environment
- Integration with async/await and Task and helps in Isolation

Disadvantages

- Actor Reentrancy
- Limited backward compatibility
- Complexity in Large codebases

Actor Reentrancy

- An actor is suspended during a task
- Another task enters the actor while the first task is suspended
- Causes by actor's reentrant behavior



Sendable

A thread-safe type whose values can be shared across arbitrary concurrent contexts without introducing a risk of data races.

Sendable and Sendable Closures SE-0302

Sendable == Thread Safety

1. **Introduced** in **Swift 5.7**
2. **Sendable** is just a **Protocol**
3. **Most base types** of Swift **Foundation** are **Sendable**

```
@available(macOS 10.10, iOS 8.0, watchOS 2.0, tvOS 9.0, *)
public struct Date : Comparable, Hashable, Equatable, Sendable {
```

`Sendable` and `@Sendable` closures

- Proposal: SE-0302
- Authors: Chris Lattner, Doug Gregor
- Review Manager: John McCall
- Status: **Implemented (Swift 5.7)**
- Implementation: apple/swift#35264
- Major Contributors: Dave Abrahams, Paul Cantrell, Matthew Johnson, John McCall
- Review: (first review) (revision announcement) (second review) (acceptance)

Contents

Sendable

```
/// Value Types
struct User: Codable, Sendable {
    let name: String
    let age: Int
}
/// Reference types that internally
manage access to their state
actor Account {
    private var balance: Int = 0
    func deposit(amount: Int) {
        balance += amount
    }
    func getBalance() -> Int {
        return balance
    }
}
```

```
/// Functions and Closures- @Sendable
func fetchData(endPoint: String, resultHandler: @Sendable
@escaping (Result<User, Error>) -> Void) {
    resultHandler(.success(User(name: "Saba", age: 1)))
}
/// Reference types with no mutable storage
final class Address: Sendable {
    let houseNo: Int
    let streetName: String
    let cityName: String
    init(houseNo: Int, streetName: String, cityName: String) {
        self.houseNo = houseNo
        self.streetName = streetName
        self.cityName = cityName
    }
}
```

What is Isolation

- ➔ Mechanism - used to make **data races impossible**
- ➔ Deals with accessing mutable state in **unsafe** ways **not all** data races
- ➔ Isolation can change when you use **await** keyword
- ➔ Isolation applies to **variables, functions, closures, protocols**

Isolation Flavours

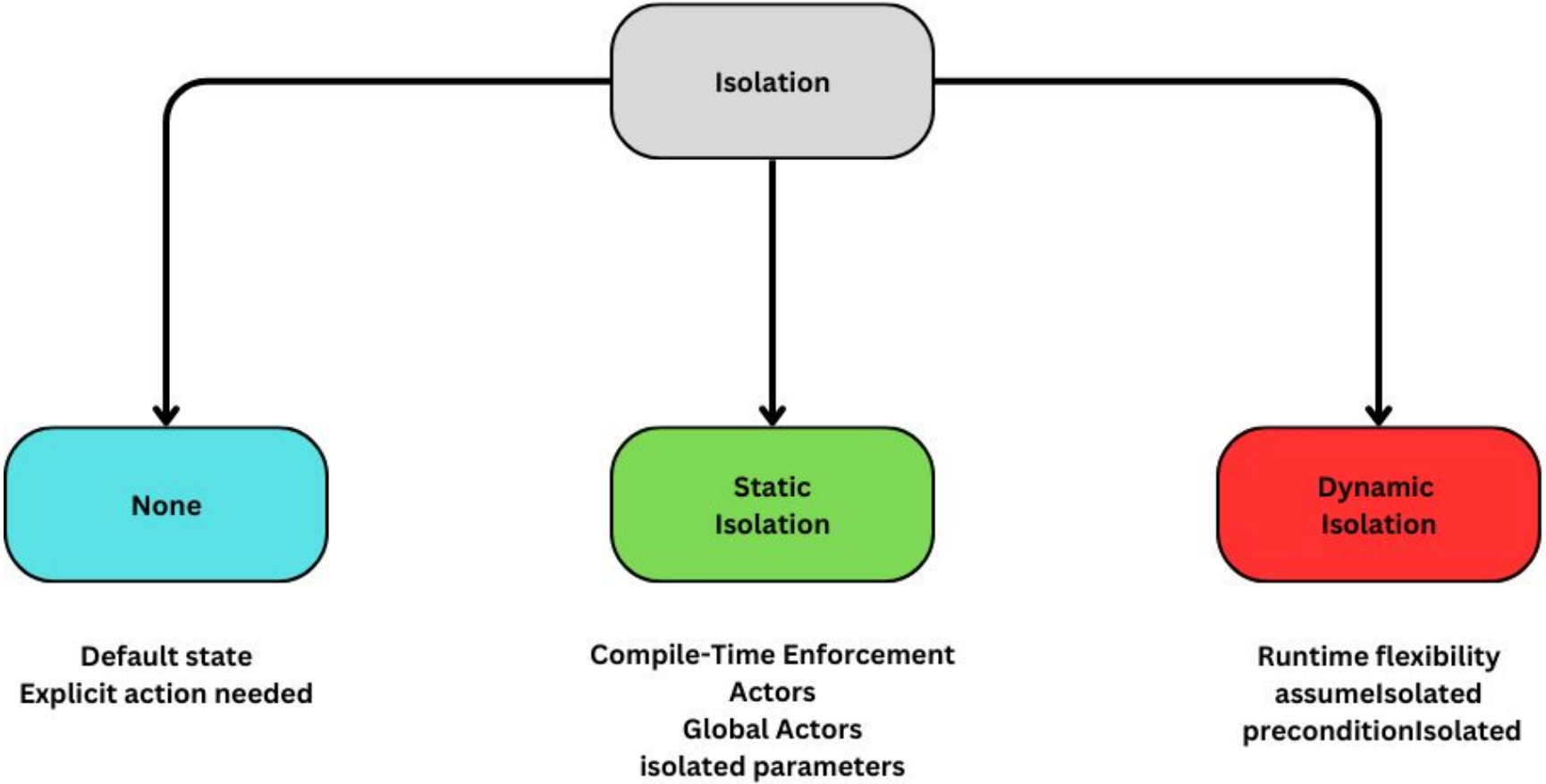
Isolation Flavours:

- **None** - By default, Everything is **non-isolated**. *Explicit action needed!* - Like actors or await
- **Static** - ***Actors***, ***global actors*** and ***isolated*** parameters - *compile-time enforcement* of Isolation
- **Dynamic** - ***assumeIsolated*** and ***preconditionIsolated*** attribute - allows at runtime

Pro Tip: Prefer **static** isolation for compile-time safety and dynamic only when reqd.

Consideration: Dynamic offers flexibility but introduce data races

Isolation in Swift Concurrency



None Isolation

None Isolation

- By default, Everything is **non-isolated.**
- Means there is no specific isolation enforced.
- This is the default for synchronous code

```
// Example of None Isolation
extension Island {
  nonisolated func meetTheFlock() async {
    let flockNames = await flock.map { $0.name }
    print("Meet our fabulous flock: \(flockNames)")
  }
}
```

Static Isolation

Actor Isolation

- Only one task can execute on an actor at a time
  - This prevents data races
- Isolate - mutable state to prevent concurrent access
  - No other task can modify the state concurrently
- Other task must wait their turn
  - Queued **but not strictly FIFO**
- Sendable checks enter or exit an actor
  - Ensures data is safe for concurrent use
- Actors are implicitly **Sendable**
  - By default actors conform to Sendable protocol

Actor Isolation

```
actor Island {
  var flock: [Chicken]
  var food: [Pineapple]
  func advanceTime() {
    let totalSlices = food.indices.reduce(0) { (total, nextIndex) in
      total + food[nextIndex].slice()
    }
    Task {
      flock.map(Chicken.produce)
    }
    Task.detached {
      let ripePineapples = await food.filter { $0.ripeness ==
.perfect }
      print("There are \(ripePineapples.count) ripe pineapples on
the island")
    }
  }
}
```

```
actor Island {
  var flock: [Chicken]
  var food: [Pineapple]
  func advanceTime() {
    let totalSlices = food.indices.reduce(0) { (total,
nextIndex) in
      total + food[nextIndex].slice()
    }
    Task {
      flock.map(Chicken.produce)
    }
  }
}
```

@MainActor Isolation

- ➔ **@MainActor**: Main Thread
- ➔ Isolates UI-related code to prevent concurrency issues
- ➔ Lot of UI Framework code and UI apps - run on it
- ➔ But only run a single job at a time
- ➔ Tasks shuttle b/w @MainActor(UI) & other actors(background)

Sendable Classes

To satisfy the requirements of the `Sendable` protocol, a class must:

- Be marked `final`
- Contain only stored properties that are immutable and sendable
- Have no superclass or have `NSObject` as the superclass

Classes marked with `@MainActor` are implicitly sendable, because the main actor coordinates all access to its state. These classes can have stored properties that are mutable and nonsendable.

@MainActor Isolation

```
@MainActor func updateView() { … }
Task { @MainActor in
    // …
  view.selectedChicken = lily
}
```

isolated vs nonisolated

Both are part of adding actor isolated control - properties and methods

isolated

- Default actor's behavior: Actors are automatically isolated
- **Explicit Control:** Mark properties or parameters as isolated

nonisolated

- Opt-Out of actor's isolation: Bypass actor isolation
- **Ideal** for accessing immutable values or when conforming to **protocol requirement**.
- Mark properties or methods as non-isolated

isolated vs nonisolated

```
actor BankAccount {
    let accountHolder: String
    var balance: Int
    init(accountHolder: String, balance: Int = 0) {
        self.accountHolder = accountHolder
        self.balance = balance
    }
    func deposit(amount: Int) {
        balance += amount
    }
    func transfer(amount: Int, to: isolated
BankAccount) {
        to.deposit(amount: amount)
    }
}
```

Actor-isolated property 'description' cannot be used to satisfy nonisolated protocol requirement

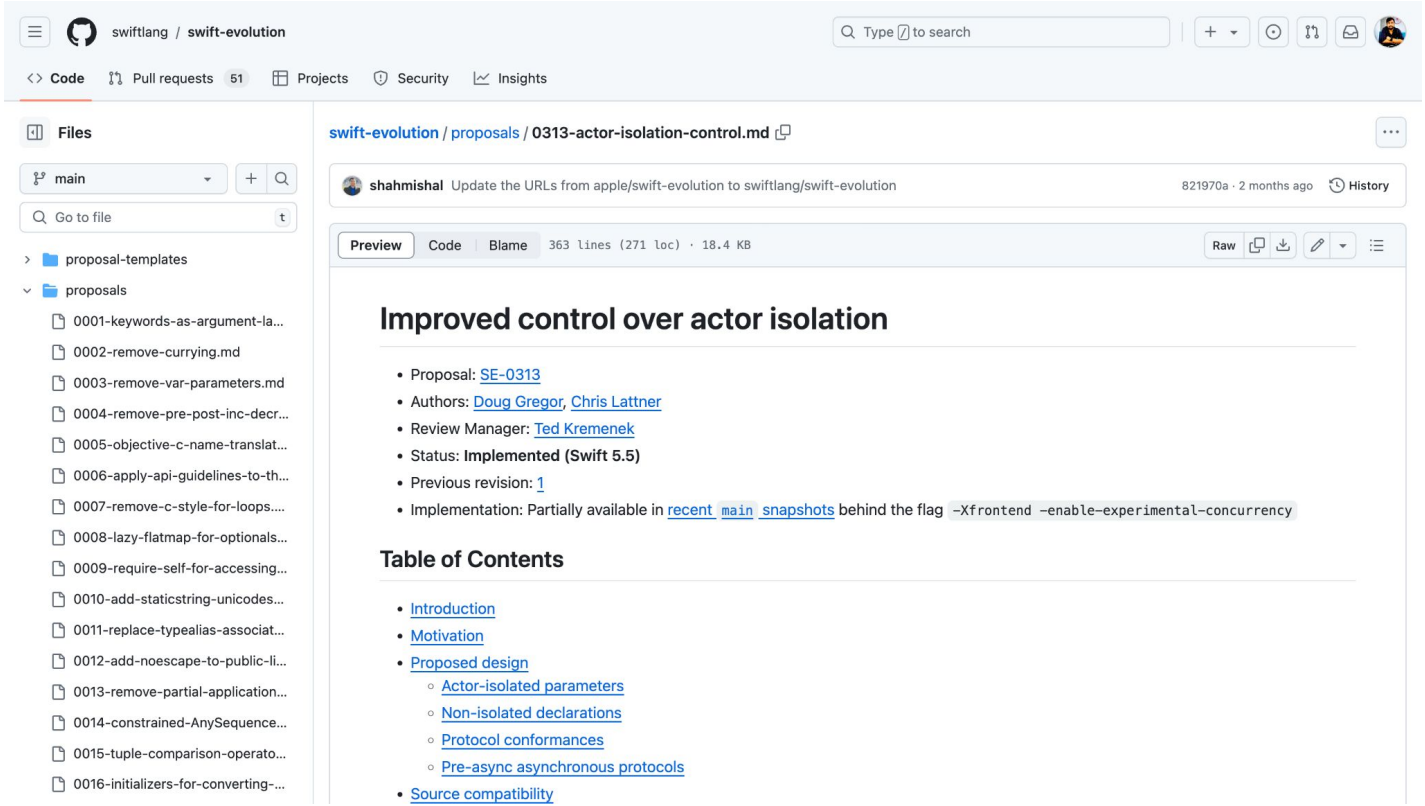
'description' declared here (Swift.CustomStringConvertible) Show

Add '@preconcurrency' to the 'CustomStringConvertible' conformance to defer isolation checking to run time Fix

```
extension BankAccount: CustomStringConvertible {
    var description: String {
        "bank \(balance)"
    }
}
```

```
extension BankAccount: CustomStringConvertible {
    nonisolated var description: String {
        "bank \(accountHolder)"
    }
}
```

isolated vs nonisolated



Isolation Boundary

```
/// Isolation Boundary
actor Account {
    private var balance: Int = 0
    func deposit(amount: Int) {
        balance += amount
    }
    func getBalance() -> Int {
        return balance
    }
}
```

- Account is **Actor**
- Internal state - *balance* is ***isolated***
- *deposit* and *getBalance* accessible within actor's boundary
- Safe modification even accessing concurrently by different tasks

Dynamic Isolation

assumeIsolated

Assume that the current task is executing on this actor's serial executor, or stop program execution otherwise.

- ➔ Synchronous
- ➔ Being able to assert isolation for non-task code

```
nonisolated public func caffeineLevel(at level: Double) {
    MainActor.assumeIsolated {
        if level < minimumCaffeine {
            // TODO: alert user to drink more coffee!
        }
    }
}
```

preconditionIsolated

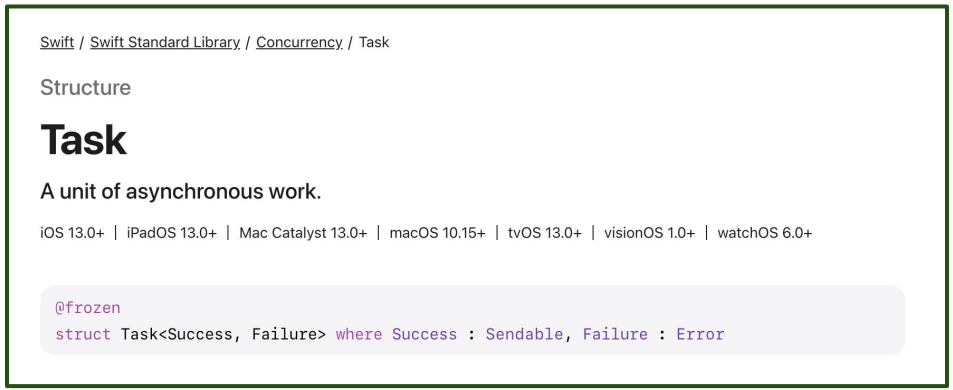
Stops program execution if the current task is not executing on this actor's serial executor.

➔ Assert isolation at runtime
➔ Adds a runtime check to ensure correctness

```
actor MyActor {
    var value: Int = 0
    func updateValue() {
        preconditionIsolated(self) // Ensures that `self` is isolated
        value += 1
    }
}
```

Task Isolation

- ➔ Tasks are isolated independently executing async operations
- ➔ Sendable checks - Ensure tasks remain isolated
- ➔ Use Sendable constraints wherever values need to be shared



Challenges of Isolation

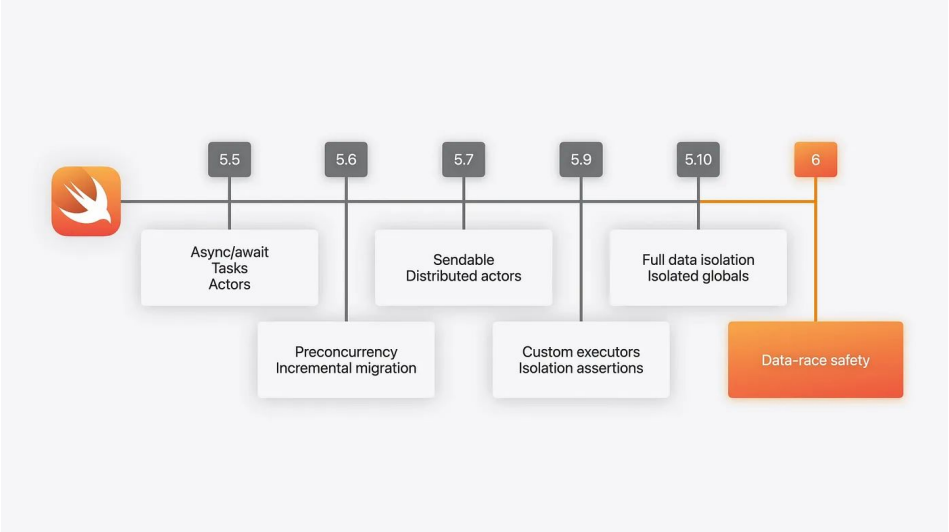
- **Performance**: Context switching and actor can introduce delay
- **Complexity:** Sequential execution can impact the performance
- Limited **Flexibility:** @unchecked Sendable can lead to bugs
- **Debugging** Race conditions can be challenging
- API and Tooling **Limitations**: Difficulty in integrating with the legacy API or libraries.


WHEN YOU FINALLY UNDERSTAND ASYNC/AWAIT...
imgflip.com

Swift 6

Swift 6

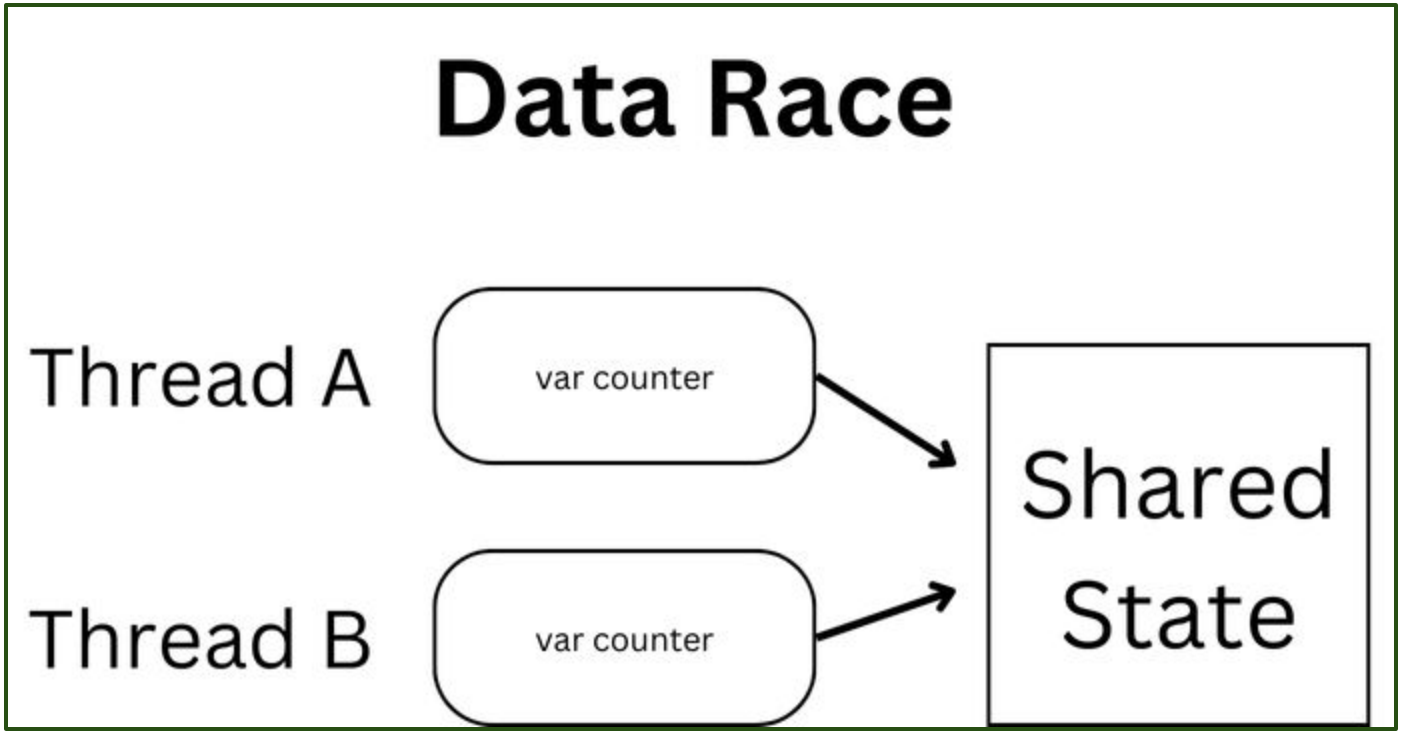
- ➔ Compiler supports from **Swift 4**.0
- ➔ **Data-race Safety**
- ➔ Everything should be **Sendable**
- ➔ **Actors** strictly not **FIFO**
- ➔ Non-isolated(**unsafe)**
- ➔ **@preconcurrency and @unchecked** with careful consideration



What are Data Races?

- Two threads concurrently access at the same time
- Write access
- Caused by a shared mutable state

```
var counter = 0
Task.detached {
    counter += 1
}
Task.detached {
    counter += 1
}
print(counter)  // The result could be 1 or 2 due to the data race
```

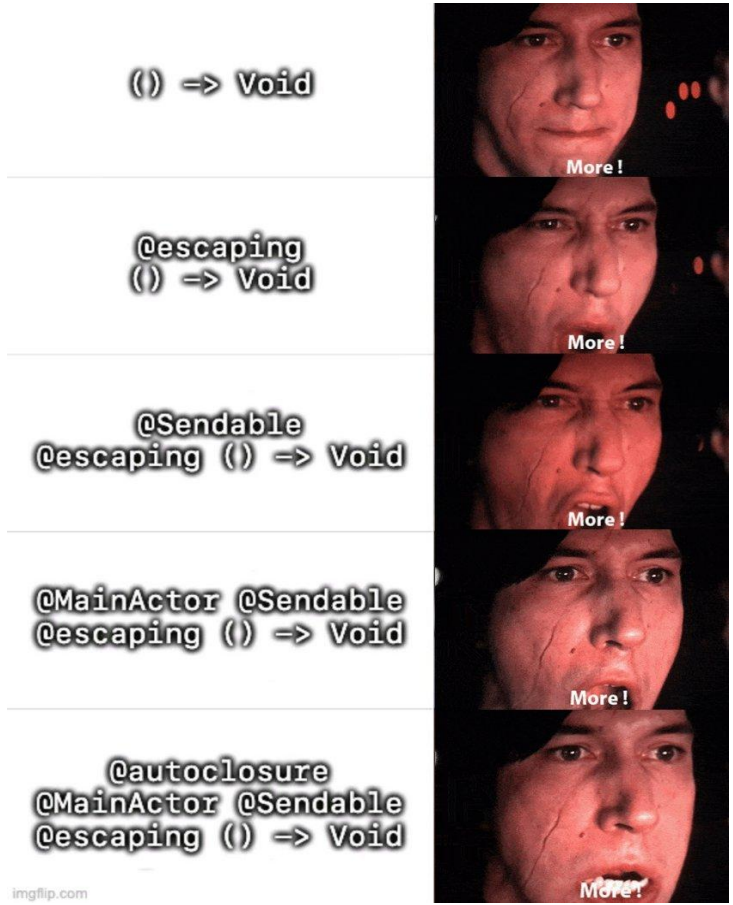

Data Race
Thread A
var counter
Thread B
var counter
Shared State

Compiler support

- ➔ Backward Compatibility
- ➔ Supports from swift 4.0
- ➔ Migration technique to leverage new features and improvements
- ➔ **Async/Await** Integration - Transition
- ➔ Large old codebases can be migrated
- ➔ Brings Stability of existing code

Everything should be Sendable

- ➔ Sendable = sign of having too much isolation boundaries
- ➔ Cause of this - introducing more actors to the code



Files

main

Go to file t

0410-atomics.md
0411-isolated-default-values.md
0412-strict-concurrency-for-glo...
0413-typed-throws.md
0414-region-based-isolation.md
0415-function-body-macros.md
0416-keypath-function-subtypin...
0417-task-executor-preference....
0418-inferring-sendable-for-me...
0419-backtrace-api.md
0420-inheritance-of-actor-isolat...
0421-generalize-async-sequenc...
0422-caller-side-default-argum...
0423-dynamic-actor-isolation.md
0424-custom-isolation-checkin...
0425-int128.md
0426-bitwise-copyable.md
0427-noncopyable-generics.md

Inferring `Sendable` for methods and key path literals

- Proposal: SE-0418
- Authors: Angela Laar, Kavon Farvardin, Pavel Yaskevich
- Review Manager: Becca Royal-Gordon
- Status: **Implemented (Swift 6.0)**
- Upcoming Feature Flag: `InferSendableFromCaptures`
- Review: (pitch) (review) (acceptance)

Introduction

This proposal is focused on a few corner cases in the language surrounding functions as values and key path literals when using concurrency. We propose Sendability should be inferred for partial and unapplied methods. We also propose to lift a Sendability restriction placed on key path literals in SE-0302 by allowing the developers to control whether key path literal is Sendable or not. The goal is to improve flexibility, simplicity, and ergonomics without significant changes to Swift.

Motivation

The partial application of methods and other first-class uses of functions have a few rough edges when combined with concurrency.

Actors are not strictly FIFO

Key difference from Serial Dispatch Queue

➔ Actors prioritize highest priority work first

➔ Eliminates priority inversion

Order of Execution

Tasks -> **Run** code in **each** task in the **specified** order. The order between tasks **isn't guaranteed**

AsyncStreams -> Deliver elements in order

@preconcurrency

The @preconcurrency declaration can be added to:

- functions
- types
- protocols
- Imports

```
@preconcurrency import MyModule
```

Can import old modules into new code
Allow usage of new code in legacy codebases

```
extension HomeViewController: @preconcurrency CBCentralManagerDelegate {
```

nonisolated(unsafe)

The nonisolated(unsafe) declaration

- can be used to annotate the global variable
- disable static checking of data isolation for the global variable
- Thread Sanitizer could still identify failures

```
class NearByKit{

    nonisolated(unsafe) static let sharedManager = NearByKit()
```

@unchecked

Bypass certain compiler checks for types and operations

Use Cases:

- Type conversion
- Data access
- Performance Optimization

```
class Services: NSObject, URLSessionDelegate, @unchecked Sendable {

    var baseUrl = "http://52.63.35.48:8080/test/"
```

@preconcurrency, nonisolated(unsafe) & @unchecked

Attribute	Purpose	Use Cases	Unsafe Opt Outs
@preconcurrency	Codebase doesn't have Swift concurrency	Older APIs to silence concurrency-related warnings	@preconcurrency Sendable considered "unsafe opt-outs" Careful consideration is must
nonisolated(unsafe)	Bypasses actor isolation without concurrency safety	Performance reasons when actor isolation not required	Potential risk
@unchecked	Bypasses compiler checks for flexibility	Type casting when compiler is too restrictive	@unchecked Sendable considered "unsafe opt-outs" Careful consideration is must

Caution: Using these can lead to data races.

Proposals related to Concurrency in Swift 6

SE-0337 - Added Feature Flag - ***StrictConcurrency*** Incremental migration to concurrency checking

SE-0411 - Isolated default value expressions

SE-0414 - Enhancing Concurrency with Region-based Isolation

SE-0417 - Task Executor Preference

SE-0418 - Inferring Sendable for methods and key path literals

SE-0420 - Inheritance of actor isolation

Proposals related to Concurrency in Swift 6

SE-0423 - Improves concurrency support when needing to operate with Objective-C frameworks.

SE-0424 - Custom isolation checking for SerialExecutor

SE-0430 - Adds a new ***Sending*** parameter

SE-0431 - *@isolated(any)* Function Types

SE-0434 - Usability of global-actor-isolated types

SE-0337 - Incremental migration to concurrency checking

Challenge
Adopting Swift's Concurrency Model in Legacy Codebases

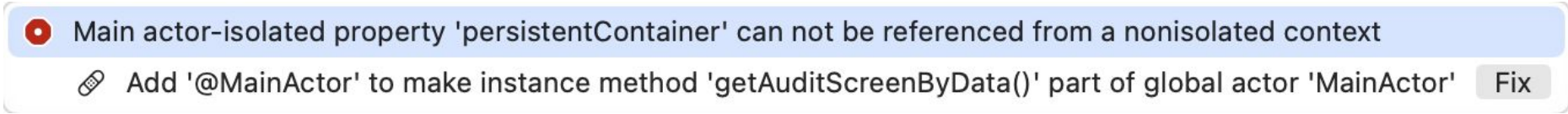
Fix
Incremental Migration Support

Impact
Smoother Transition to Concurrency Safety

Why it's Important?
Facilitates Gradual Adoption

Upcoming Feature Flag: **StrictConcurrency** (Implemented in **Swift 6.0**) (Enabled in Swift 6 language mode)

We will look into depth in upcoming slides



SE-0414 - Region-based Isolation

Challenge
Swift 5.10 banned passing all non-Sendable values across isolation boundaries

Fix
Introduces a new mechanism to enforce memory isolation within regions of code

Impact
It's just a beginning. Makes your code safer by reducing the risk of data conflicts in concurrent environments

Why it's Important?
Helps improve the reliability and safety of your code when working with concurrency

⚠ Passing argument of non-sendable type 'NonSendable' into main actor-isolated context may introduce data races

```swift
class NonSendable {}
func doSomething(with: NonSendable) async {}
@MainActor
func modifyOnMainActor(_ x: NonSendable) async {
    let value = NonSendable()
    // WARNING: Passing argument of non-sendable type 'NonSendable' outside
    // of main actor-isolated context may introduce data races
    await doSomething(with: x)
}
```

```swift
struct Animal: Sendable {}
class NonSendable {
    var animal: Animal
}
func doSomething(with x: NonSendable) async {
    x.animal = Animal()
}
@MainActor
func modifyOnMainActor(_ x: NonSendable) async {
    let value = NonSendable(animal: Animal())
    await doSomething(with: x)
    _ = x.animal // Doesn't produce ERROR - could race with doSomeThing
}
```

SE-0417 - Task Executor Preference

Challenge
Tasks in Swift might not always run on the best executor, which can slow things down.

Fix
Allows you to choose the preferred executor for tasks, giving you more control over how they run.

Impact
Helps tasks run more efficiently by using the right resources.

Why it's Important?
Gives developers better control, leading to faster and smoother performance in Swift apps.

The `SerialExecutor` guarantees mutual exclusion, and the `TaskExecutor` provides a source of threads.

```
nonisolated func doSomething() async {
    // ...
}
Task(executorPreference: preferredExecutor) {
    // doSomething body would execute on 'preferredExecutor'
    await doSomething()
}
// doSomething body would execute on 'default global concurrent executor'
await doSomething()
```

SE-0418 - Inferring Sendable for methods and key path literals

Challenge
Manually declaring Sendable for methods and key paths was tedious and prone to mistakes.

Fix
Swift now automatically infers Sendable for methods and key paths, reducing manual effort.

Impact
Makes code cleaner and safer by ensuring methods and key paths are correctly handled in concurrent contexts.

Why it's Important?
Eases the burden of concurrency management, making your code more reliable.

```
struct MyStruct: Sendable {
    var value: Int
    func update() -> Int {
        return value
    }
}
@MainActor let keyPath: KeyPath<MyStruct, Int> = \.value
```

SE-0420: Inheritance of actor isolation

Challenge
Complexity in Actor Inheritance

Fix
Inheritance of Actor Isolation

Impact
Consistency in Isolation. Isolation parameters prevent suspension at the call site.

Why it's Important?
Ensures Safe Concurrency in Subclasses

```
func doStuff(isolatedTo actor: isolated (any Actor)?) async {
}
// this is non-isolated
await doStuff(isolatedTo: nil)
```

```
func doStuff(isolatedTo actor: isolated (any Actor)? = #isolation)
async {
}
@MainActor
class MyClass {
    func doLotsOfStuff() {
        await doStuff()
        await doStuff()
        await doStuff()
    }
}
```

SE-0423 - Dynamic Isolation enforcement from non-strict-concurrency contexts

Challenge
Ensuring Safe Actor Interaction in Non-Strict Concurrency Contexts

Fix
Dynamic actor isolation enforcement - using @preconcurrency

Impact
Increased Safety in Mixed Concurrent codebases

Why it's Important?
Bridges the gap between the Legacy and Modern Concurrency by using ***@preconcurrency***

```
@MainActor
class MyViewController: @preconcurrency
ViewDelegateProtocol {
    func respondToUIEvent() {
        // no need for nonisolated!
    }
}
```

SE-0424 - Custom isolation checking for SerialExecutor

Challenge
Ensuring tasks on custom executors follow isolation rules.

Fix
Allows custom executors to define how they check for isolation.

Impact
Increases safety by letting custom executors enforce isolation, just like Swift's built-in executors.

Why it's Important?
Gives more control over task execution, making custom concurrency safer.

```
/// Proposal extends the SerialExecutor protocol
public protocol SerialExecutor : Executor {
   @available(macOS 15.0, iOS 18.0, watchOS 11.0,
tvOS 18.0, visionOS 2.0, *)
   func checkIsolated()
}
```

```
// implementation - DispatchSerialQueue
extension DispatchSerialQueue {
  public func checkIsolated() {
    dispatchPrecondition(condition: .onQueue(self)) //
existing Dispatch API
  }
}
```

SE-0430 - Adds a new Sending parameter

Challenge
Ensuring Safe Data Transfer Across Concurrency Boundaries

Fix
Introduction of sending Keyword

Impact
Stricter Concurrency Safety

Why it's Important?
Standard library integrated 'sending' keyword. For eg: Task.init()
Sendable is more important. *sending* is less important.

```
@discardableResult
init(
    priority: TaskPriority? = nil,
    operation: sending @escaping @isolated(any) () async -> Success
)
```

SE-0431 - @isolated(any) Function Types

Challenge
Inconsistent Isolation Control

Fix
Introduction of @isolated(any) Attribute

Impact
Improved Safety and Clarity

Why it's Important?
Ensures Actor-Safe Code Execution

```
/// Problem
func scheduleSomeWork(_ f: @Sendable @escaping () async -> Void) {
    // We've lost all the static isolation information
    // available where f was defined.
    Task {
        await f()
    }
}
/// Problem 2
func defineClosure() {
    scheduleSomeWork { @MainActor in
        print("I'm on the main actor")
    }
}
```

```
/// Solution
func scheduleSomeWork(_ f: @Sendable @escaping @isolated(any) ()
async -> Void) {
    // closures have properties now!
    let isolation = f.isolation
    // do something with "isolation" I guess?
}
```

SE-0434 - Usability of global-actor-isolated types

Challenge
Limited Usability of
Global-Actor-Isolated Types

Fix
Improved Usability Across Contexts

Impact
Greater Flexibility

Why it's Important?
Enables Safer and More Modular Code

```
// Problem
@MainActor
struct SomeMainActorType {
    let x: Int
    var y: Int
    nonisolated func readValues() {
        print(x) // this is allowed!
        print(y) // this is not?
        //       Main actor-isolated property 'y' can not be referenced
from a non-isolated context
    }
}

// Problem - 2
let closure = { @MainActor in   //  Let 'closure' is not
concurrency-safe because it is not either conforming to 'Sendable'
or isolated to a global actor; this is an error in Swift 6
    // capture a bunch of non-Sendable stuff
}
Task {
    // Error: capturing non-Sendable `closure`
    await closure()
}
```

SE-0411 - Isolated default value expressions

Challenge
Default values in functions could access shared data unsafely in concurrent code.

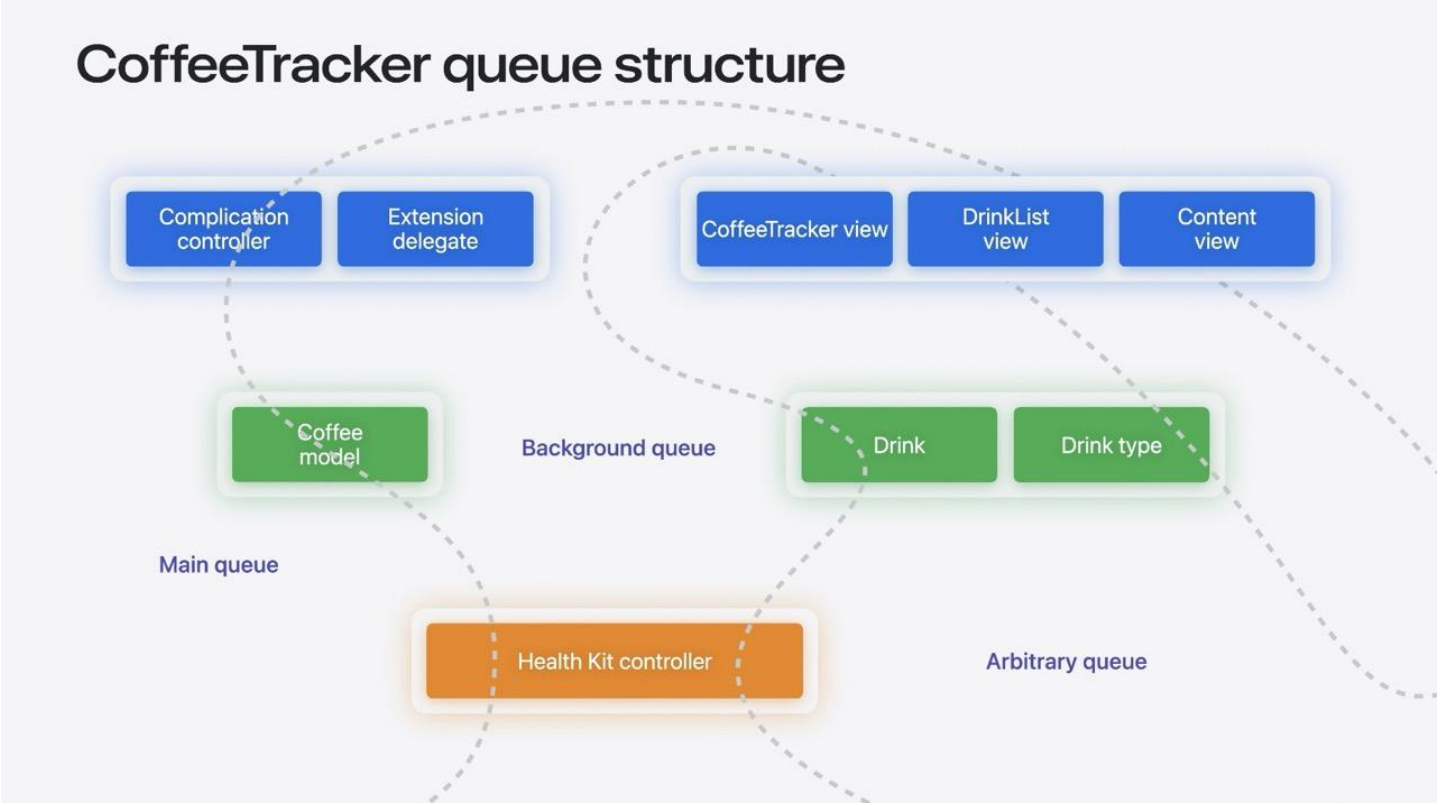
Fix
Ensures default values are executed within the correct isolation context.

Impact
Makes concurrent code safer by preventing data conflicts in default value expressions.

Why it's Important?
Strengthens Swift's concurrency model, making your code more reliable and secure.

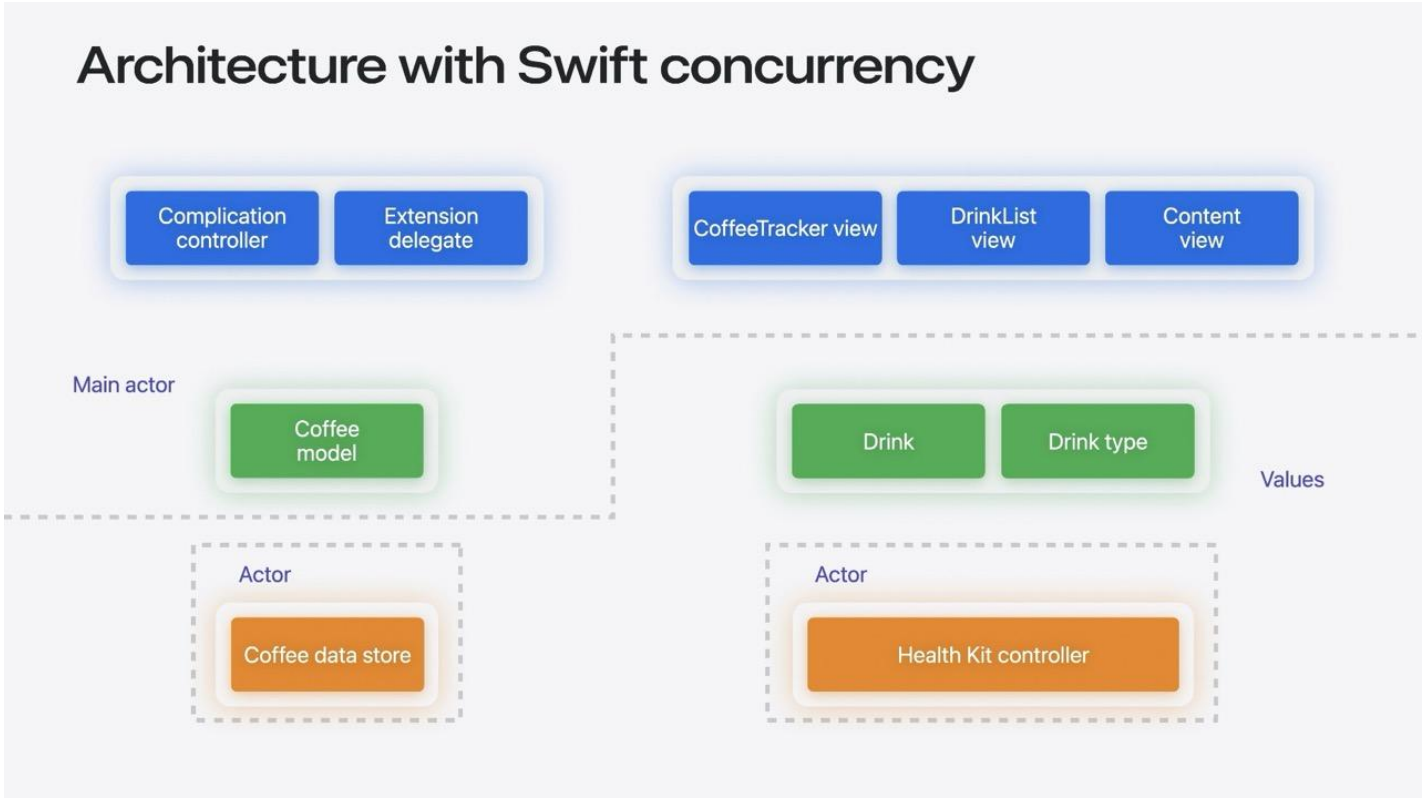
Swift 6 Migration

Pre-concurrency queue structure



Swift 6 Migration

Architecture with Swift concurrency



How to Migrate to Swift 6

- ➔ Determine the isolated part
- ➔ Enable complete concurrency checking
- ➔ Enable Swift 6 mode
- ➔ Audit any unsafe opt-outs

When to Migrate to Swift 6

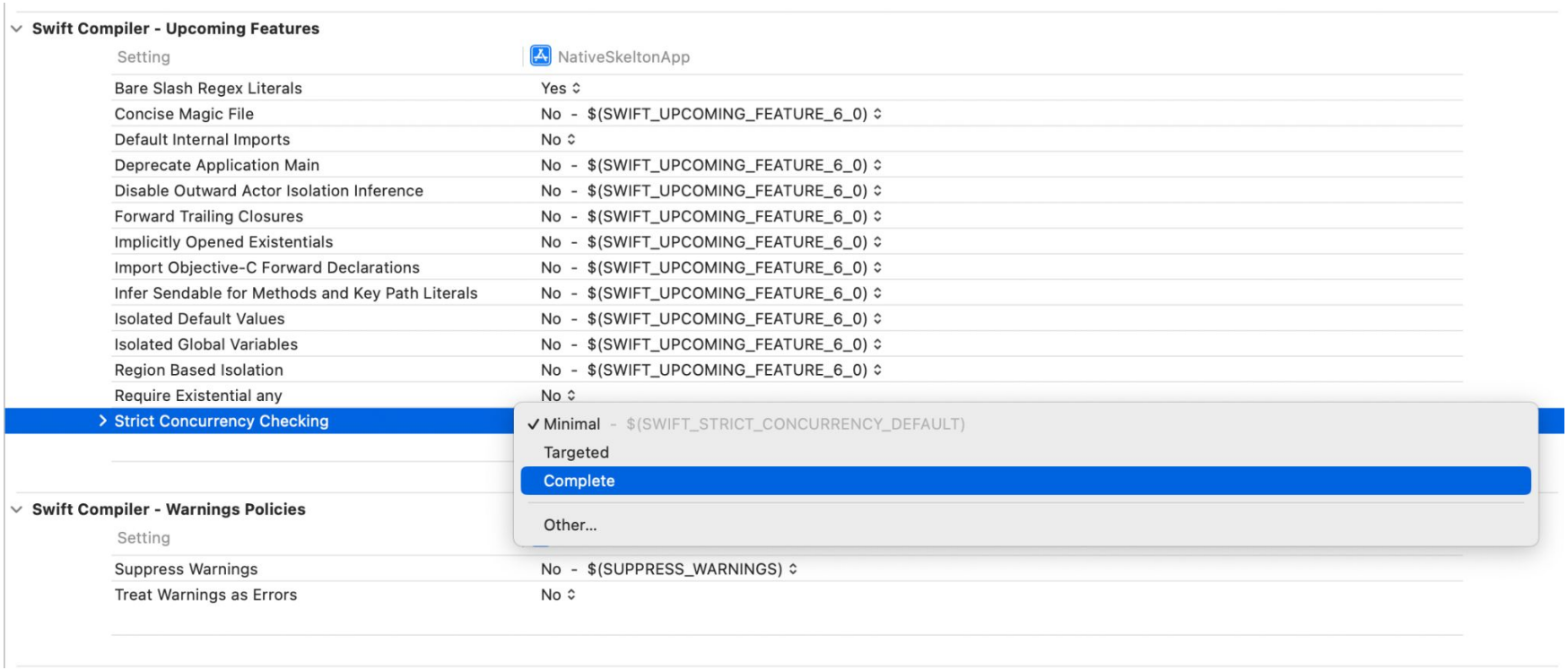
- ➔ Identifying the mistakes in concurrent code is tedious
- ➔ Hard to reproduce crashes
- ➔ Integrating more concurrency
- ➔ If you have public SPM, migrate the package to Swift 6

Swift 6 - Feature Flags

-enable-upcoming-feature

- ➔ *GlobalConcurrency* - Strict concurrency for global variables
- ➔ *InferSendableFromCaptures* - Inferring Sendable for methods and key path literals
- ➔ *RegionBasedIsolation* - Region based Isolation
- ➔ *StrictConcurrency* - Incremental migration to concurrency checking
- ➔ *DisableOutwardActorInference* - Remove Actor Isolation Inference caused by Property Wrappers

Minimal Strict Concurrency Checking



Only Checks explicit Sendable

Minimal Strict Concurrency Checking

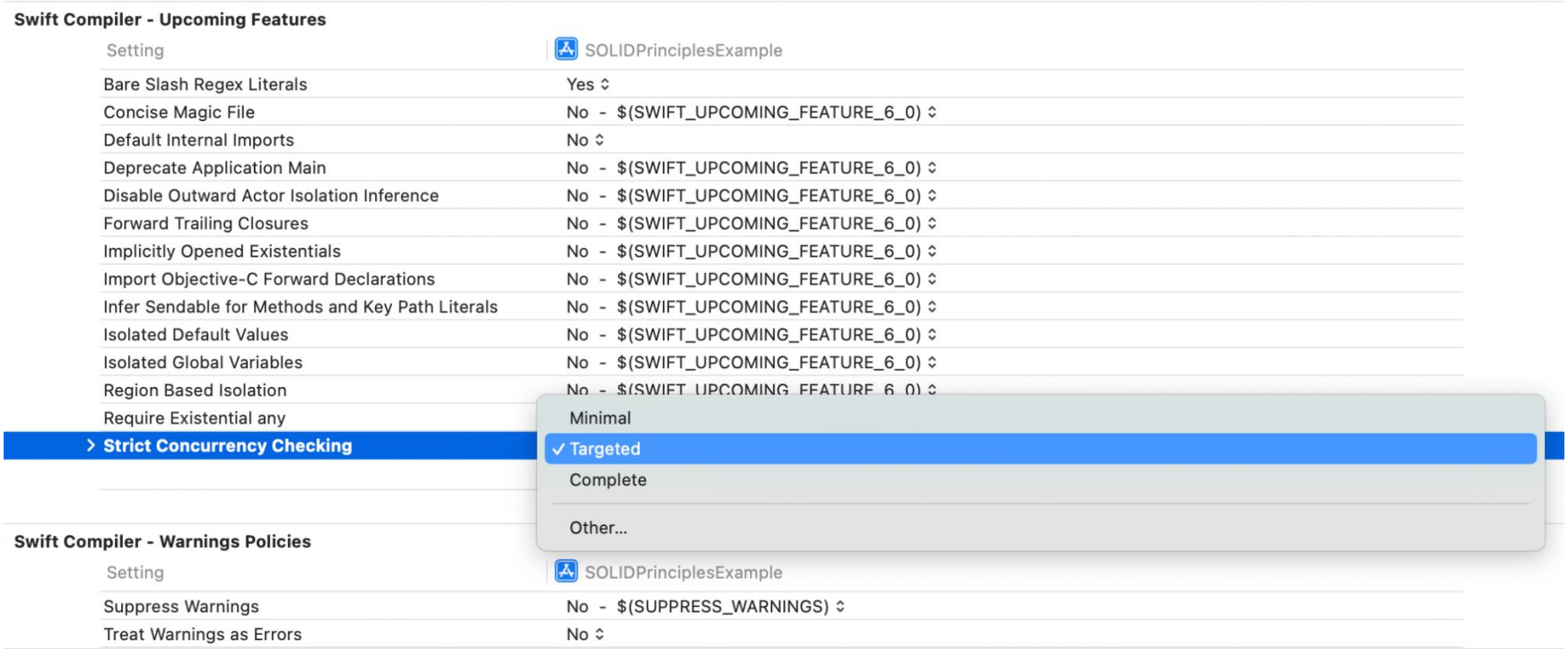
Actor-isolated property 'balance' can not be mutated from a nonisolated context

Mutation of this property is only permitted within the actor Show

```
actor BankAccount {
    var balance: Int = 0
    func deposit(amount: Int) {
        balance += amount
    }
}
func performTransaction(account: BankAccount, amount: Int) {
    Task {
        account.balance += amount
    }
}
```

```
actor BankAccountMinimalConcurrentCheck {
    var balance: Int = 0
    func deposit(amount: Int) {
        balance += amount
    }
}
func performTransaction(account: BankAccountMinimalConcurrentCheck, amount: Int) {
    Task {
        await account.deposit(amount: amount)
    }
}
```

Targeted Strict Concurrency Checking



@preconcurrency attribute can be used

Targeted Strict Concurrency Checking

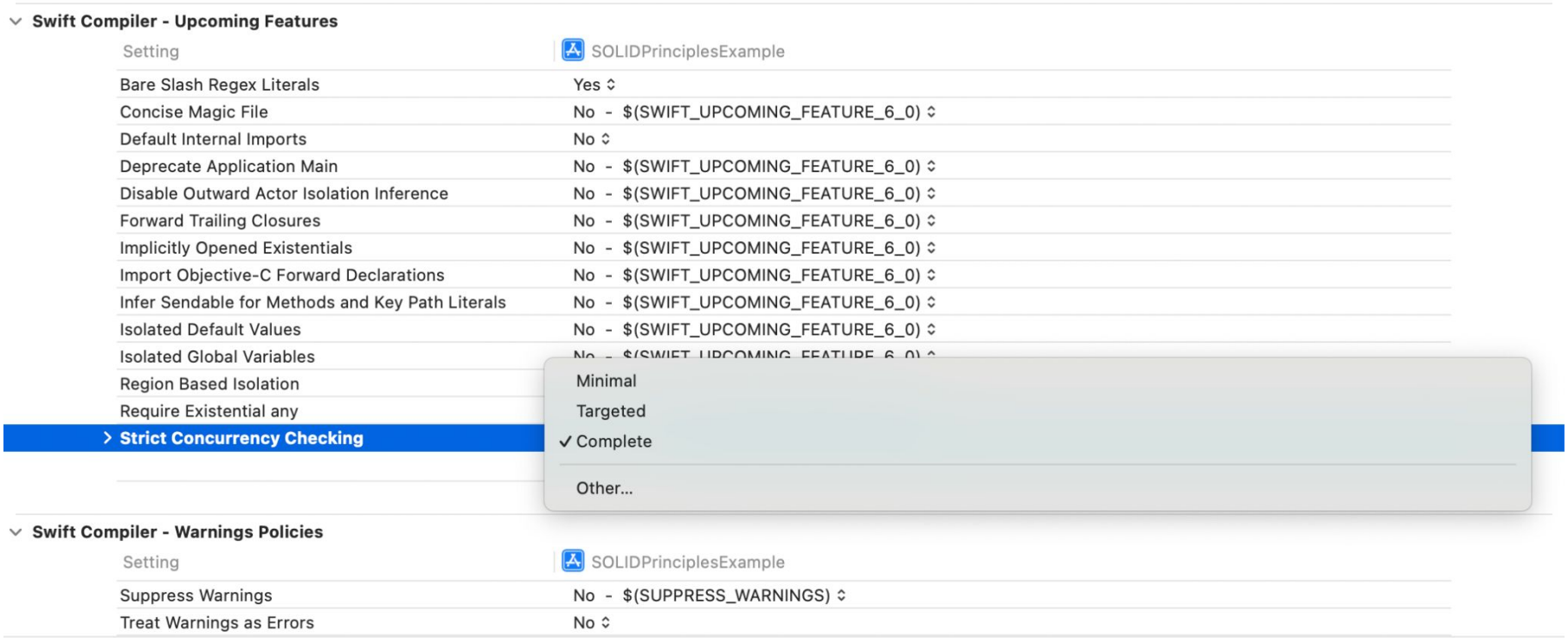
⚠ Passing argument of non-sendable type 'UserProfile' into actor-isolated context may introduce data races; this is an error in the Swift 6 language mode

ⓘ Class 'UserProfile' does not conform to the 'Sendable' protocol Show

```swift
// Non-Sendable class
class UserProfile {
    var name: String
    init(name: String) {
        self.name = name
    }
}
actor BankAccount {
    private var balance: Int = 0
    // Attempting to pass a non-Sendable type across actor boundaries
    func updateProfile(profile: UserProfile) {
        print("Updating profile for \(profile.name)")
    }
}
func performTransaction(account: BankAccount, profile: UserProfile) {
    Task {
        await account.updateProfile(profile: profile)  // Error: 'UserProfile' is not Sendable.
    }
}
```

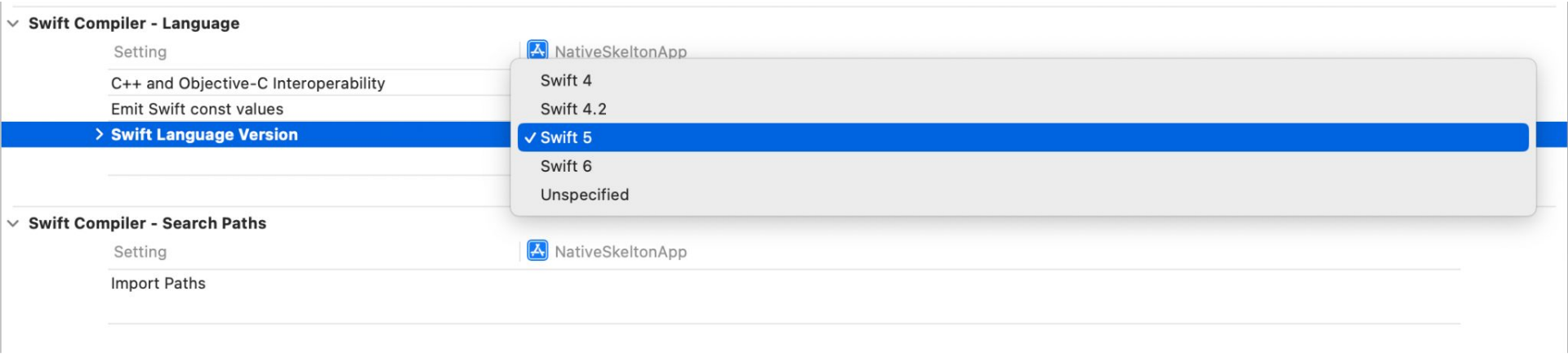
```swift
struct UserProfile: Sendable {
    let name: String
}
actor BankAccount {
    private var balance: Int = 0
    func updateProfile(profile: UserProfile) {
        print("Updating profile for \(profile.name)")
    }
}
func performTransaction(account: BankAccount, profile: UserProfile) {
    Task {
        await account.updateProfile(profile: profile)  // No error because UserProfile is now Sendable.
    }
}
```

Complete Strict Concurrency Checking



Stricter concurrency checking one module at a time

Enable Swift 6 mode

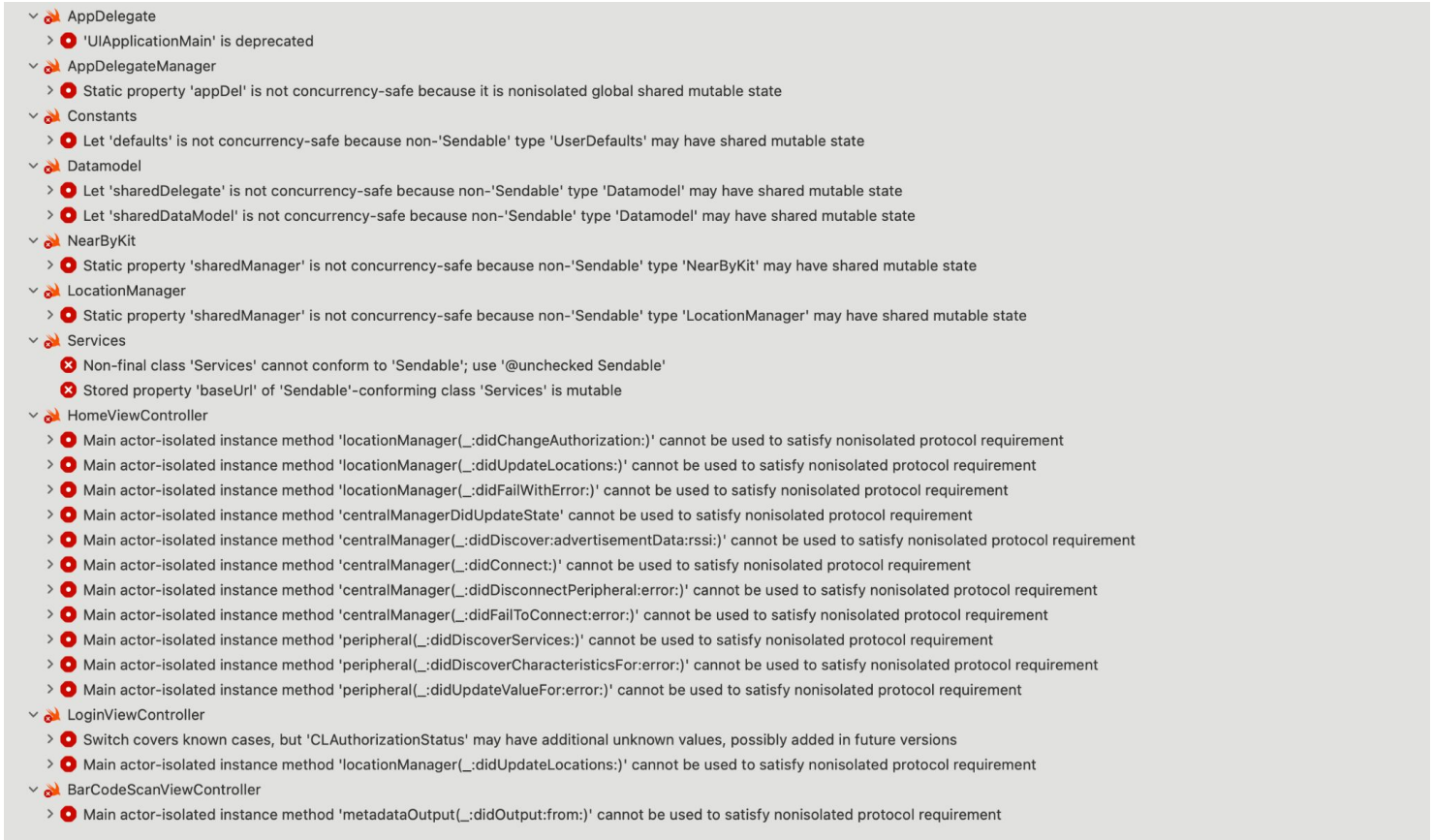


Final Step of the Migration for the Xcode Project

Requires to change the Language mode -> **Swift 6**

Go to the Building Settings and Search for ***Swift Language Version***

Compile Errors during Migration



Common Error - Main actor-isolated property

Main actor-isolated property 'persistentContainer' can not be referenced from a nonisolated context

Add '@MainActor' to make instance method 'getAuditScreenByData()' part of global actor 'MainActor' Fix

```
func getAuditScreenByData() -> ([[String:String]], [String : [Date]]){
    var nearByKitScreenDict = [[String:String]]()
    var auditKitSterilizedDates = [String:[Date]]()

    let context = appDelegateObj.persistentContainer.viewContext
    // Fetch Kit records
    let fetchRequest : NSFetchRequest<NearByKitColle
    fetchRequest.predicate = NSPredicate(format: "ki
```

Main actor-isolated property 'persistentContainer' can not be referenced from a nonisolated context

Add '@MainActor' to make instance method 'getAuditScreenByData()' part of global actor 'MainActor' Fix

```
@MainActor func getAuditScreenByData() -> ([[String:String]], [String : [Date]]){
    var nearByKitScreenDict = [[String:String]]()
    var auditKitSterilizedDates = [String:[Date]]()

    let context = appDelegateObj.persistentContainer.viewContext
    // Fetch Kit records
```

Common Error - Static Property because Non-Sendable

```
class NearByKit{

    static let sharedManager = NearByKit()


    // Packets Data
    private var upTime: String?
    private var firstMPAutoClavePowerReverseCycl
    private var sumMPCycles: String?
```

Static property 'sharedManager' is not concurrency-safe because non-'Sendable' type 'NearByKit' may have shared mutable state

- Class 'NearByKit' does not conform to the 'Sendable' protocol — Show
- Annotate 'sharedManager' with '@MainActor' if property should only be accessed from the main actor — Fix
- Disable concurrency-safety checks if accesses are protected by an external synchronization mechanism — Fix

```
class NearByKit{

    @MainActor static let sharedManager = NearByKit()
```

```
class NearByKit{

    nonisolated(unsafe) static let sharedManager = NearByKit()
```

Common Error '@unchecked Sendable'

```
class Services: NSObject, URLSessionDelegate {
    var baseUrl = "http://52.63.35.48:8080/test/"
```

Non-final class 'Services' cannot conform to 'Sendable'; use '@unchecked Sendable'

Stored property 'baseUrl' of 'Sendable'-conforming class 'Services' is mutable

```
class Services: NSObject, URLSessionDelegate, @unchecked Sendable {

    var baseUrl = "http://52.63.35.48:8080/test/"
```

Reference - URLSessionDelegate

```
@available(iOS 7.0, *)
public protocol URLSessionDelegate : NSObjectProtocol, Sendable {

    optional func urlSession(_ session: URLSession, didBecomeInvalidWithError error: (any Error)?)

    optional func urlSession(_ session: URLSession, didReceive challenge: URLAuthenticationChallenge, completionHandler: @escaping @Sendable
        (URLSession.AuthChallengeDisposition, URLCredential?) -> Void)

    optional func urlSession(_ session: URLSession, didReceive challenge: URLAuthenticationChallenge) async -> (URLSession.AuthChallengeDisposition,
        URLCredential?)

    @available(iOS 7.0, *)
    optional func urlSessionDidFinishEvents(forBackgroundURLSession session: URLSession)
}
```

@preconcurrency

```
extension HomeViewController: CBCentralManagerDelegate {

    // Checking bluetooth connectivity
    func centralManagerDidUpdateState(_ central: CBCentralManager) {
        switch central.state {
        case .unknown:
            print("central.state is .unknown")
        case .resetting:
            print("central.state is .resetting")
        case .unsupported:
            print("central.state is .unsupported")
```

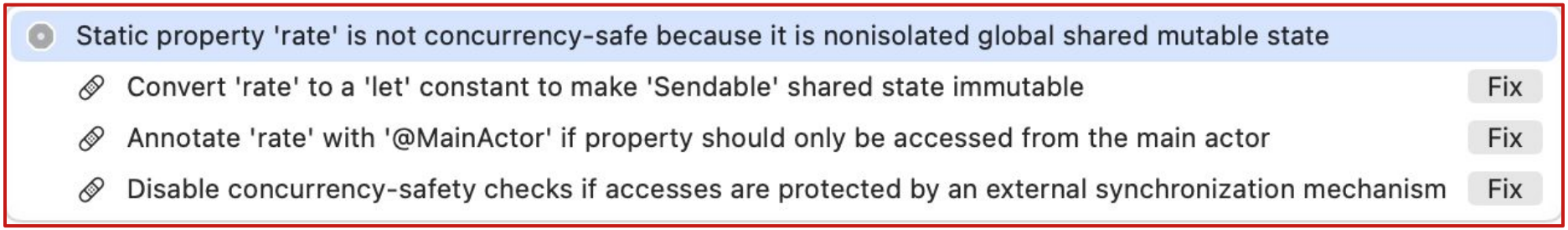
Main actor-isolated instance method 'centralManagerDidUpdateState' cannot be used to satisfy nonisolated protocol requirement

- 'centralManagerDidUpdateState' declared here (CoreBluetooth.CBCentralManagerDelegate) — Show
- Add 'nonisolated' to 'centralManagerDidUpdateState' to make this instance method not isolated to the actor — Fix
- Add '@preconcurrency' to the 'CBCentralManagerDelegate' conformance to defer isolation checking to run time — Fix

```
extension HomeViewController: @preconcurrency CBCentralManagerDelegate {

    // Checking bluetooth connectivity
    func centralManagerDidUpdateState(_ central: CBCentralManager) {
        switch central.state {
        case .unknown:
            print("central.state is .unknown")
        case .resetting:
            print("central.state is .resetting")
```

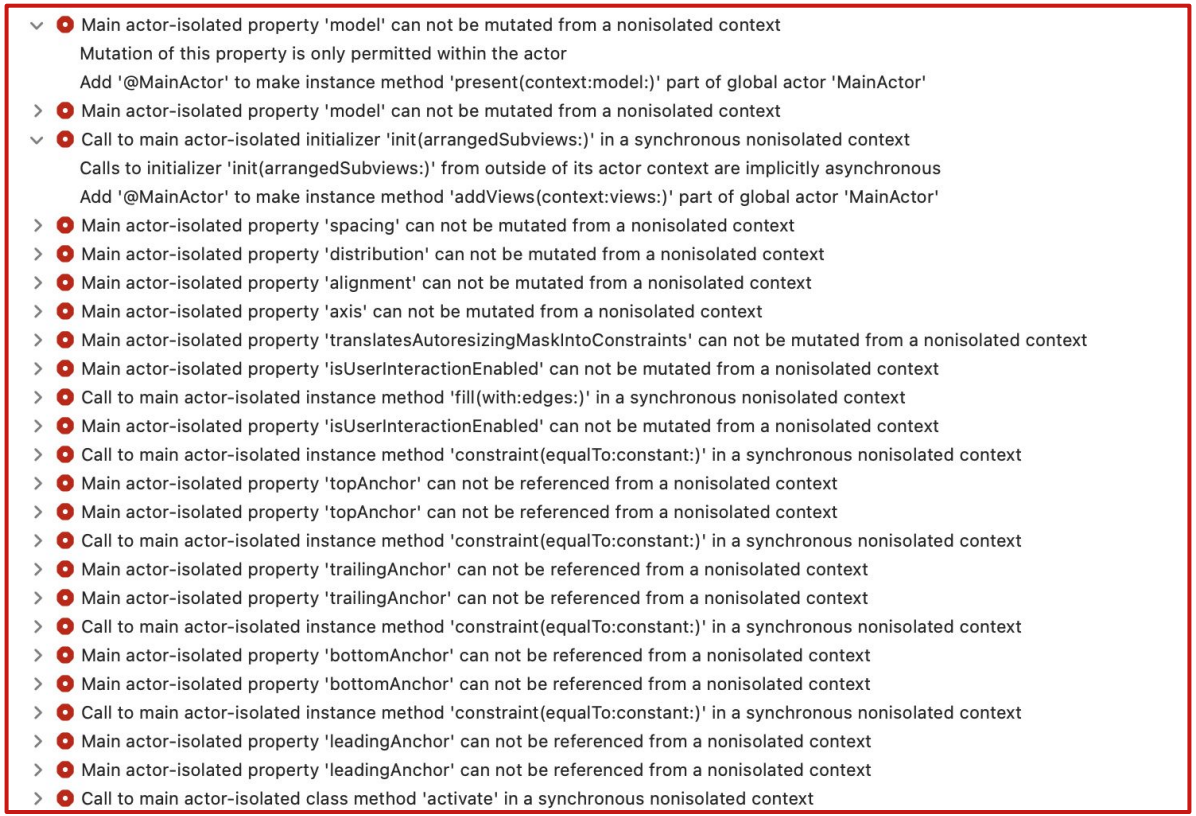
Static property



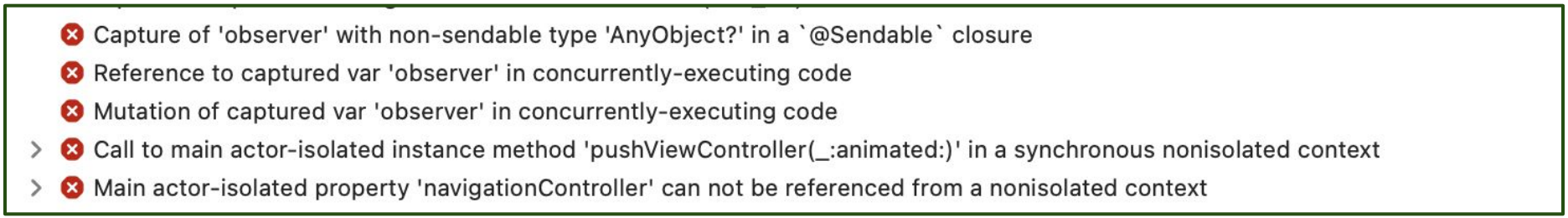

```
private struct Initialize {
    static var rate = "rate"
```

```
private struct Initialize {
    static let rate = "rate"
```

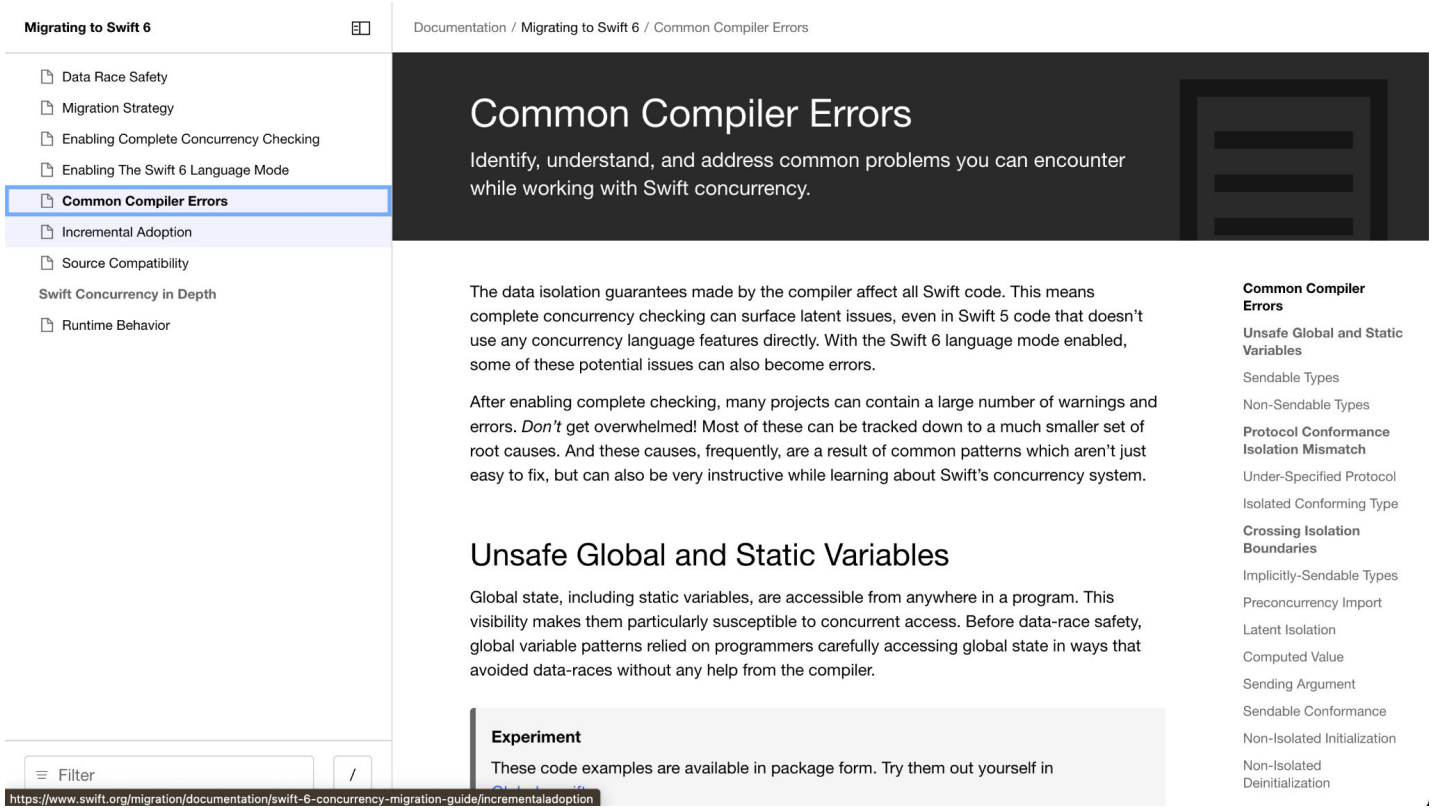
Other Common Errors



Other Common Errors



Common Errors



StrictConcurrency

```
1  // swift-tools-version: 5.8
2  // The swift-tools-version declares the minimum version of Swift required to build this package.
3
4  import PackageDescription
5
6  let package = Package(
7      name: "NetworkKit",
8      platforms: [
9          .iOS(.v15),
10         .macOS(.v12),
11         .watchOS(.v8)
12     ],
13     products: [
14         // Products define the executables and libraries a package produces, making them visible to other packages.
15         .library(
16             name: "NetworkKit",
17             targets: ["NetworkKit"])
18     ],
19     targets: [
20         // Targets are the basic building blocks of a package, defining a module or a test suite.
21         // Targets can depend on other targets in this package and products from dependencies.
22         .target(
23             name: "NetworkKit",
24             swiftSettings: [
25             .enableUpcomingFeature("StrictConcurrency")
26         ]),
27         .testTarget(
28             name: "NetworkKitTests",
29             dependencies: ["NetworkKit"])
30     ]
31 )
32
```

StrictConcurrency

```
public func sendRequest<T: Decodable>(endpoint: EndPoint,
                                      resultHandler: @escaping (Result<T, NetworkError>) -> Void) {

    guard let urlRequest = createRequest(endPoint: endpoint) else {
        return
    }
    let urlTask = URLSession.shared.dataTask(with: urlRequest) { data, response, error in
        guard error == nil else {
            resultHandler(.failure(.invalidURL))
            return
        }
        guard let response = response as? HTT
            resultHandler(.failure(.unexpecte
            return
        }
```

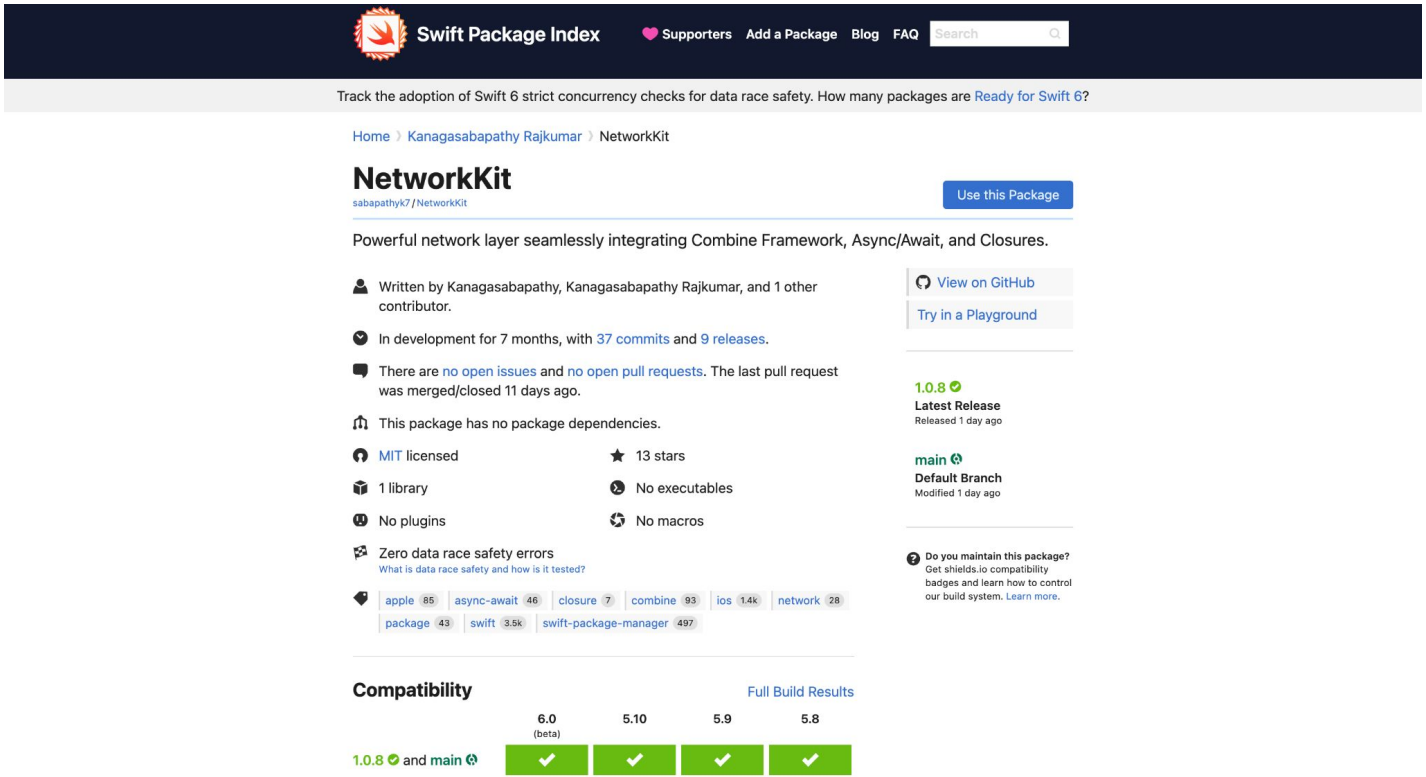
⚠ Capture of 'resultHandler' with non-sendable type '(Result<T, NetworkError>) -> Void' in a `@Sendable` closure; this is an error in the Swift 6 language mode

● A function type must be marked '@Sendable' to conform to 'Sendable' Show

```
public func sendRequest<T: Decodable>(endpoint: EndPoint,
                                      resultHandler: @Sendable @escaping (Result<T, NetworkError>) -> Void) {

    guard let urlRequest = createRequest(endPoint: endpoint) else {
        return
    }
    let urlTask = URLSession.shared.dataTask(with: urlRequest) { data, response, error in
        guard error == nil else {
            resultHandler(.failure(.invalidURL))
            return
        }
        guard let response = response as? HTTPURLResponse, 200...299 ~= response.statusCode else {
            resultHandler(.failure(.unexpectedStatusCode))
            return
        }
```

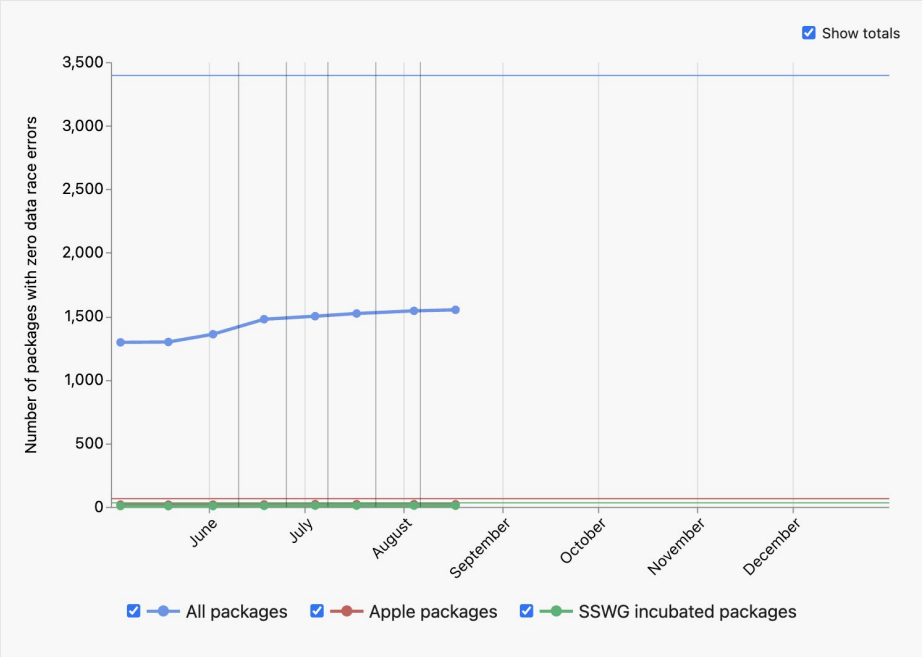
Zero data Races safety errors



Zero data Races safety errors

Total packages with Swift 6 zero data race safety errors

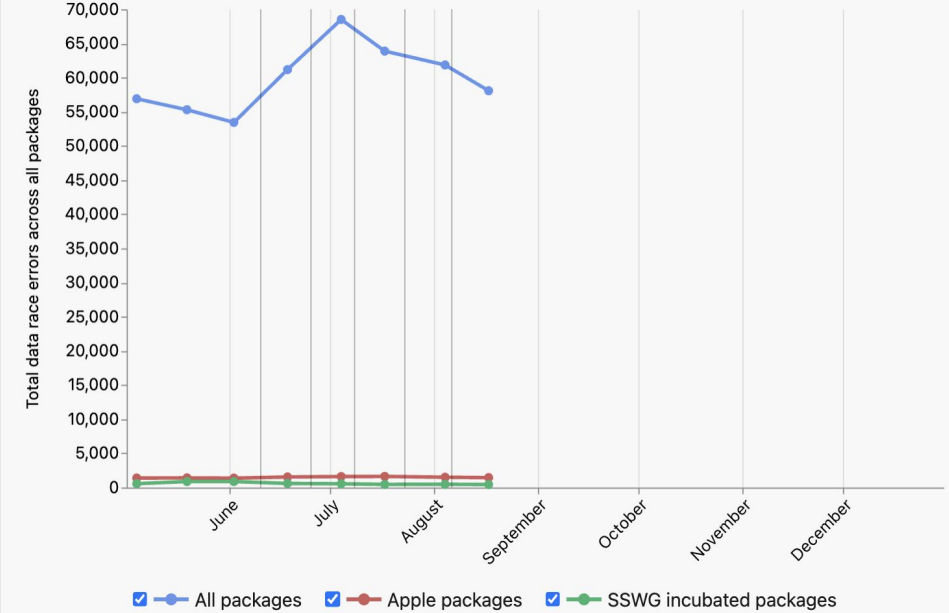
This chart shows packages with zero data race safety compiler diagnostics during a successful build on at least one tested platform.



Data Races safety errors

Total Swift 6 data race safety errors

This chart shows the total number of all data race safety diagnostics across *all* packages.




CONCURRENCY IN SWIFT 6.
JUST TRYING TO KEEP EVERYTHING IN SYNC!

Key Takeaways from Swift Concurrency

- ➔ Use **async/await** for API Executions
  - ◆ Simplifies async code and more readability compared to callbacks/completion handlers
- ➔ Replace Callbacks/Completion Handlers with **Continuations**
  - ◆ Bridging existing callbacks
- ➔ Use **async-let** for Concurrent Operations
  - ◆ Run multiple async operations concurrently - Best fit for downloading images
- ➔ Use **Structured Concurrency** to Manage Task Lifecycles
  - ◆ Preventing potential memory leaks or child tasks
- ➔ Use **Sendable** for Safe Concurrency
  - ◆ Safe shared across isolation boundaries and reducing data races
- ➔ Use **Actors** and **Isolation** to Eliminate Data Races
  - ◆ Built-in mechanism
- ➔ Use **@preconcurrency** for Legacy Code
  - ◆ Silence concurrency warnings in legacy codebase
- ➔ Enable Concurrency Checking and Prepare for **Swift 6**
  - ◆ Concurrency checks and catch potential issues

Scan the QR Code to Download

Connect with me on LinkedIn - *sabapathy7*

Q & A

Thank You