CS 326
Dependencies and Decoupling

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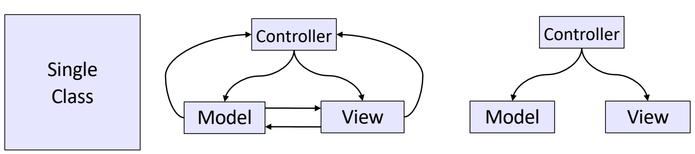
1

Limits of Scaling

- What prevents us from building huge, intricate structures that work perfectly and indefinitely?
  - Not just friction
  - Not just gravity
  - Not just wear-and-tear
- ... The difficulty of managing complexity
- http://www.visualcapitalist.com/millions-lines-of-code/
- Modularity, and minimize interactions

Cohesion and Coupling

- Split Design into parts that don't interact much
  - Coupling: amount of interaction between parts
  - Cohesion: similarity/behavior within a part



"god class" *Strongly coupled* *Weakly coupled*

Design Exercise #1

- Write a typing-break reminder program
  - Offer user occasional reminders to take a break from typing a stretch.
- Naive Design:
  - Main program makes a timer
  - Timer loops performs actions periodically
  - Action = "Display message and offer exercises"
  - (Ignore fancy multi-threaded solutions...)

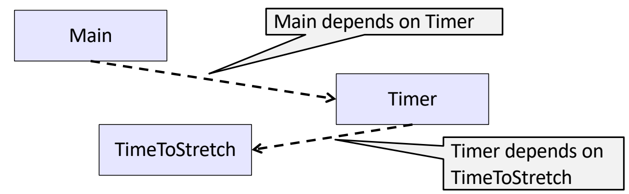
Code, Version 1

```
// MARK: Module 1: Time To Stretch

public class TimeToStretch {
  public func run() {
    print("Take a Break!
          \(suggestExercise())")
 }

  private func suggestExercise() ->
                                    String {
    if Int(arc4random_uniform(2)) == 0 {
      return "Touch Toes"
    } else {
      return "Do 100 Push Ups"
    }
  }
}
```

```
// MARK: Module 2: Timer

public class Timer {
  private let tts = TimeToStretch()
  public func start() {
    while true {
      sleep(3)
      tts.run()
    }
  }
}

// MARK: Module 3: Main

let timer = Timer()
timer.start()
```

Module Dependency Diagram (MDD)

- Arrow indicates “depends on” or "*knows about*"
  - Simplest notion: any name mentioned in the source code



- What’s wrong with this diagram?
  - Does Timer really need to depend on TimeToStretch?
  - Is Timer re-usable in a new context?

Decoupling

- Timer needs to call the run method
  - but doesn't need to know what exactly it does
- Weaken dependency of Timer on TimeToStretch
  - Introduce a weaker specification, in the form of an interface or abstract class

```
public protocol TimerTask {
     func run()
}
```

- Timer works with anything conforming to TimerTask

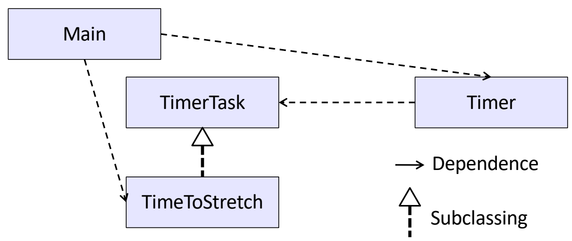
Code, Version 2

```
public protocol TimerTask {
  func run()
}



// MARK: Module 1: Time To Stretch

public class TimeToStretch : TimerTask {
  public func run() {
    print("Take a Break!
          \(suggestExercise())")
  }

  private func suggestExercise() ->
                                  String {
     ...
  }
}
```

```
// MARK: Module 2: Timer

public class Timer {

  private let task : TimerTask

  public init(_ task : TimerTask) {
    self.task = task
  }

  public func start() {
    while true {
      sleep(3)
      task.run()
    }
  }
}

// MARK: Module 3: Main

let timer = Timer(TimeToStretch())
timer.start()
```

MDD (version 2)

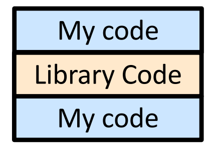
- Timer depends only on TimerTask
  - Timer is much easier to reuse
  - Main depends on the constructor for TimeToStretch

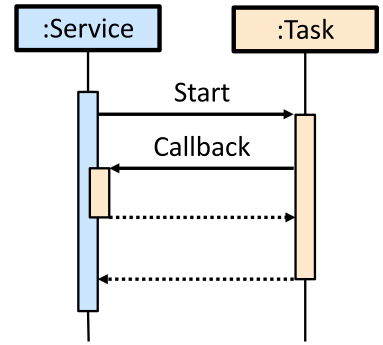


- Main still depends on Timer (is this necessary?)

Callback Design Pattern

- Synchronous Callback
- Time increases down
- Solid Arrow: Call
- Dotted Arrow: Return
- Call Stack:

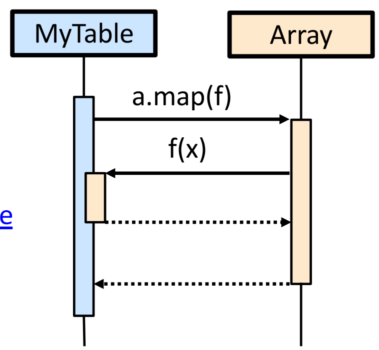




- Benefit: Library does not depend on my service, only on some super type of my service

Synchronous Callback Examples

- Collections:
  - Array, Dictionary, Set
  - map/filter/first/etc.
- UIKit Delegates
  - [UITableViewDataSource]
- Useful when callback result is immediately needed



Synchronous Callback Examples

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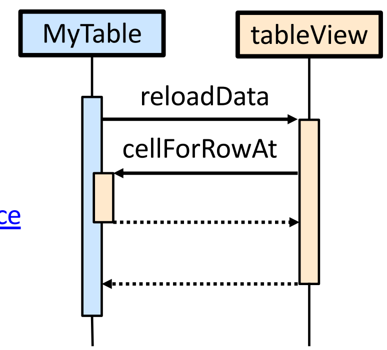
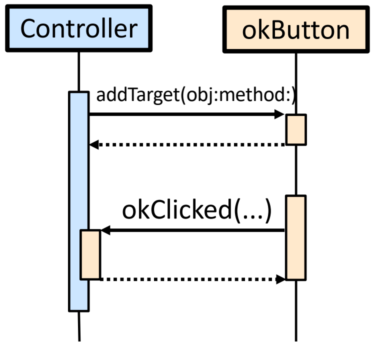


Asynchronous Callback Examples

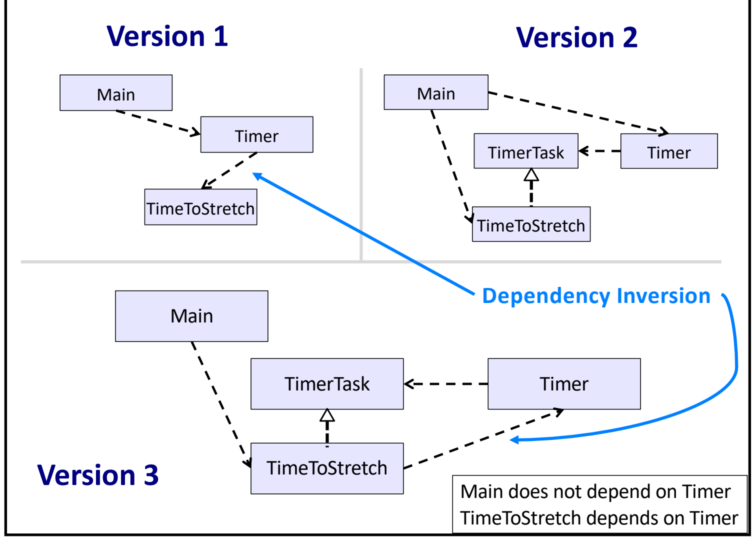
- GUI listeners
  - Register interest in event and where to call back (@IBAction)
  - Useful when callback should run when something interesting occurs
- Tasks to put on DispatchQueues



Code, Version 3

```
public protocol TimerTask {
  func run()
}

// MARK: Module 1: Time To Stretch

public class TimeToStretch : TimerTask {
  private var timer : Timer?

  public func start() {
    timer = Timer(self)
    timer?.start()
  }

  public func run() {
    print("Take a Break!
          \(suggestExercise())")
  }

  private func suggestExercise() ->
                       String { ... }
}
```

```
// MARK: Module 2: Timer

public class Timer {

  private let task : TimerTask

  public init(_ task : TimerTask) {
    self.task = task
  }

  public func start() {
    while true {
      sleep(3)
      task.run()
    }
  }
}

// MARK: Module 3: Main
let tts = TimeToStretch()
tts.start()
```



Closures vs. Objects w/ Protocol

- Closures are great for "one-off" callbacks
  - Example: Sort an array
  - **`array.sort(by: { $0.dst < $1.dst })`**
  - decouples **`sort()`** from the comparison
- Object w/ Protocols better for multiple, related closures
  - eg: **`Comparable, TableViewDataSource`**
  - common terminology for concept, can store data
  - provides type and organization for idiom

Decoupling and Design

- A good design has dependences (coupling) only where it makes sense
- During design, examine dependences
  - **Before you code**
  - Don't introduce unnecessary coupling
- Coupling is an easy temptation if you code first
  - You realize a method needs information from another object and hack in a way to get that information:
    - It might be easy to write
    - It will damage the code's modularity and reusability

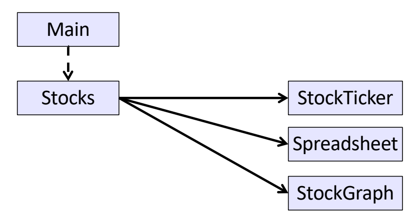
Design Exercise #2

- A program to display information about stocks
  - Stock tickers
  - Spreadsheets
  - Graphs
- Naive Design
  - Make a class to represent stock information
  - That class updates all views of that information when it changes
    - graphs, tickers, portfolio networth, etc.

The Old Way...

```
class Stocks {

  ...

  func updateViewers() {
    ticker.update(priceInfo)
    spreadsheet.update(priceInfo)
    graph.update(priceInfo)
  }

}

// Main

let stocks = new Stocks()
...
stocks.updateViewers()
```

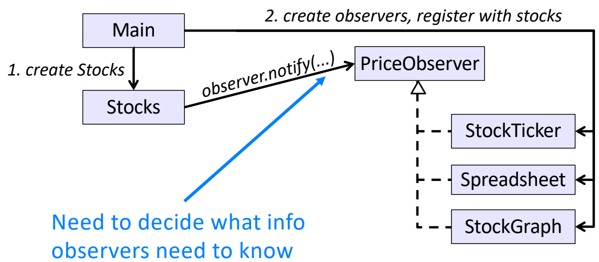
MDD



- Problem
  - To add/change a viewer, must change `Stocks`
- Better Design
  - insulate `Stocks` from the vagaries of the viewers

The Observer Pattern

- **`Stocks`** keeps list of **`PriceObservers`**, notifies them of changes
- **`Main:`** creates viewers and passes them to **`Stocks`** as *observers*



Weaken the Coupling

```
protocol PriceObserver {
  func update(priceInfo: PriceInfo)
}

class Stocks {
  private var observers = [PriceObserver]()

  public func add(observer : PriceObserver) {
    observers.append(observer)
  }

  private func notify(priceInfo : PriceInfo) {
    for observer in observers {
      observer.update(priceInfo: priceInfo)
    }
  }
}
```

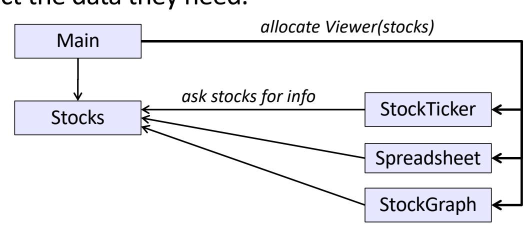
Weaken the Coupling

```
protocol PriceObserver {
  func update(priceInfo: PriceInfo)
}

class Stocks {
  private var observers =

  public func add(observe
    observers.append(observer)
  }

  private func notify(priceInfo : PriceInfo) {
    for observer in observers {
      observer.update(priceInfo: priceInfo)
    }
  }
}
```

```
let stocks = Stocks()
stocks.add(observer: Ticker())
stocks.add(observer: Graph())
stocks.add(observer: Spreadsheet())
...
stocks.notify(priceInfo: ...)
```

Push vs. Pull

- Observer Pattern implements push functionality.
- Pull model: give viewers access to Stocks, let them extract the data they need.



- "Push" versus "Pull" efficiency can depend on frequency of operations
  - Also possible to use both patterns simultaneously.

Pull Code

```
class Stocks {
  ...
  func info() : ... { ... }
}

class Chart {
  let stock : Stocks
  ...
}

// Main:

let stocks = Stocks()
let chart = Chart(stocks)
let ticker = Ticker(stocks)
let sheet = Spreadsheet(stocks)
```

Reusable Classes

```
protocol Observer {
  func update(info : Observable)
}

class Observable {
  var observers = [Observer]()

  func add(observer : Observer) {
    observers.append(observer)
  }

  func notify() {
    for observer in observers {
      observer.update(info: self)
    }
  }
}
```

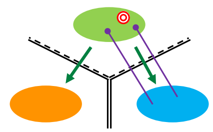
Reusable Classes

```
class SignupSheet : Observable {
  var students = [String]()
  func add(student : String) {
    students.append(student)
    notify()
  }
}

class SignupWatcher : Observer {
  func update(info: Observable) {
    if let sheet = info as? SignupSheet {
      print("Count is now \(sheet.students.count)")
    }
  }
}
```

```
let sheet = SignupSheet()
sheet.add(student: "Springer")
sheet.add(observer: SignupWatcher())
sheet.add(student: "Wally")
```

```
class SignupSheet : Observable {
  var students = [String]()
  func add(student : String) {
    students.append(student)
    notify()
  }
}

class SignupWatcher : Observer {
  func update(info: Observable) {
    if let sheet = info as? SignupSheet {
      print("Count is now \(sheet.students.count)")
    }
  }
}
```

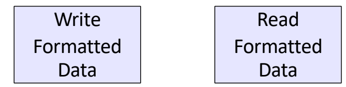
UIs: MVC to Limit Dependencies



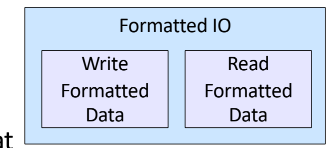
- Avoid tangling data, logic, and appearance
- Easy for dependencies between model/controller/view to creep in
  - It's happened to all of us...
  - Leads to complex, brittle, non-reusable code
- Callbacks, delegates, listeners, observers reduce coupling
  - central in UIKit and other frameworks

Shared Constraints

- Coupling can result from "shared constraints" from specs, not just code dependencies

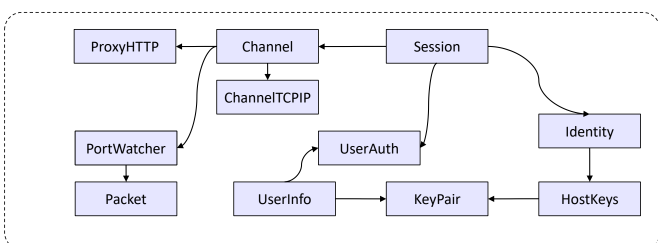


  - If one fails to write the correct format, the other will fail to read
- Shared constraints are easier to reason about if they are well encapsulated
  - A single module should contain and hide all information about the format



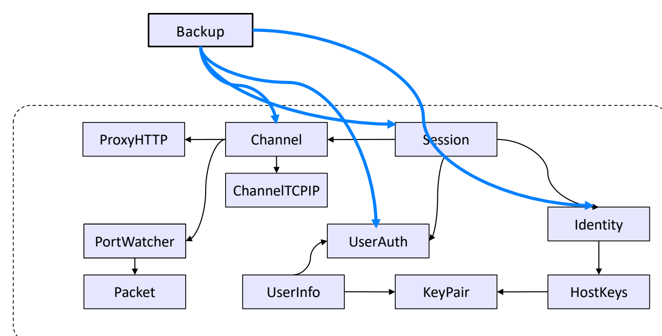
Facade Design Pattern

- Want to support secure file copying to a server
  - you have a powerful general purpose library
  - but a secure file copy exposes its complexity
  - creates many dependencies on library components



Facade Design Pattern

- Want to support secure file copying to a server



Facade Design Pattern

- Build a interface to that library to hide the (mostly irrelevant) complexity