Designing Interactive Systems 2

Lecture 5: macOS

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CHAPTER 11

Classic Mac

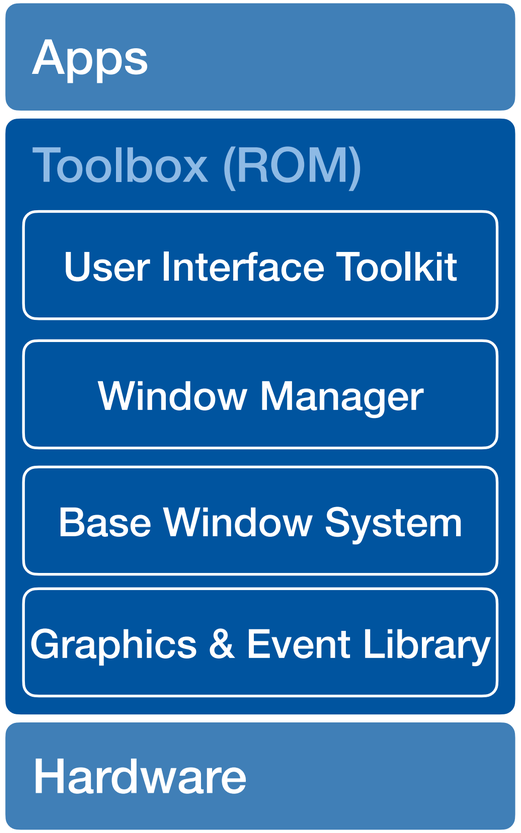
Mac

Macintosh 128k & Macintosh System 1

- Introduced in 1984
- Based on Xerox PARC Smalltalk, Star, Tajo
- Few technical innovations (QuickDraw)
- But landmark in UI design and consistency policies
- First commercially successful machine
- Price of ~2500$

Macintosh 128k & Macintosh System 1

- Saving hardware for an “affordable” product
  - No hard disk
  - 128k RAM
  - 64k ROM containing the Macintosh Toolbox
- Single process, single address space
  - No OS, the app is in charge
  - No multitasking



Macintosh Toolbox

- **Event Manager**
  Event loop core of any app
  Application polls for new events with a GetNextEvent( )

- **Control Manager**
  Create, manipulate, redraw buttons, checkboxes, scroll bars, …
  Respond to user actions

- **Dialog Manager**
  Create and manage dialogs and alerts

Macintosh Toolbox

- **Window Manager**
  Creates, moves, updates windows

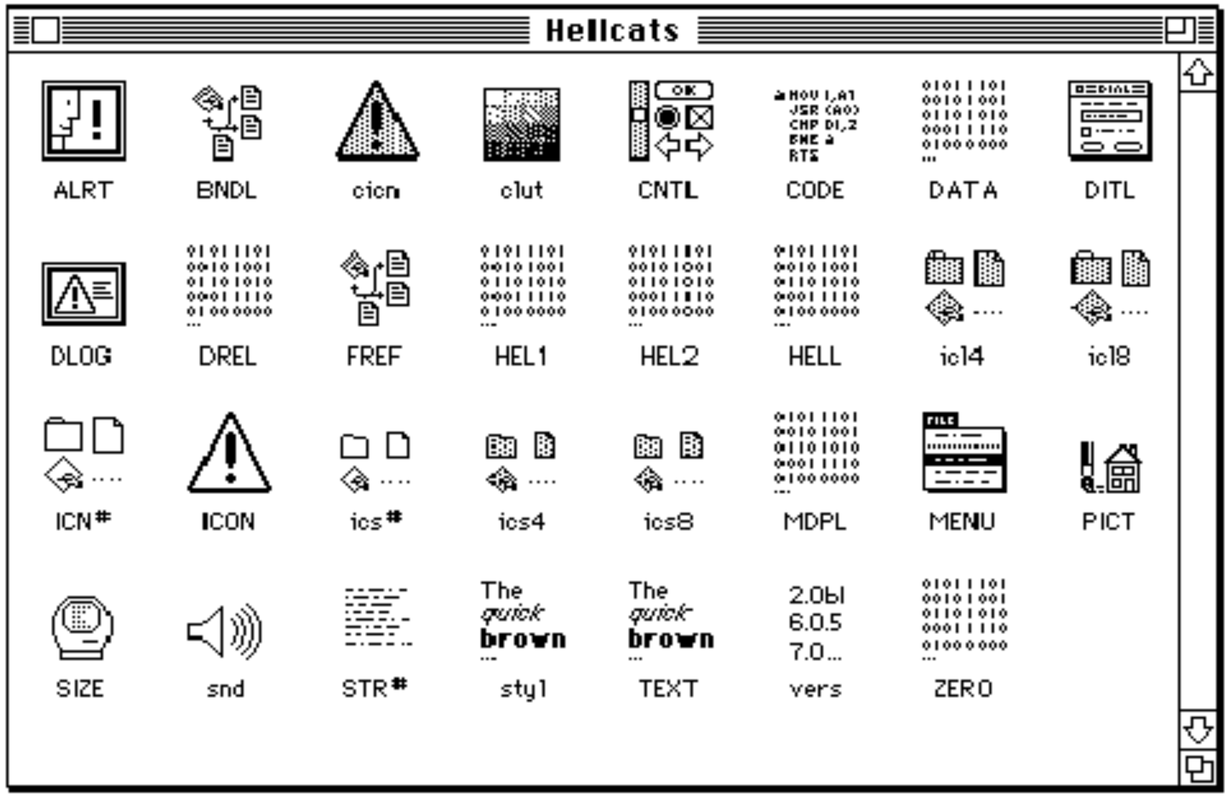
- **Menu Manager**
  Offers menu bar, pull-down and cascading menus

- **Finder interface**
  Defining icons for applications and documents
  Interacting with the Finder

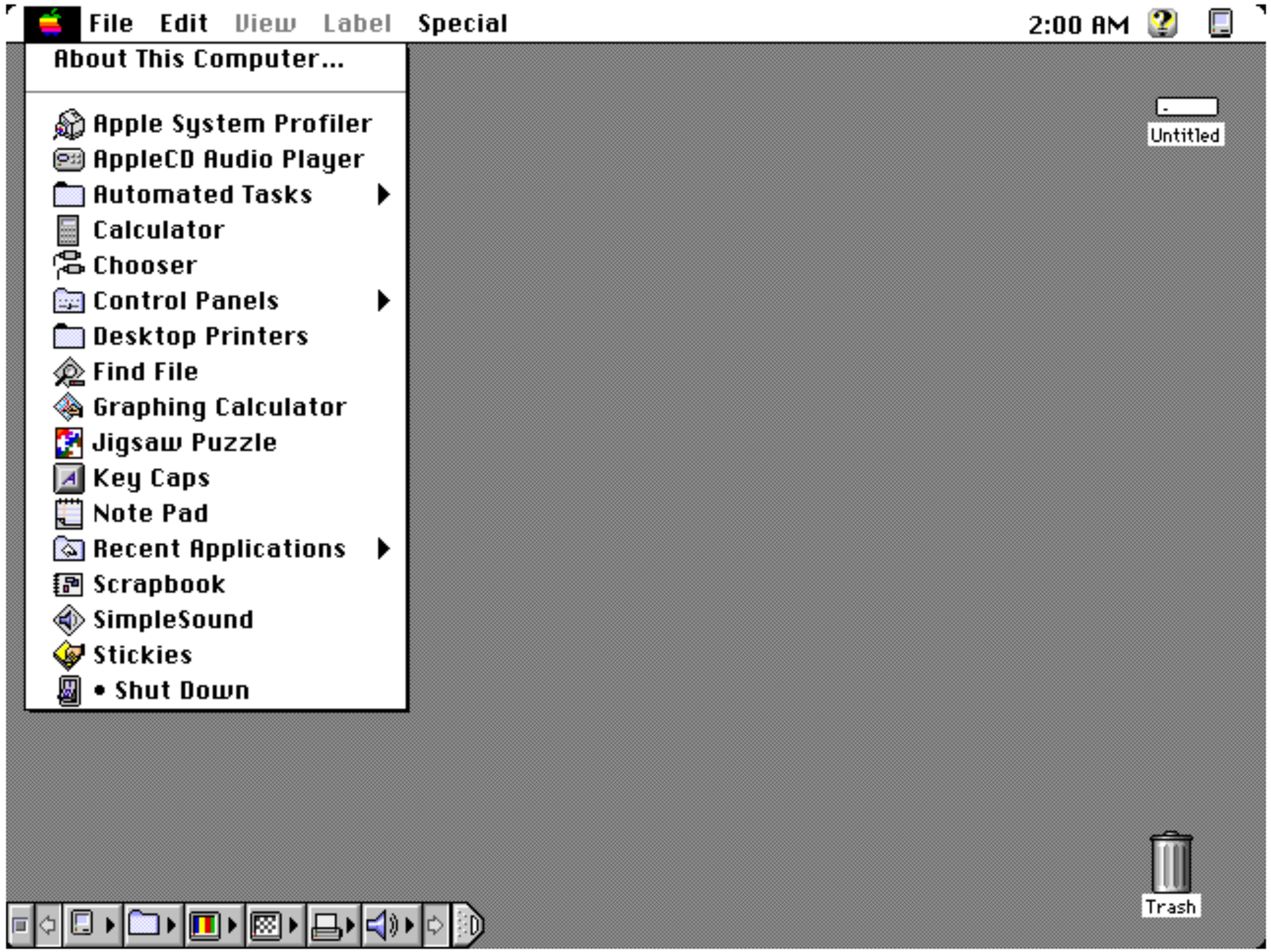
- Many more
  Scrap Manager, Help Manager, Sound Manager, Memory Manager, …

ResEdit

- Graphical Resource Editor (Apple)
- Overview of resources in resource fork of any file (app or doc), sorted by resource type
- Opening a type shows resources of that type sorted by their ID
- Editors for basic resource types built in (ICON,DLOG,...)



Mac System 7

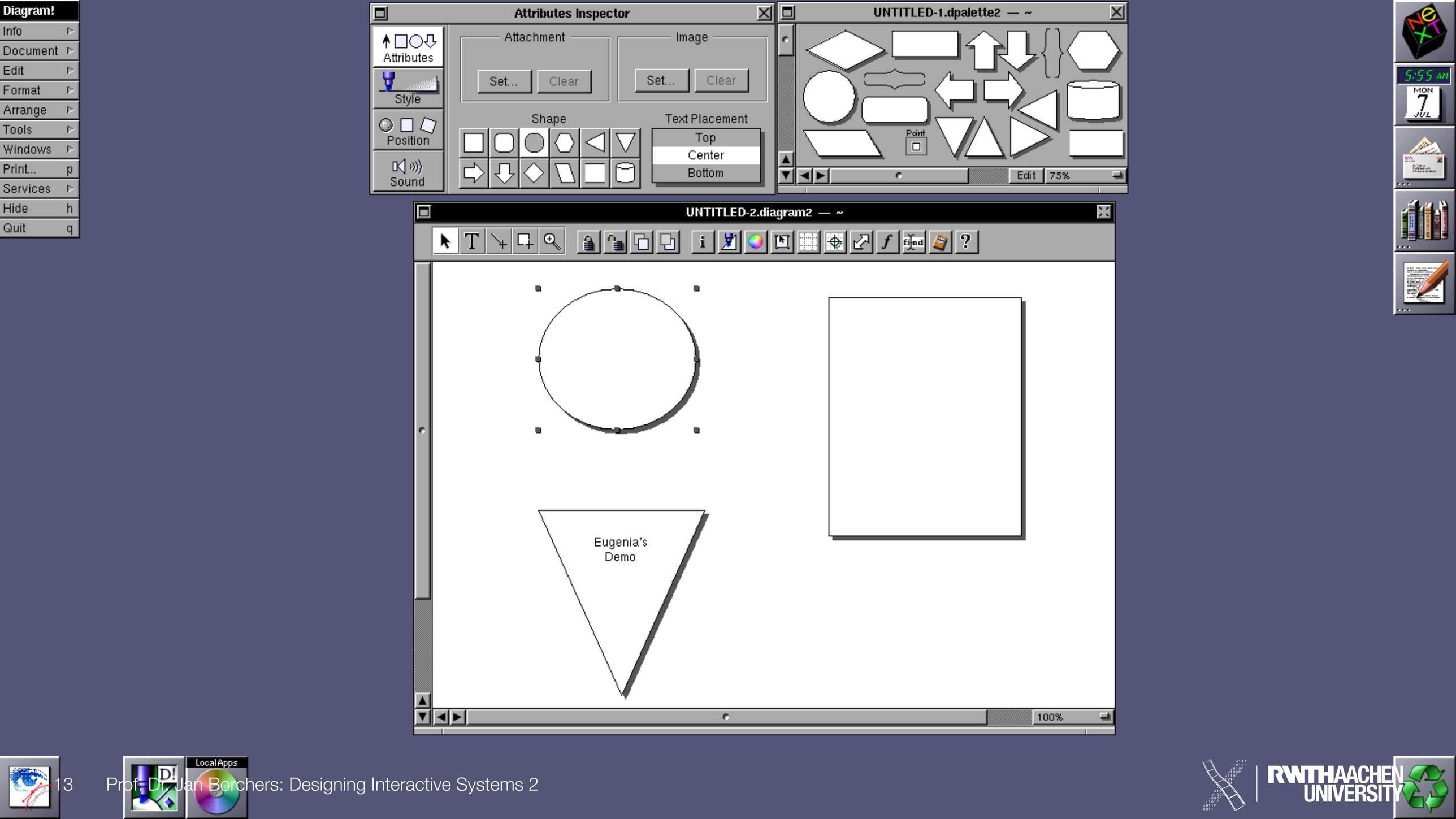


Demo: Mac OS 9

CHAPTER 12

Mac OS X – macOS

Mac OS X Roots: NeXT



Mac OS X

Darwin

- The open-source base operating system of macOS
- Mach kernel
  - Preemptive multitasking
  - Protected memory
- BSD
  - Process model
  - Threading
  - Networking

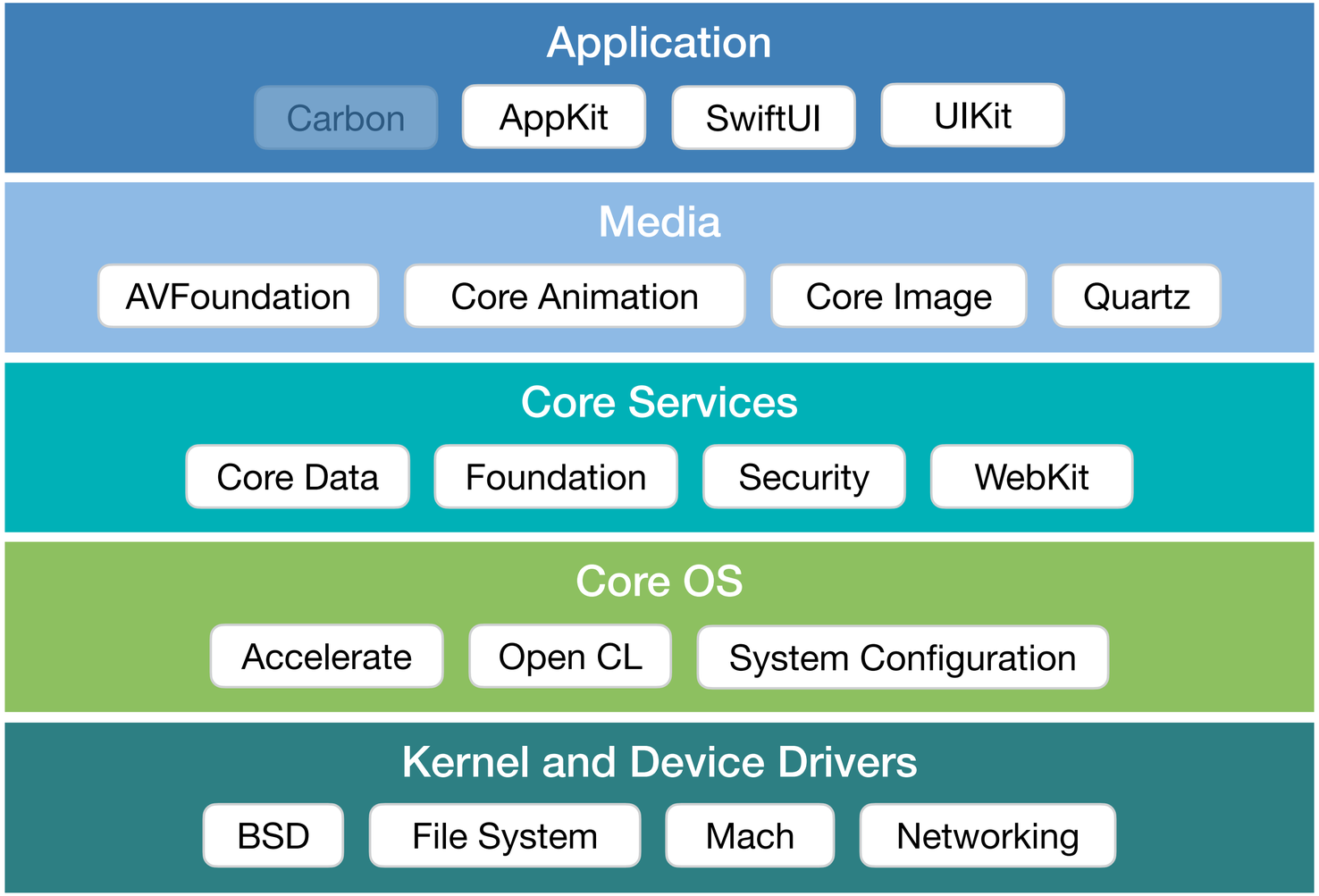
Cocoa

- The OO API for developing macOS Apps, evolved out of NeXTSTEP
- Three main frameworks
  - Foundation
  - AppKit
  - Core Data
- Programming languages
  - Objective-C
  - Swift

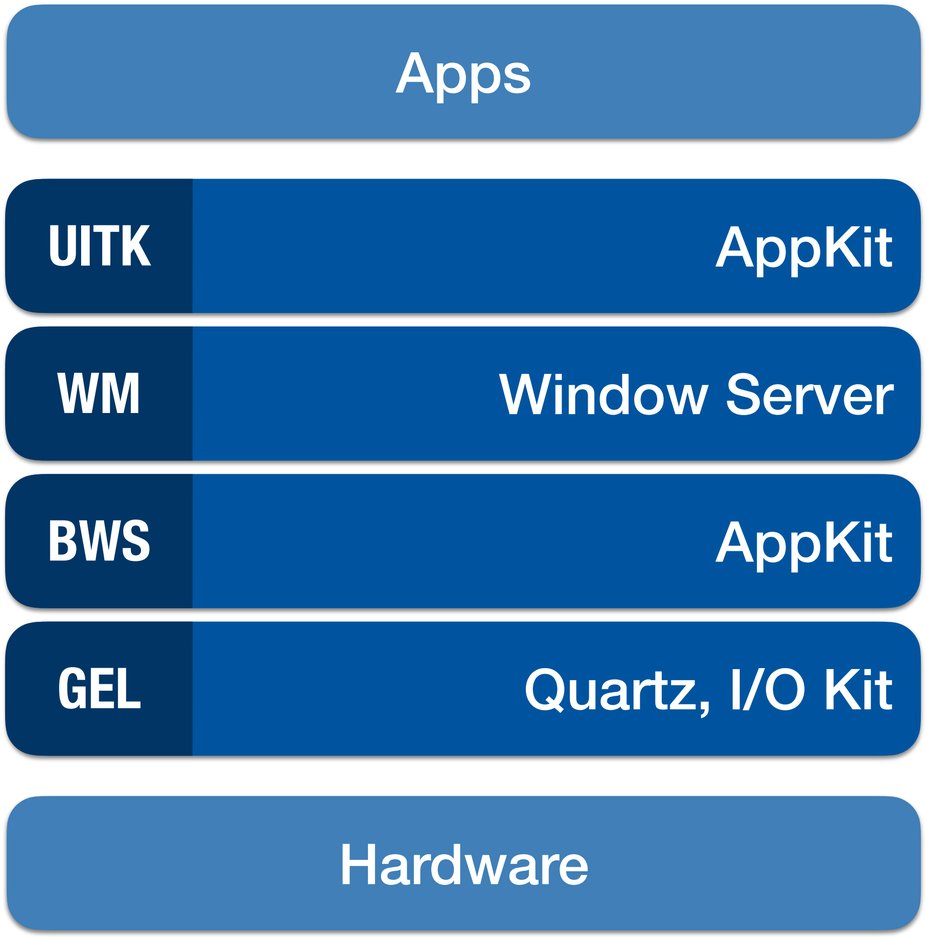
Carbon

- Encapsulates the functionality of the Mac Toolbox in one API
- Runs on top of the native OS X, i.e. not an emulator
- Large parts of Foundation had to be reimplemented in C
- Finally deprecated in 2012

macOS: Architecture

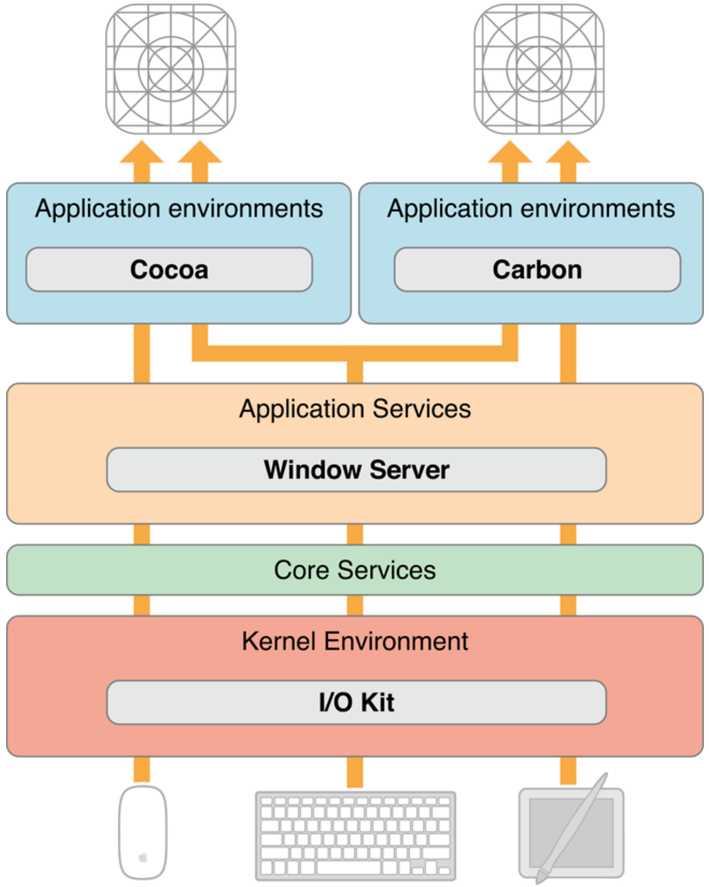


macOS: Four Layer Model



Event Handling

- Similar to our Reference Model
- Window Server distributes events to queues
- Single queues per process



CHAPTER 13

Cocoa & Objective-C

Cocoa

- **Foundation**
  - Basic programming support
  - NSObject, values, strings, collections, OS services, notifications
- **AppKit**
  - Interface, fonts, graphics, color, documents, printing, OS support, international support, InterfaceBuilder support
- **CoreData**
  - Object-graph management and persistence framework

Objective-C

- Implementation language of the Cocoa framework
- Created in 1983 to combine OO principles with C
- Dynamic typing, binding, and loading
- **Categories** allow to extend classes without subclassing
- **Protocols** as alternative to multiple inheritance

Objective-C: Syntax

```
NSImage *image = [self importImage:@"sheep.png" withScaleFactor:3];
```

- Square brackets make it clear which object receives a message
  - Increases readability
  - Method signature contains names for all parameters
- Prefixes determine the type of a declared method
  - **–** for instance methods
  - **+** for class methods

Objective-C: Dynamic Typing

- Objective-C checks whether a method exists at runtime
- You can call known methods of a subclass without casting
- **id** is the type that matches any Objective-C object
- Example:

```
id unknownThing = @5;
if ([unknownThing isKindOfClass:[NSNumber class]]) {
    NSLog(@"%ld", [unknownThing integerValue]);
}
```

This check is optional

Objective-C: Dynamic Binding

- A `Method` is a tuple of a selector (`SEL`) that defines the method signature, the type of the parameters, and an implementation pointer (`IMP`)
- Each object has a method list and executes a method when it receives a known selector message from another object
- Hence, the invoked method is resolved at runtime
- You can even change methods and method lists at runtime

Objective-C: Dynamic Loading

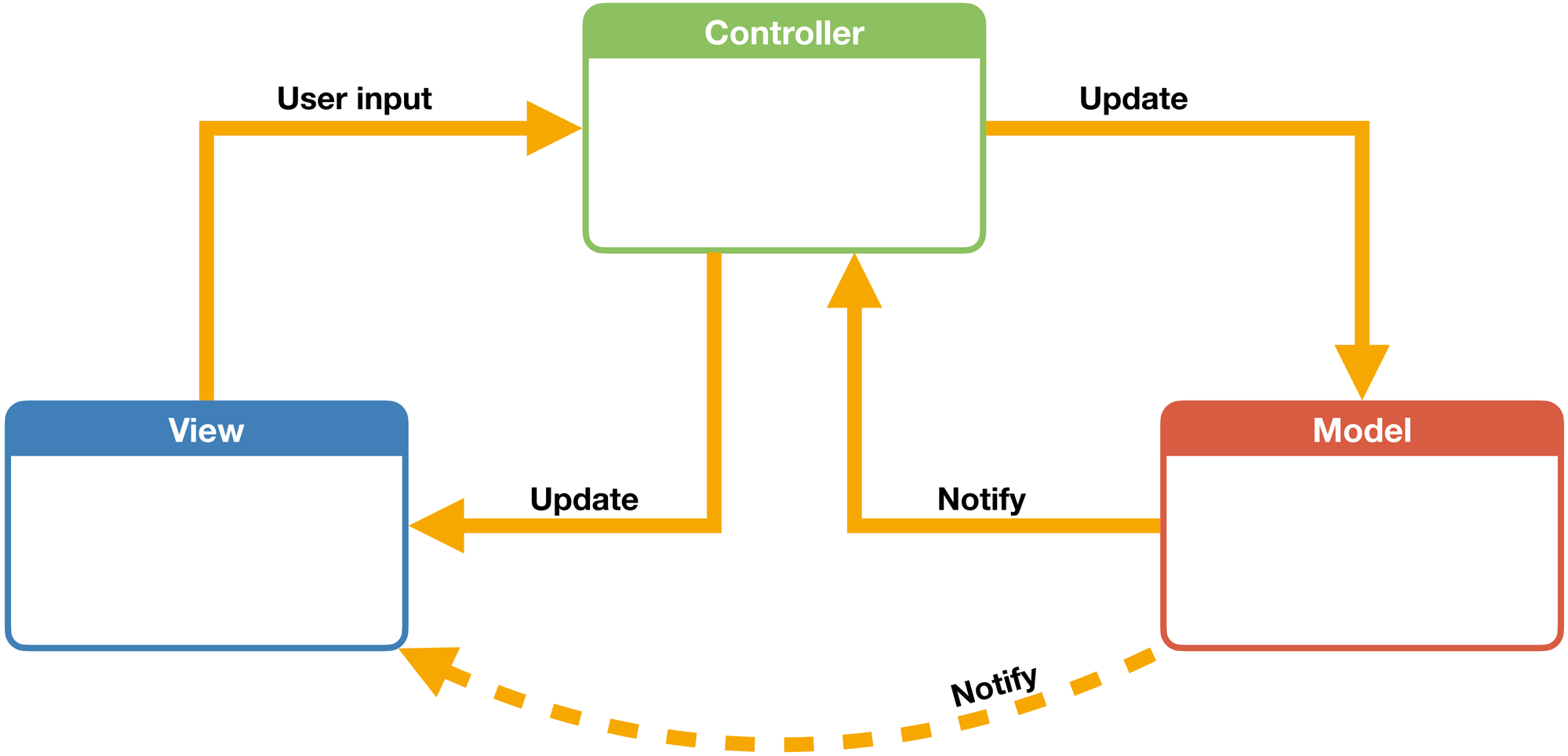
- An `NSBundle` is a representation of code and resources on disk
- These bundles can arbitrarily be loaded and removed from memory during program execution
- After loading a bundle, its contents can be accessed as if they were present right from the start

Demo

Cocoa Class Hierarchy

- **NSObject**
  - NSEvent
  - NSResponder
    - NSWindow
    - NSView
      - NSControl
        - NSButton etc.
    - NSApplication
  - NSCell (lightweight controls)
  - NSMenu
  - NSMenuItem
  - etc.

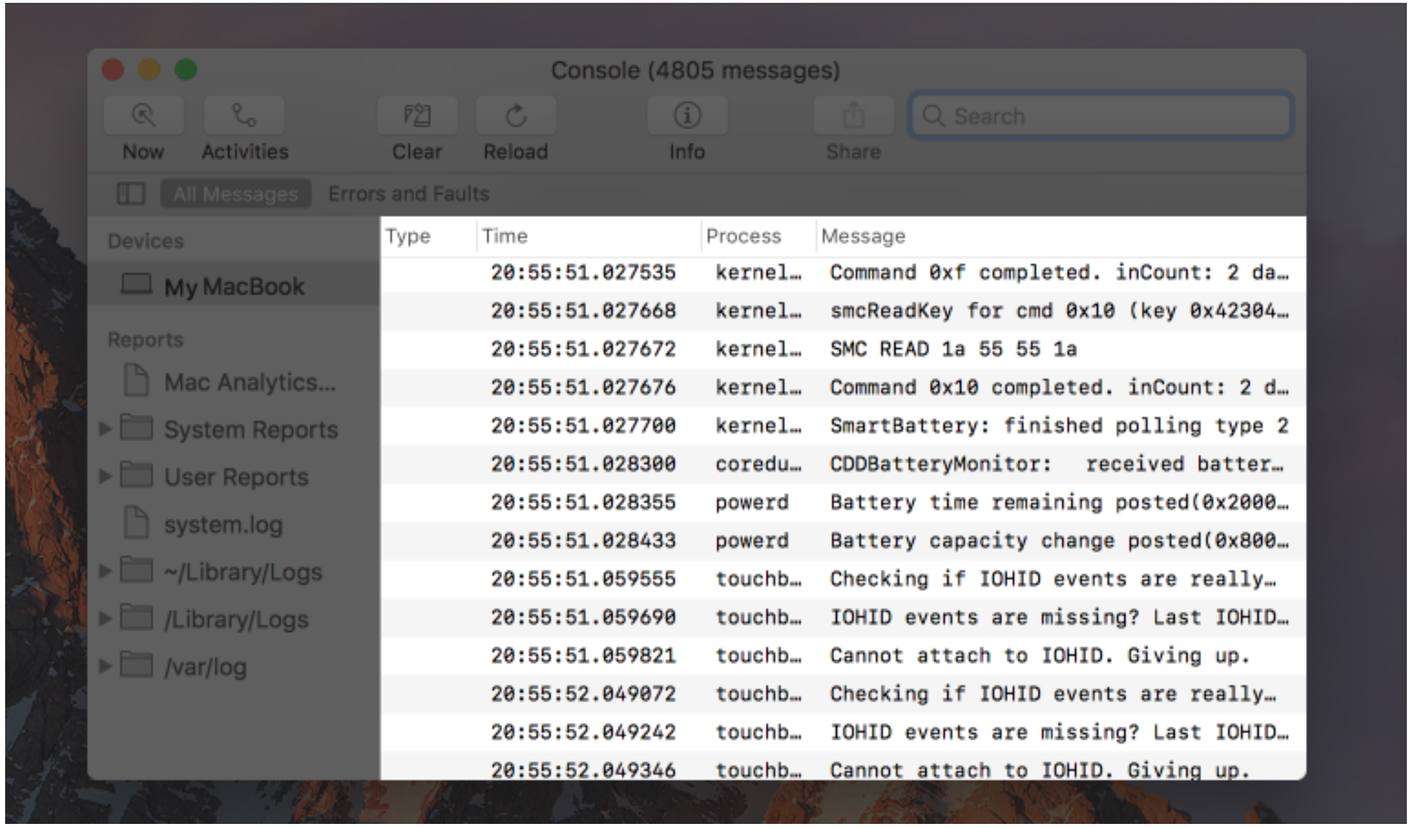
MVC Paradigm



Delegation

- A delegate is a class whose methods are called from another class that wants to plan for extending its functionality

Example: NSTableView



Example: NSTableView

- **NSTableViewDataSource**
  - numberOfRowsInTableView:
  - tableView:objectValueForTableColumn:row:

- **NSTableViewDelegate**
  - tableView:viewForTableColumn:row:
  - tableView:heightOfRow:
  - tableView:shouldEditTableColumn:row:
  - tableViewColumnDidResize:
  - selectionShouldChangeInTableView:

Categories

- How could we extend the functionality of **`NSString`**?
  - Could create a subclass, e.g. **`MyNSString`**
    but then we have to change all code to use that new class
  - Could change **`NSString`** itself
    but this requires access to the source code for that class
  - Instead: Create a **category**

```
@interface NSString (NSStringExtensions)
- (NSString *)reversedSentence;
@end
```

Responder Chain

- Most UI objects are subclasses of **`NSResponder`** and can respond to events
- Sending an event up the chain:
```
[NSApp sendAction:NSSelectorFromString(@"hello") to:nil from:self];
```
- The focused widget is called the **first responder**
- The framework takes care of **responder chain** and passes along an event until it can be handled by some object

Demo

CHAPTER 14

Swift

Swift

- Syntax very similar to scripting languages
- Compatibility to Objective-C code
- Designed for type-safety
- Introduces powerful tuples
- You can also implement functions in enums
- Open source

Hello Swift

- Declaration of a constant (with an inferred type)
```
let a = 5
```

- Declaration of a variable (with a specified type)
```
var b: Double = 7
```

- Type safety forces us to have two matching types on both sides of a math operation
```
b = Double(a) * b
```

- You can even use emoji as names for your variables or classes
```
let 🤯 = "That's mind-blowing."
```

Optionals

- By default, variables and constants cannot be `nil`
  - But Cocoa and Objective-C love putting `nil` into properties
  - Hence, a more expressive way for nullable items is needed

- **Optionals** allow to express variable that can also be nil
  - Enum that can either have a value `Some(T)`
    or no value `None`
  - Note: Different definitions of nil between Objective-C and Swift
  - Optionals are identified by the ? in their type

```
var someValue: Int?
```

Optional Binding

```
var error: NSError?
methodCallThatMightRaiseAnError(&error)

if let err = error {
    print(err.localizedDescription)
} else {
    print("No error occurred!")
}
```

Optional Chaining

- Often used in combination with delegates
```
var delegate: MyDelegate?
```

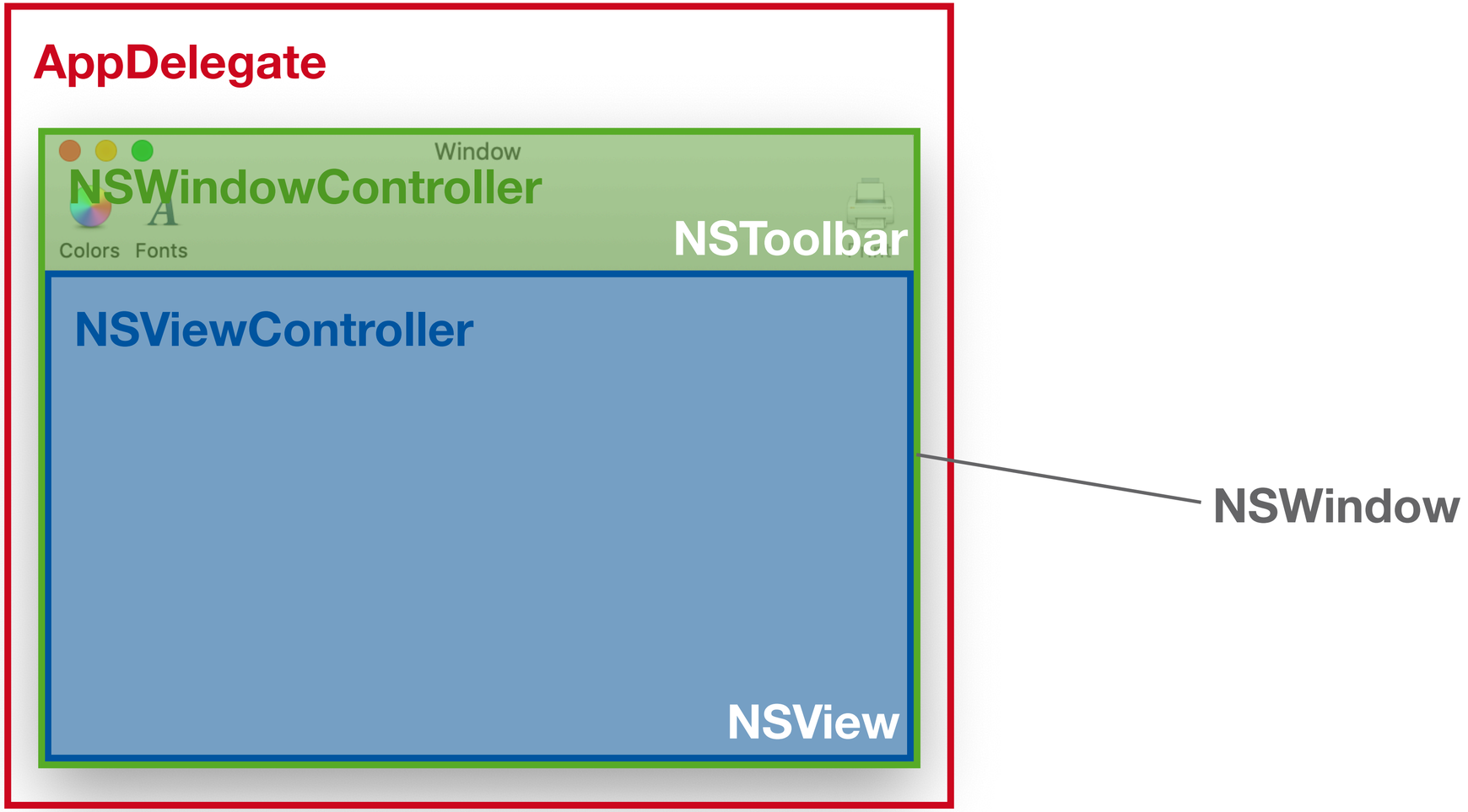
- Optional chaining for elegant way to check for nil
```
self.delegate?.numberOfItems(in: self)
```

- Explicitly unwrapping this variable if it is nil would result in an exception
```
self.delegate!.numberOfItems(in: self)
```

CHAPTER 15

Cocoa App Basics

Views & Controllers



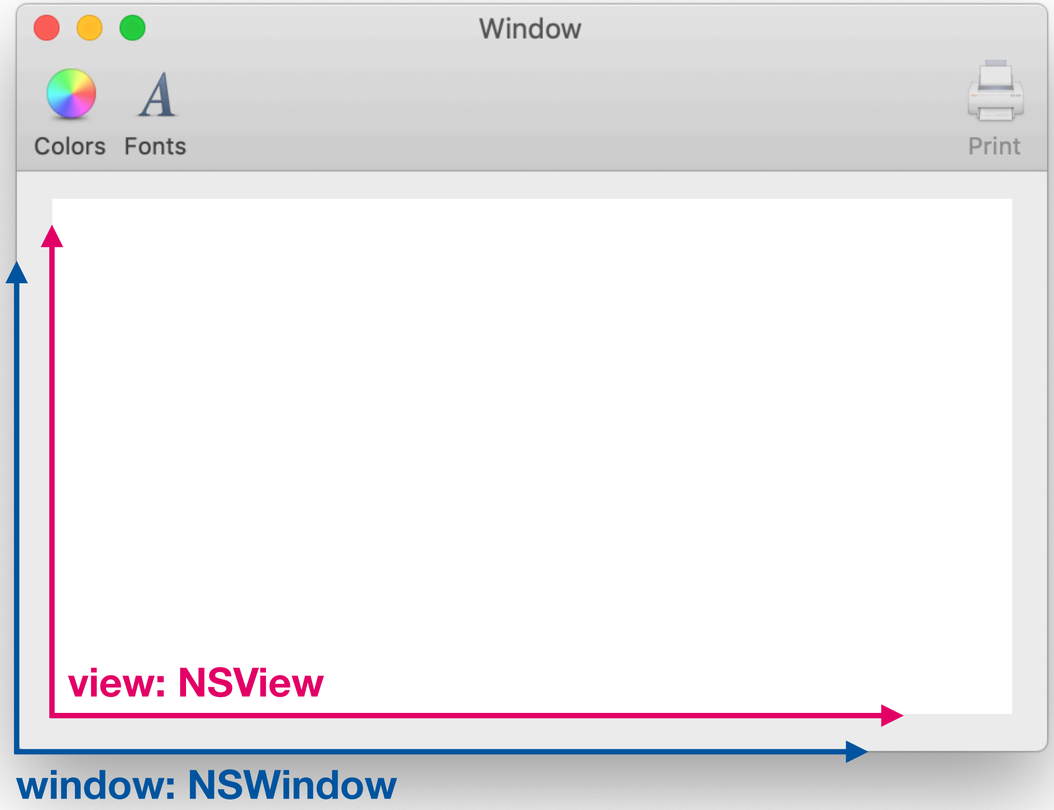
Views & Controllers

- Window: **`NSWindow`** class
- **`NSWindowController`** manages a window
  - E.g., load, show, close a window
  - Useful if app has multiple windows, one NSWindowController for each NSWindow
- **`NSWindow`** has a `contentView` property of type **`NSView`**
- **`NSViewController`** manages an **`NSView`** (property: `view`)
  - Methods, e.g., `viewDidLoad`, `viewWillAppear`, `viewWDidDisappear`, ...
  - Connect to Actions and Outlets

Coordinates

- NSPoint, NSSize, NSRect

- A view has two ways to access its position:
  - `bounds`
    in widget's coordinate system
  - `frame`
    in parent's coordinate system



NSEvent

- Event objects are emitted for both mouse and keyboard events

- Contain the mouse's position in the window's coordinate system

```
override func mouseDown(with event: NSEvent) {
    self.mouseLocation = event.locationInWindow
    let windowPoint = event.locationInWindow
    let localPoint = self.convert(windowPoint, from: nil)
    ...
}
```

Drawing

- NSViews perform their drawing code in `draw(_ dirtyRect: NSRect)`
- Override this method and put all view-specific drawing instructions here
- If the view does not directly inherit from NSView, call `super.drawRect(…)`
- Calling `setNeedsDisplay(_ invalidRect: NSRect )` or `needsDisplay = true` will force a redraw

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Swift

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- Compatibility to Objective-C code
- Designed for type safety
- Introduces powerful tuples
- You can also implement functions in enums
- Open source
- Compact: No need to import standard libs, no main(), no semicolon ;)

Hello Swift

- Declare a constant (with an inferred type)
```
let a = 5
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CHAPTER 15

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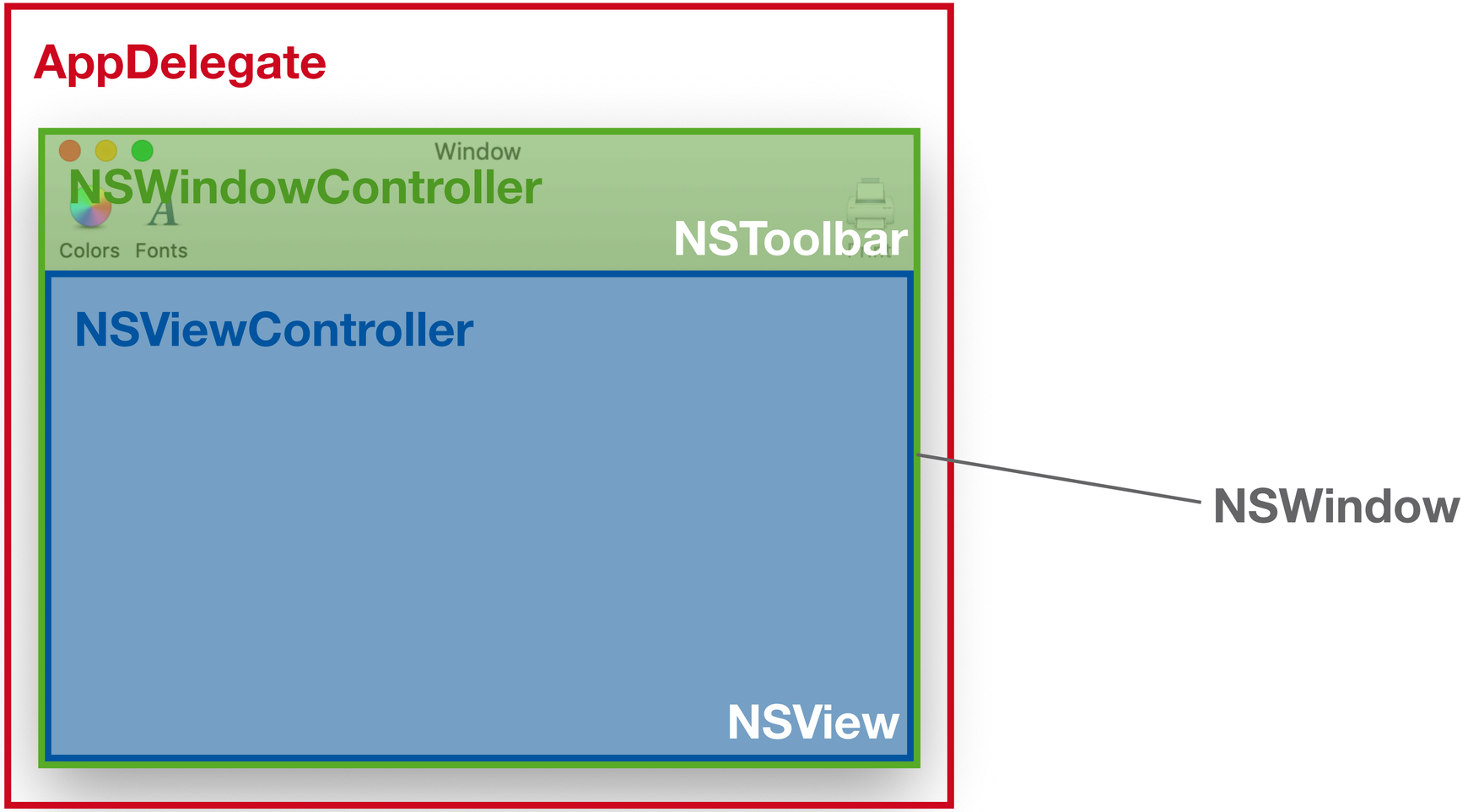

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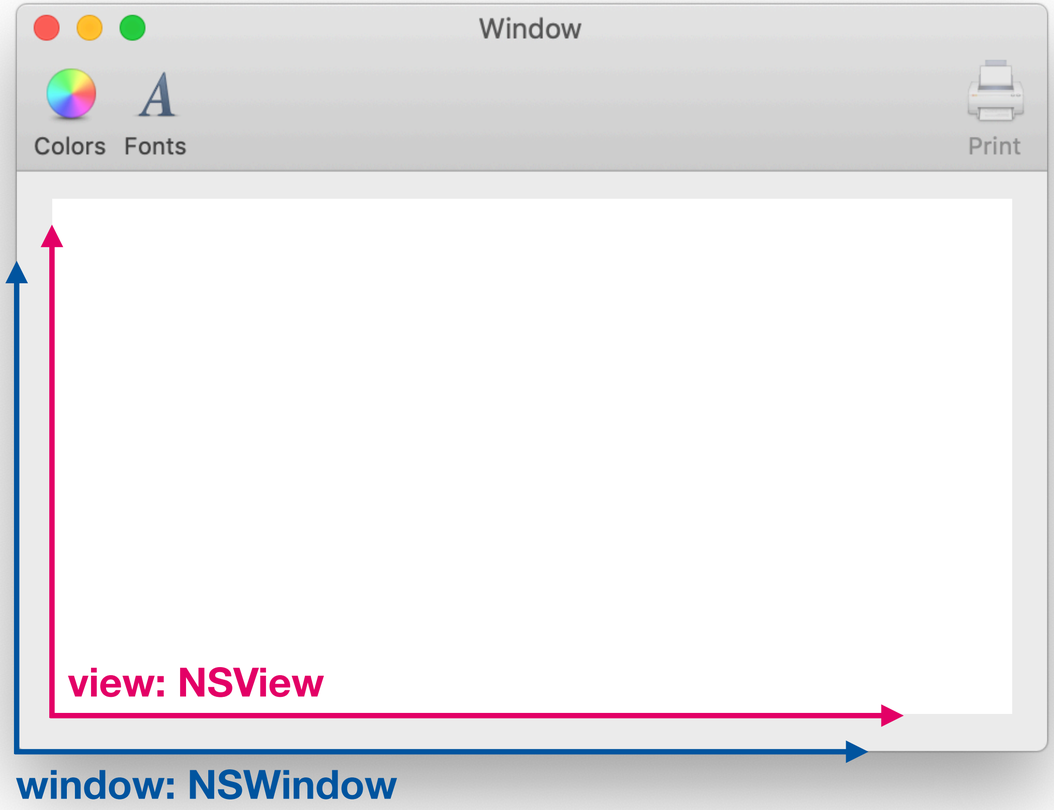

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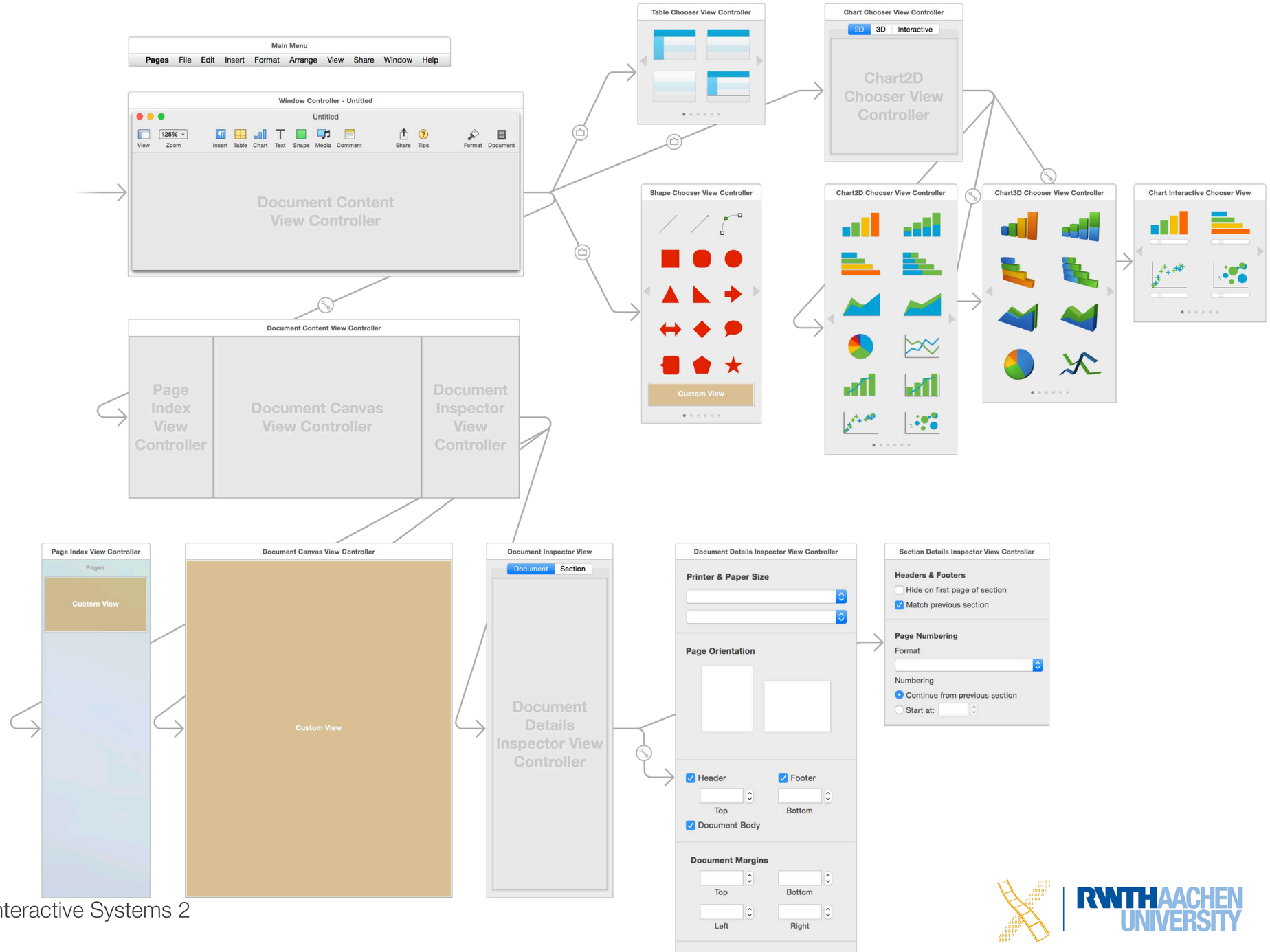
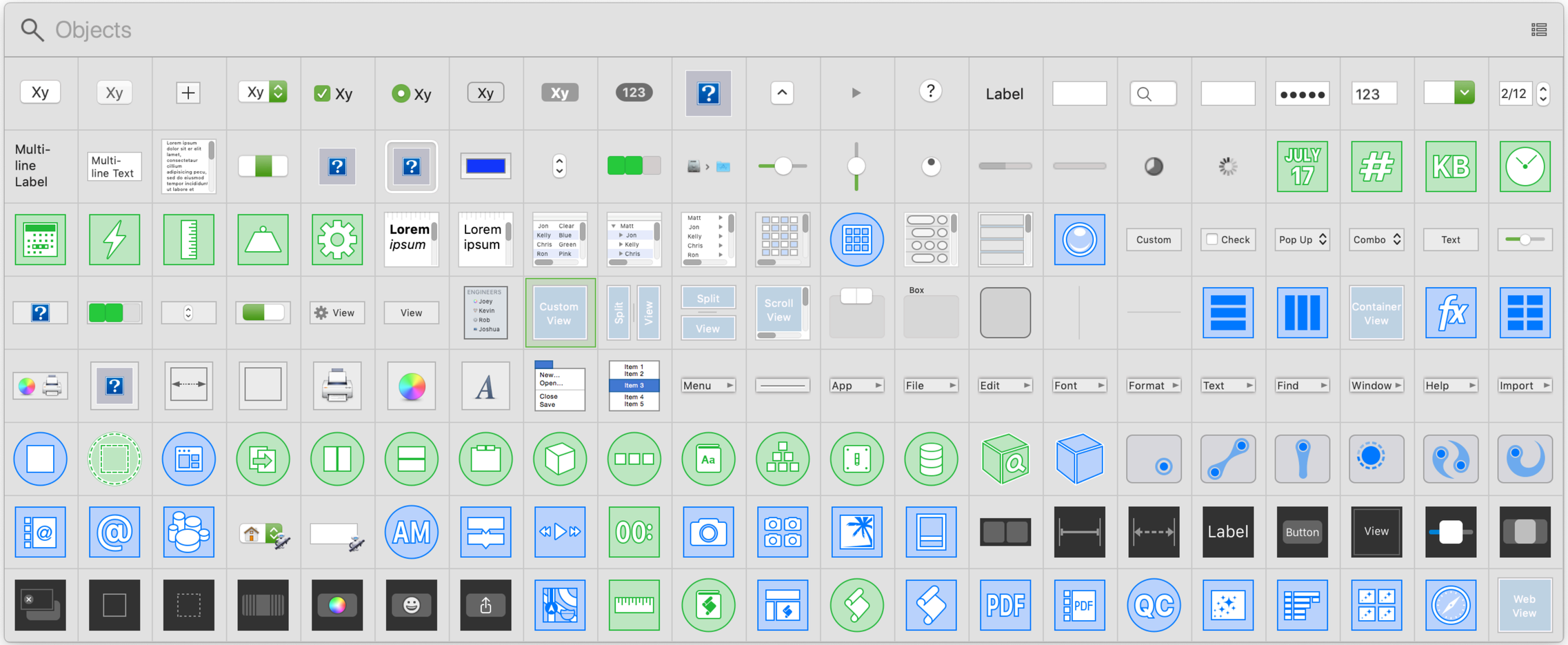
CHAPTER 16

Interface Builder Basics

Storyboard

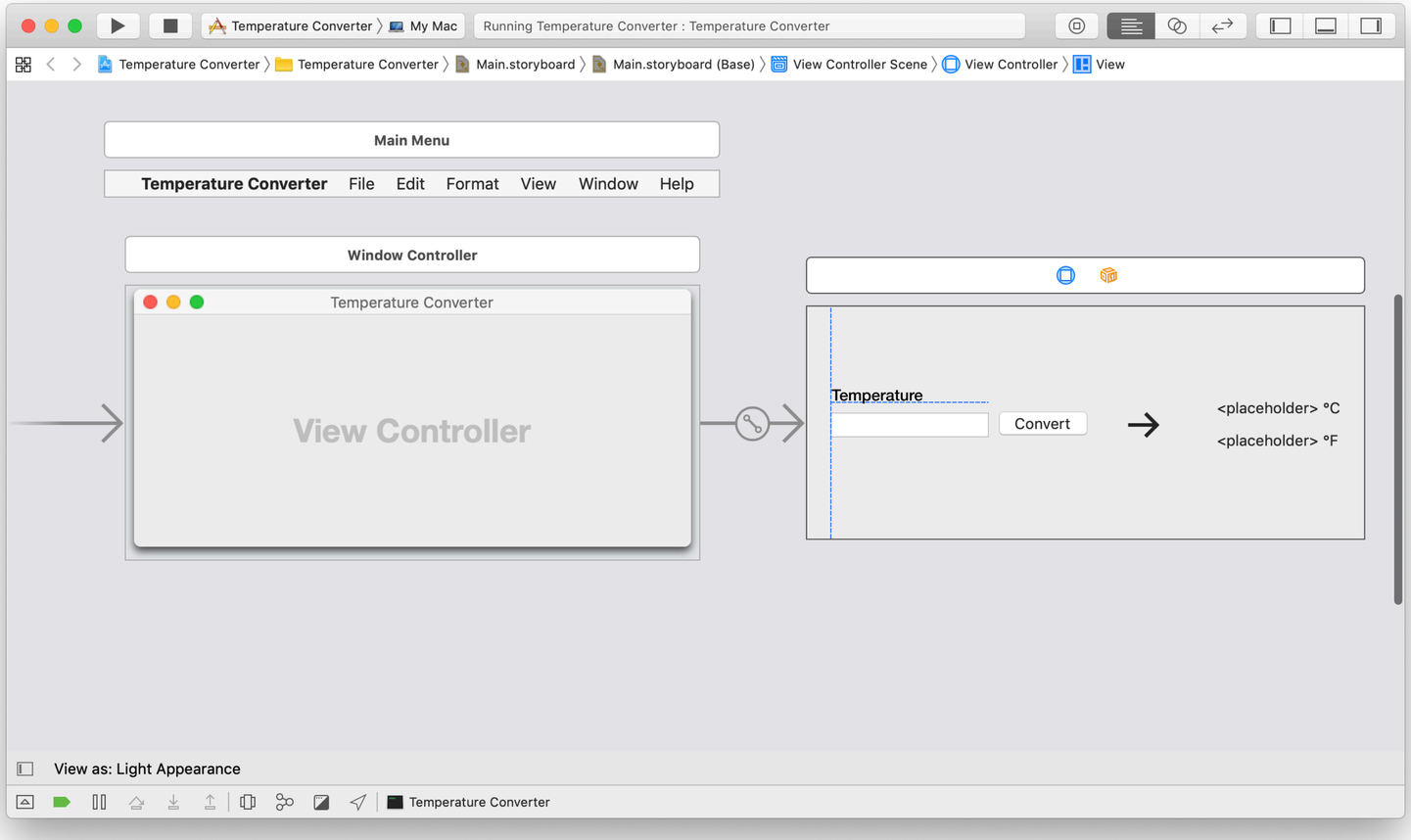


Widget Library



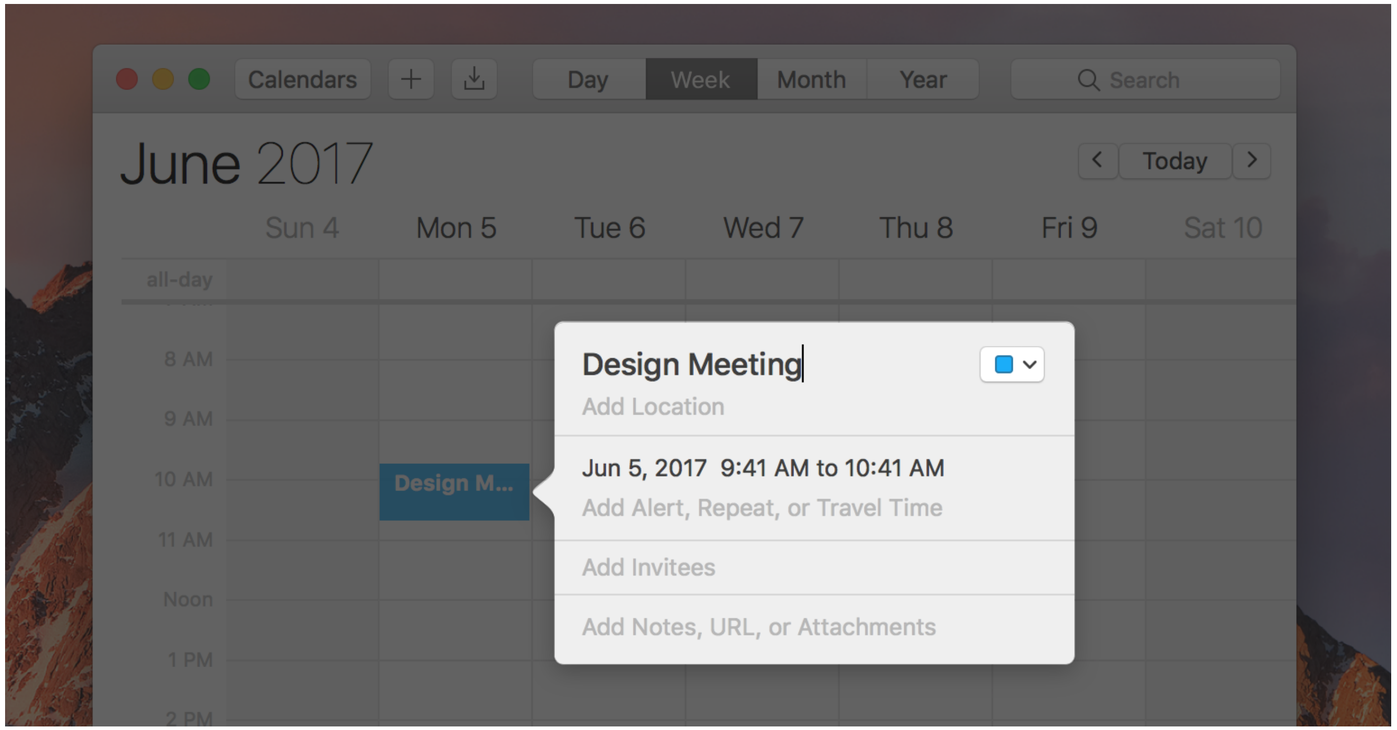
Guides

- Interface Builder helps developer implement a macOS-consistent look by recommending positions for widgets
- Considers margins, centerlines and baselines

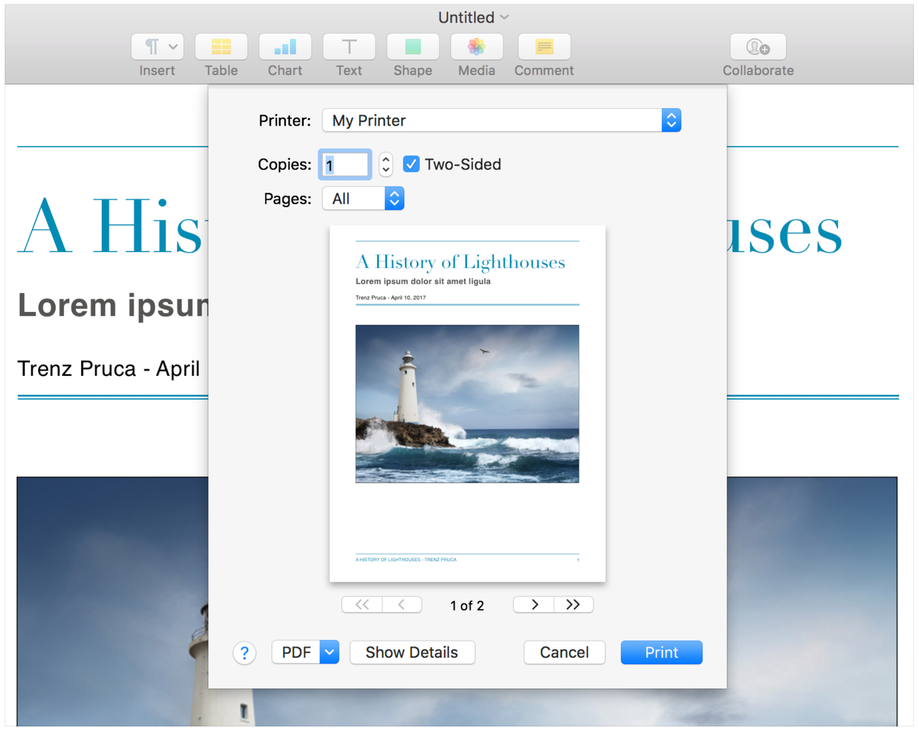


Segues

- A transition from one screen to another in the storyboard
- Typically opened in new window, but other styles possible



Popover



Sheet

Actions & Outlets

- Interface Builder lets you connect your Controller code with the UI you are designing by **dragging connections**

- In your code, properties with the `@IBOutlet` keyword are widgets that are defined in the Interface Builder, not in your source code

- Methods with the `@IBAction` keyword are instance methods that Interfacte Builder can find, and thus can be called from widgets (connect by dragging)

Designables & Inspectables for Custom Widgets

- Widget implementations with the `@IBDesignable` keyword will render a preview in Interface Builder

- Properties with the `@IBInspectable` keyword can be set from the Attribute Inspector UI in Interface Builder

Demo

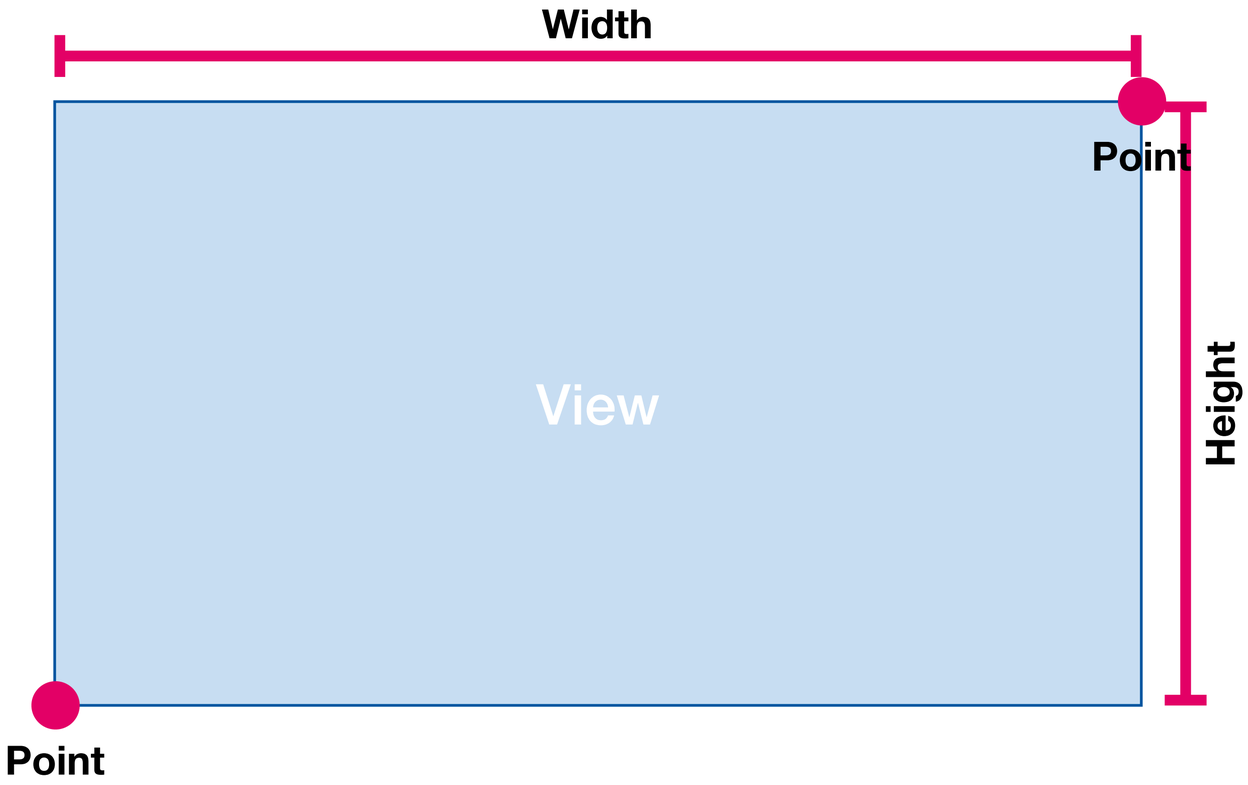
CHAPTER 17

Auto Layout

Auto Layout

- Constraint based UI layout engine
- Tries to fulfill a set of equations when UI appears
- Support for internationalization

Frame-based Layout



Σ 2 pieces of information needed per direction

Layout is Dynamic...

External Changes

Window is resized

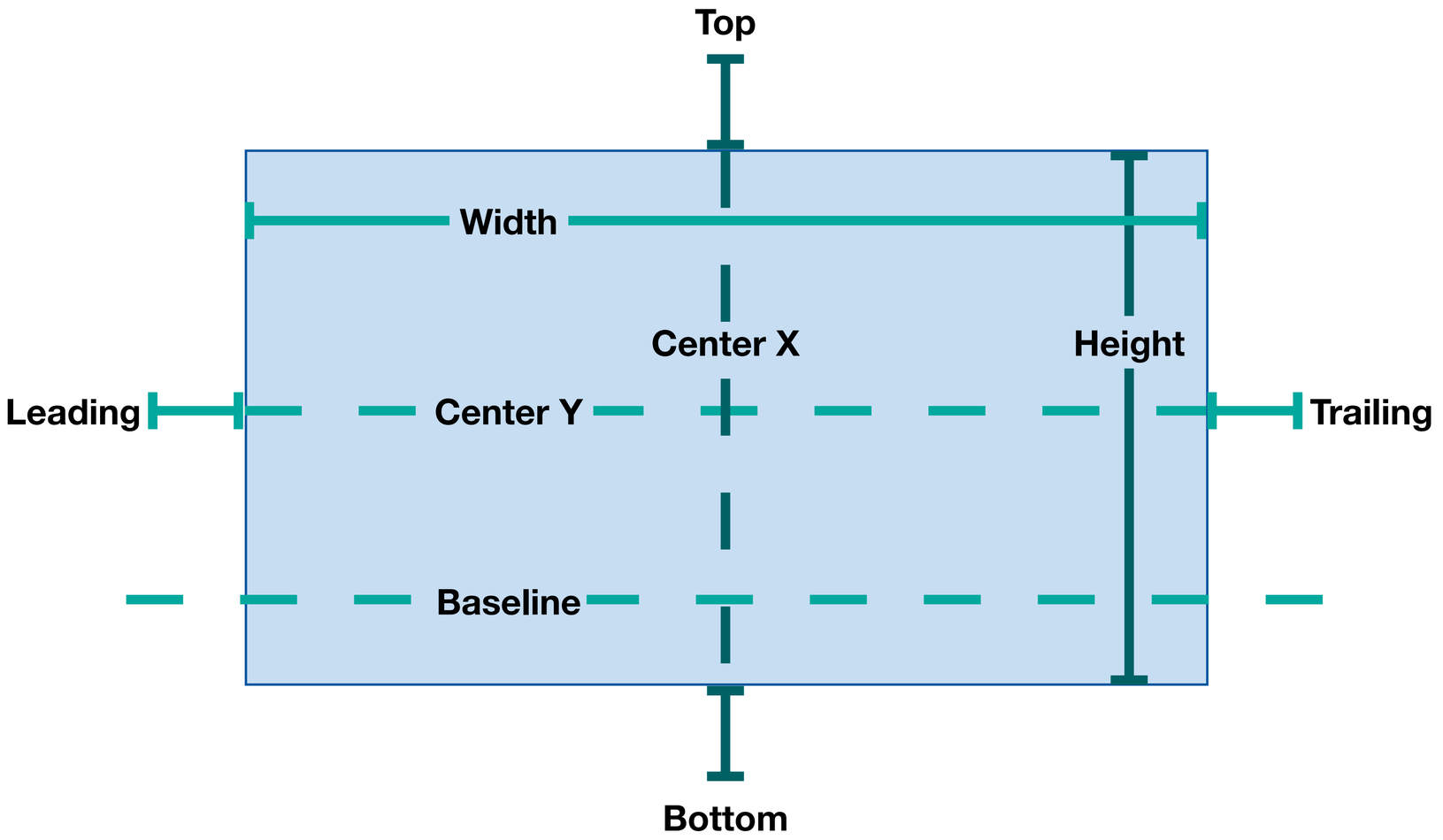
Support different screen sizes

Internal Changes

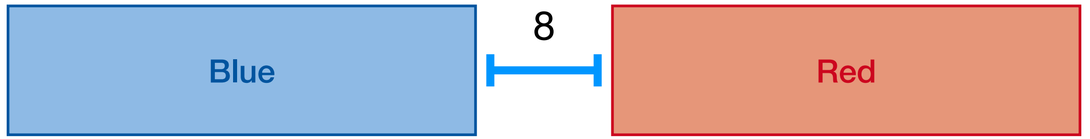
Displayed content changes

Language is changed

More Measures



Constraints



Relationship

Constant

red.leading = 1.0 × blue.trailing + 8.0

Item 1 Attribute 1 Multiplier Item 2 Attribute 2

```
NSLayoutConstraint *constraint =
                [red.leadingAnchor constraintEqualToAnchor:blue.trailingAnchor
                                                  constant:+8];
[constraint setActive:YES];
```

Goal

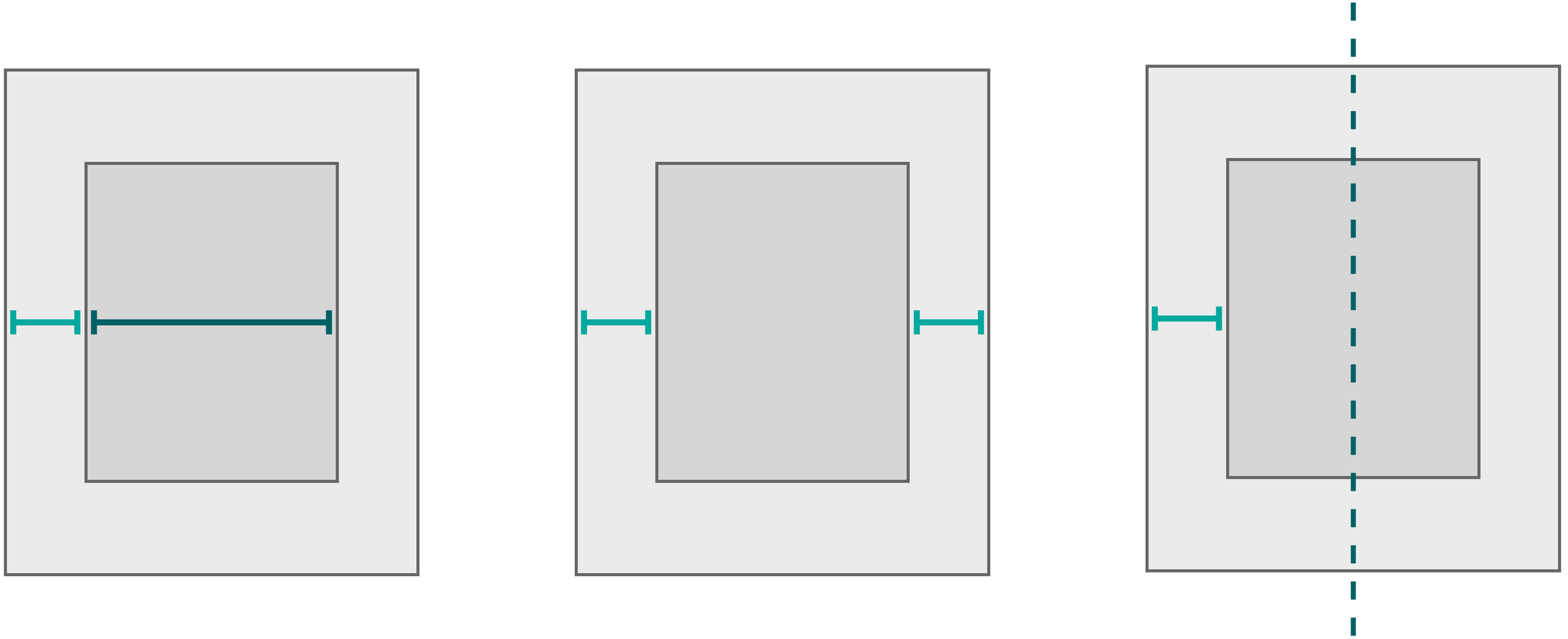
- Provide a series of equations
  that have one and **only one possible solution**

- Ambiguous constraints
  have more than one solution

- Unsatisfiable constraints
  do not have valid solutions.

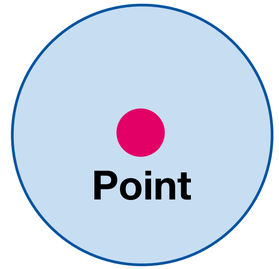
- In general, the constraints must define both
  the size and the position of each view

Three Similar Designs?



Intrinsic Size

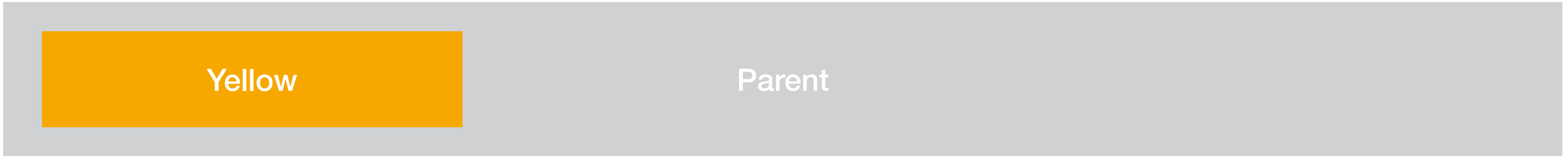
- Some views have a natural size given their current content
- E.g., a button’s intrinsic content size is the size of its title plus a small margin
- Views that have an intrinsic content size can be defined by two constraints alone



Priorities

- When creating a UI that suits multiple screens, we sometimes have more than one requirement on the position of a view

- **Example**
  A view that ideally takes 25% of the screen's width
  but is always at least 40pt wide

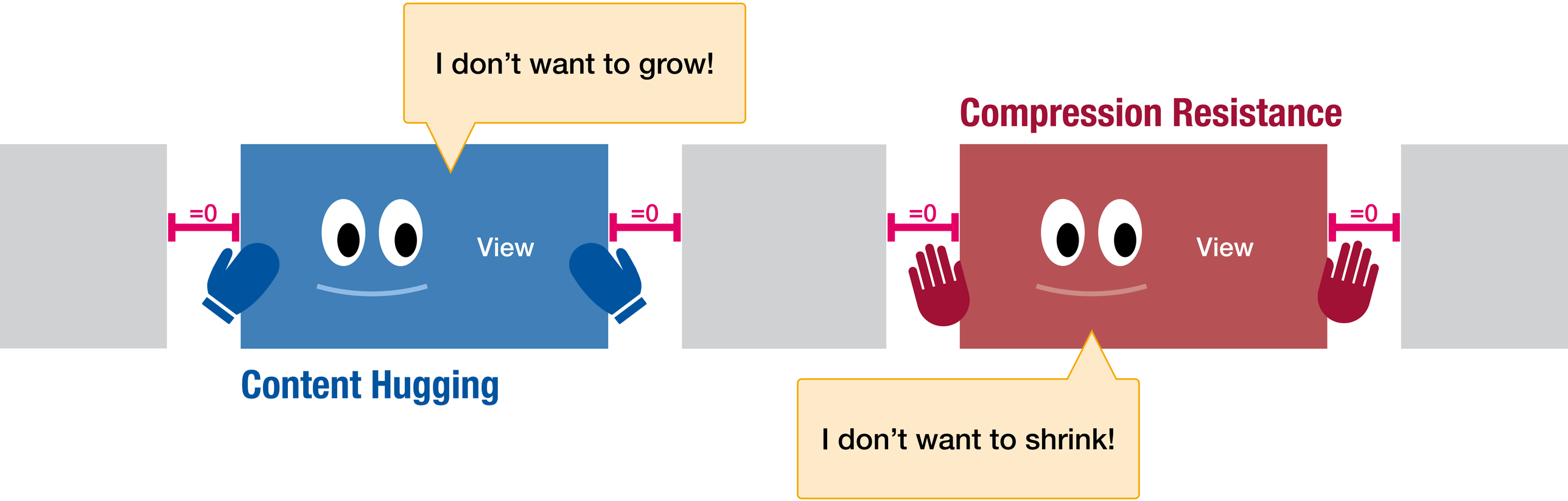


$$\text{yellow.width} = 0.25 \times \text{parent.width} + 0 \quad \text{(Priority 250)}$$

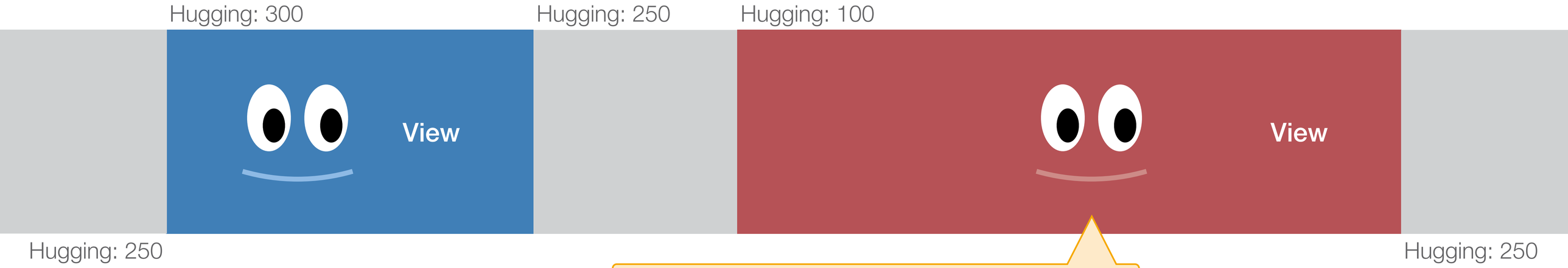
$$\text{yellow.width} \geq 1 \times \text{NotAnAttribute} + 40 \quad \text{(Priority 1000)}$$

Combining Widgets

Hugging Priority & Compression Resistance



Hugging Priority & Compression Resistance



I did not shrink,
and I am fine with being stretched.

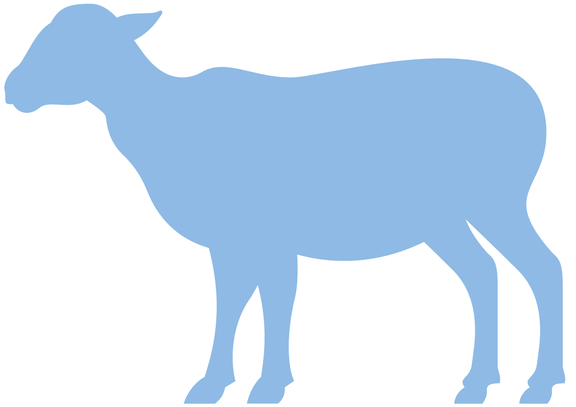
Demo

CHAPTER 18

Cocoa Bindings & Core Data

Cocoa Bindings

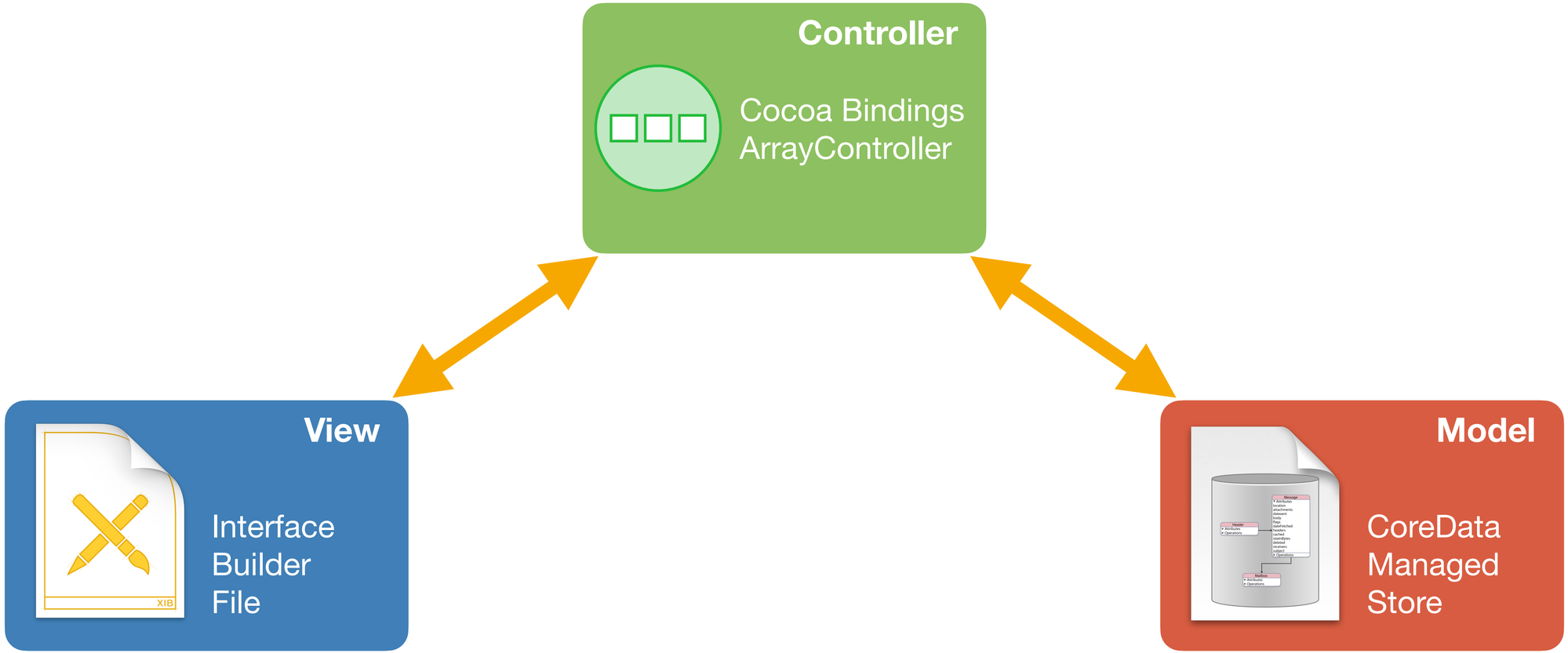
- Keep MVC Model and View synchronized without writing lots of glue code
- ⇒ **Define (simple) MVC controllers graphically**
- Example: Keeping a displayed table of sheep **(View)** synchronized with the corresponding array **(Model)** of sheep data in memory, and also with a label showing the number of selected sheep (another **View**)



Core Data

- Object-graph management and persistence framework
- ⇒ **Define (simple) MVC models graphically**
- Provides common functionality
  - Undo, Redo
  - Persistence (save to disk, read from disk in XML or SQLite format)

MVC with Interface Builder + Cocoa Bindings + CoreData



Demo

SNEAK PREVIEW

SwiftUI

SwiftUI

- **Unified** framework across all Apple platforms
  - Only a subset of the API is available on all platforms
  - Results in generated UI code using the platform-specific toolkit
- **Declarative** instead of imperative code
  - SwiftUI decides what a suitable presentation is on that platform
  - Developer loses some control, limited customization
- A SwiftUI view is a **structs**, therefore **immutable** once created.
  Different programming paradigm: A view is a construction recipe.
  (As structs are lightweight, discarding them for a view update is fine)

SwiftUI: Teaser

```
struct ContentView : View {
    var rooms: [Room] = []

    var body: some View {
        NavigationLinkView {
                List(rooms) { room in
                    NavigationLink(destination: DetailView(room)) {
                        Image(room.thumbnailName)
                            .cornerRadius(8)

                        VStack(alignment: .leading) {
                            Text(room.name)
                            Text("\(room.capacity) people")
                                .font(.subheadline)
                                .foregroundColor(.secondary)
                        }
                    }
                }
                .navigationBarTitle(Text("Rooms"))
        }
    }
}
```