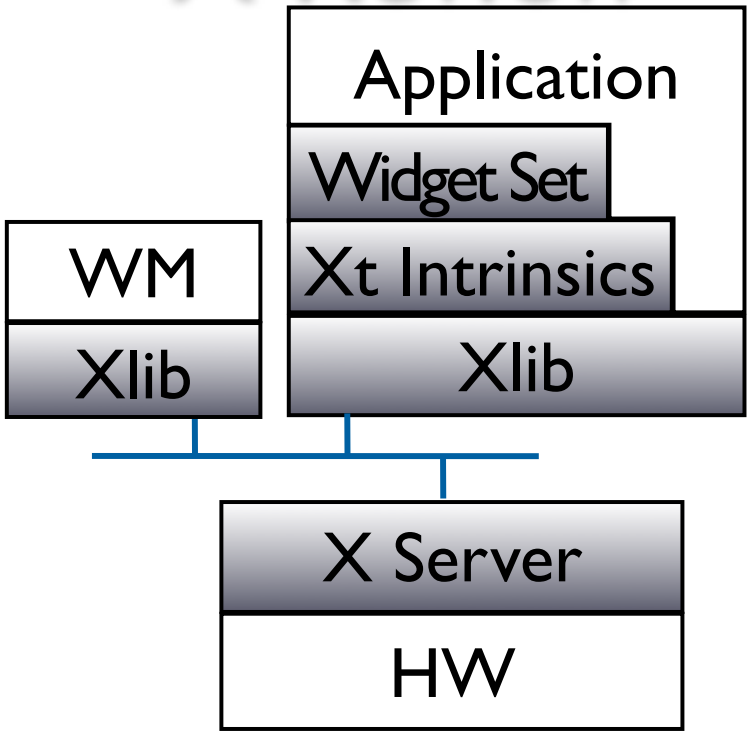
X Review

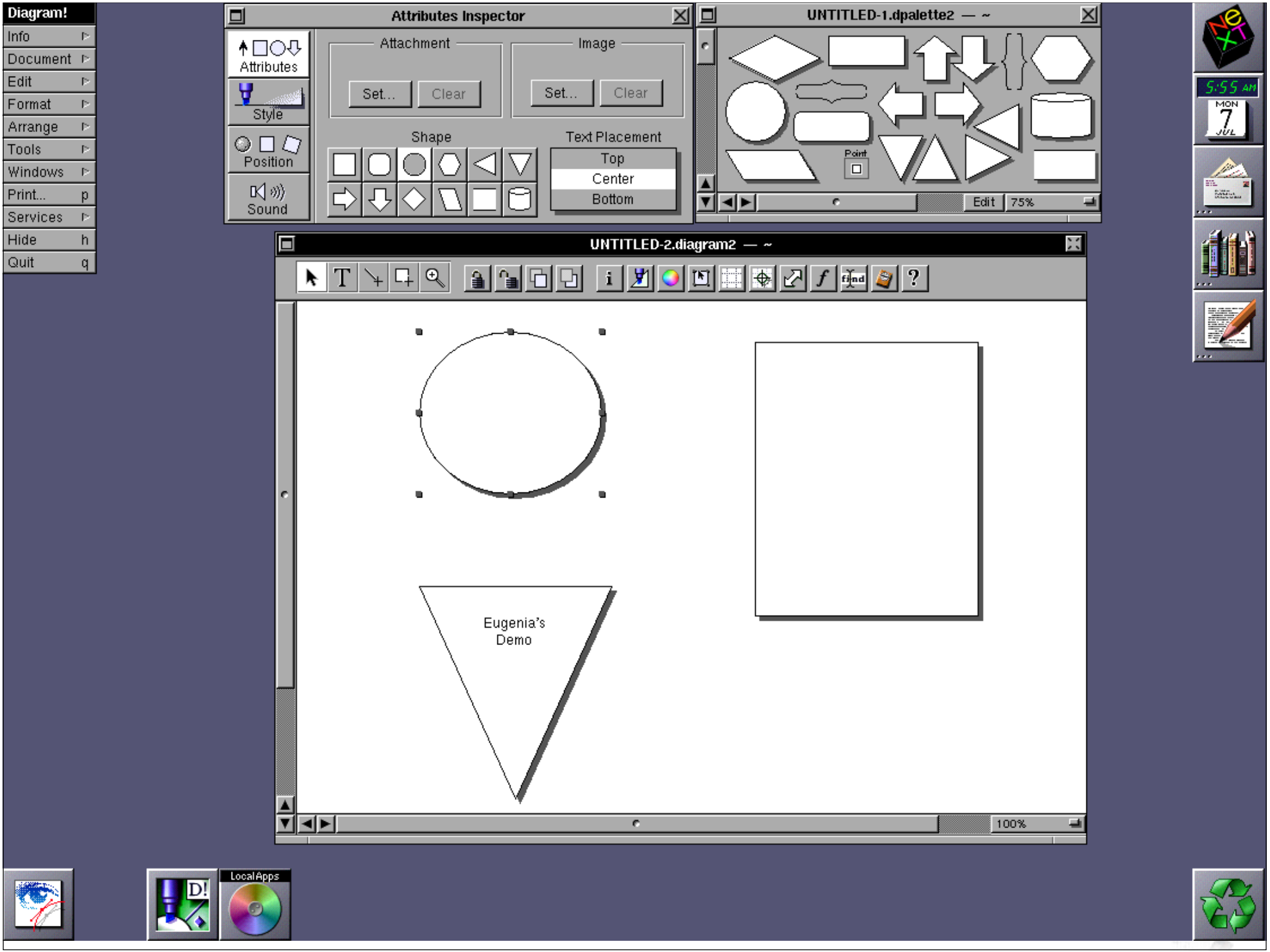


- Distributed window system
  - Server is the user's Terminal
  - Client runs the application
- Highly modular
  - (exchange WM, Widget Set)
- Available for virtually every OS
- Very successful in the UNIX world (with Motif)
- Many Open Source implementations available
- Xt intrinsics already allow OO GUI application programming


Mac OS X Snow Leopard
Mac OS X Snow Leopard
The world's most advanced operating system. Finely tuned.
Version 10.6
Apple

Mac OS X Roots: NeXT

- 1985 Apple kicks out Jobs, who founds NeXT
- 1988 NeXTSTEP 0.8: 68k, Mach kernel, 4.3BSD, Display PostScript, new Objective-C, platform for first web browser at CERN
- 1990 NeXTSTEP 2.0: Interface Builder (OO)
- 1993 Intel, SPARC, HP PA-RISC support (fat binaries), NeXT hardware dead
- NeXT&Sun: OPENSTEP, used by SunOS, HP-UX, MacOS, also on Windows NT, GNUstep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LocalApps

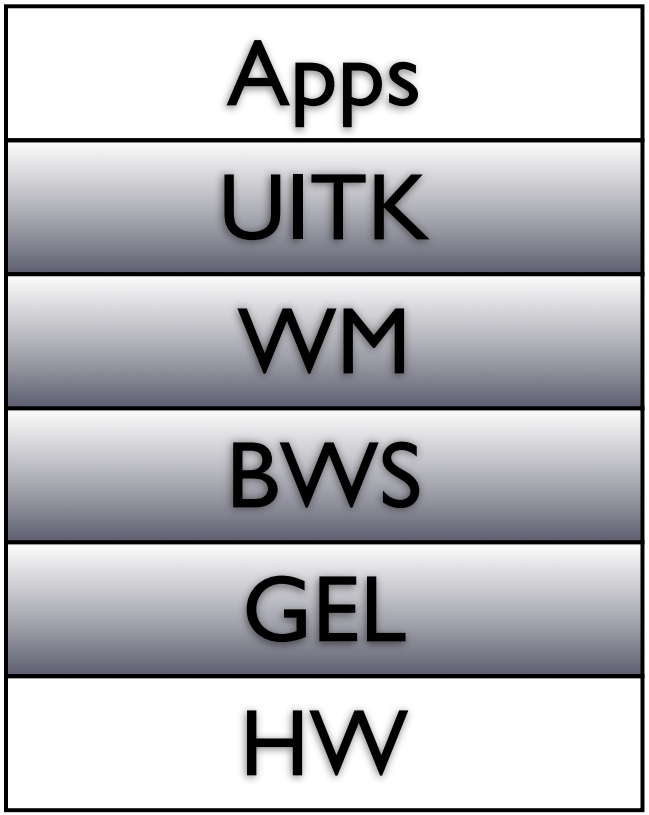
Mac OS X Roots: NeXT

- 1996 Apple purchases NeXT, Jobs back at Apple, begins replacing Mac OS towards NeXTSTEP
- 1999 Apple releases Mac OS X Preview

➡ Mac OS X is directly derived from NeXTSTEP/ OPENSTEP (Mach/BSD, Objective-C, Cocoa, Interface Builder, NetInfo), and combines this with other Apple technologies (UI, Multimedia)

It's spelled "Ten"

Mac OS X: Architecture



Cocoa, Carbon, Java

WindowServer (user-level process)

Quartz 2D / Core Graphics, IOKit

Base Operating System

- Darwin (Open Source for PowerPC+Intel)
- Based on a Mach microkernel + BSD Unix
- Protected memory, preemptive multitasking
  - Single application cannot corrupt/freeze entire system

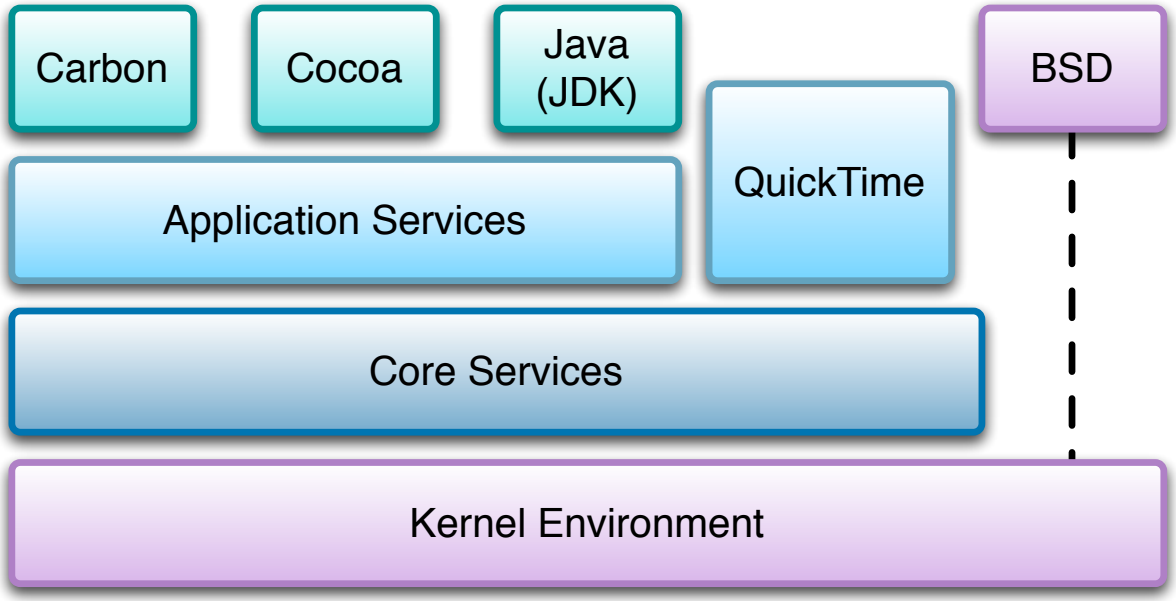
Graphics and Event Library

- Quartz 2D / Core Graphics, Display PDF
- Roots: NeWS, NeXTSTEP (Display PostScript)
- Vector-based, resolution-independent
- Quartz Extreme: GPU-based compositing (pipe entire screen through OpenGL if available)
- Quartz Extreme 2D / QuartzGL: GPU-based UI rendering (still experimental)
- Vista's XPS is similar to (Display) PDF
- The Event Library is contained in IO Kit

Demo: Quartz Extreme

User Interface Toolkit

- Cocoa AppKit, OO framework
- Implements Aqua Look&Feel
- Other part of Cocoa (Foundation framework) contains threads, sockets, etc.
- Written in Objective-C



- Cocoa is the recommended API for Mac OS X
  - Can be used with Objective-C or Java*
- Java SE 6 SDK is used for 100% Java/Swing applications
- Carbon is an updated version of the old Macintosh Toolbox
  - Used to easily port existing applications
  - Carbon apps run on Mac OS 9 and Mac OS X
- BSD is used for existing standard Unix applications
- WebObjects for web-based services

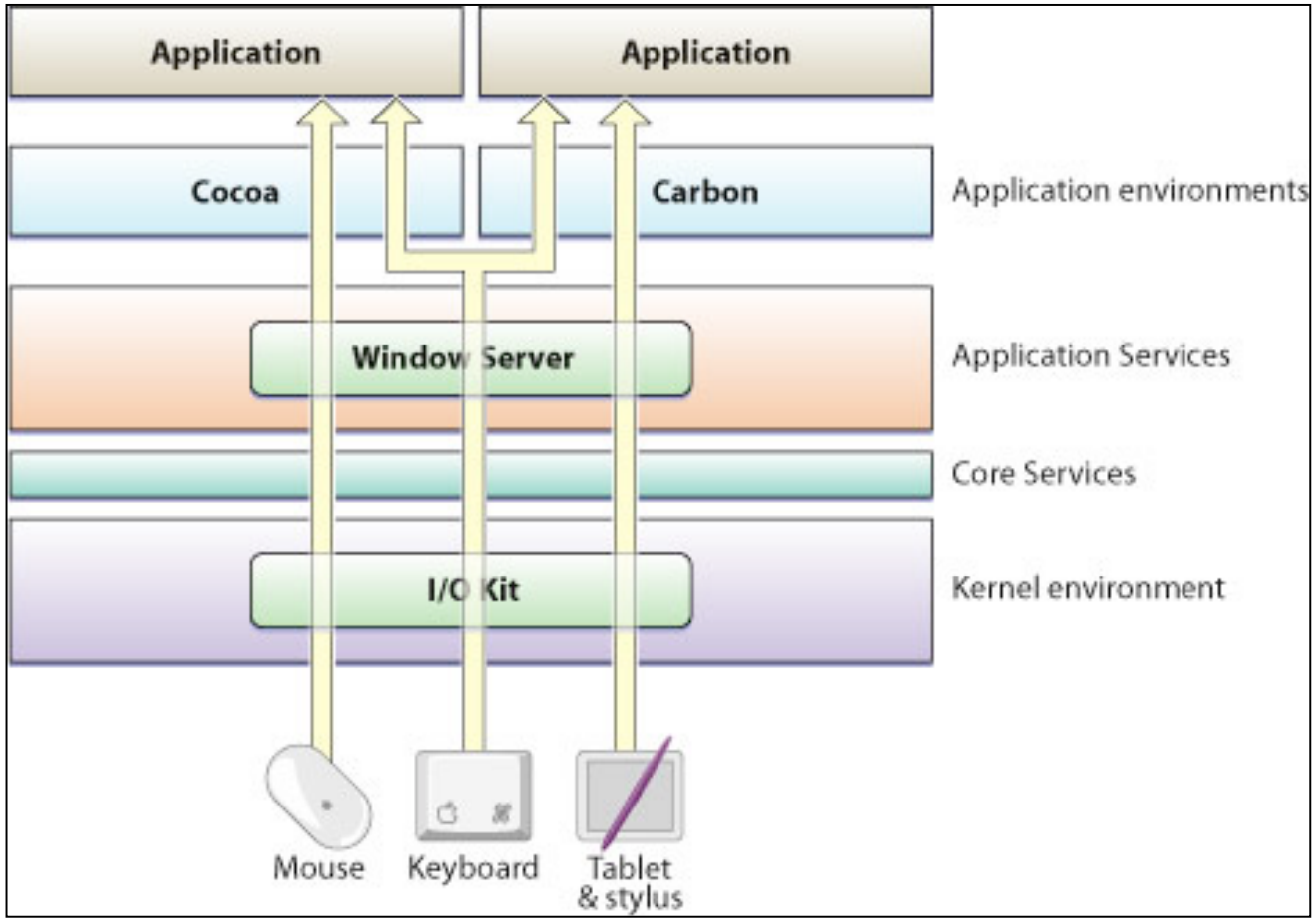
* Multi-API Problems

- Mac OS X has tried to please everyone
- Problem: High cost for supporting many APIs
- Consequences in 2006:
  - No new Java bindings for new Cocoa features in Mac OS X 10.5 and beyond (= "Use Objective-C!")
  - New Intel Macs do not support Classic Mac OS emulation anymore (= "Classic's dead!")
- But: New bridges for Ruby and Python since Leopard

Steve Jobs burying Mac OS 9 at WWDC 2002 (personal photo)

Event Handling

- Similar to our Reference Model
- Window Server distributes events to per-application (really per-process) queues



Objective-C

- Implementation language of the Cocoa framework
- Created in 1983 to combine OO principles with C
  - Inspired by Smalltalk
- In its concepts very similar to Java, unlike C++
- Dynamic typing, binding, and loading
- Protocols are analogous to Java's interfaces
- Classes are objects of type Class
  - Reflection possible (not in C++)
- Introduces few new language constructs to C

Objective-C: New C Language Constructs

- `status = [socket connectToAddress:127.0.0.1 withPort:80]` is analogous to Java's
  `status = socket.connectToAddressWithPort(127.0.0.1, 80)`
- `–` for instance methods, `+` for class methods
- `id` corresponds to Object, `self` corresponds to this
- `@` compiler directives
  - `@interface..@end, @implementation..@end,…`
- Interface categories allow transparent subclassing

Dynamic Typing/Binding/Loading

- C++ is a static language, Java and Obj-C are dynamic
- Calling known methods of a subclass
  - Example: Building objects from data read from a file
  - In C++, you cannot directly call a method defined in a subclass
    - You would have to do a dynamic_cast<>
  - Obj-C (and Java) move this check to run-time
- Fragile Base Class Problem
  - To add a method to a superclass, all subclasses must be recompiled
  - In C++, a superclass must contain all methods any subclass will use
  - Dynamic Binding avoids bloated superclasses, and minimizes recompilation due to this problem

Demo: Dynamic Binding

Objective-C 2.0 (since Leopard)

- Supports automatic accessor method generation for object properties
- Allows Java-like short-hand syntax to access properties
  - `[object setName:newName];`
    `object.name = newName;`
- Features an optional garbage collection
  - only works for Objective-C Objects
  - you still have to manage any C pointers yourself
- Supports fast enumeration of collections
  - `for (object in list) [object doSomething];`

Manual Memory Management

- Reference counting
  - Each object stores how often it is referenced by other objects
  - If it is not used anymore, call dealloc (free memory)
- Only five methods affect reference counts
  - alloc—allocate object and set reference count to 1
  - copy—copy an object. Copy will have reference count 1
  - retain—increment reference count
  - release—decrement reference count
  - autorelease—automatically decrement reference count sometime after the current method

Cocoa

- The UITK (and general toolkit) of Mac OS X
  - Evolved out of NeXTSTEP
  - Cocoa's class names still give away its heritage (NSObject,…)
- Two main parts
  - Foundation: Basic programming support
    - NSObject, values, strings, collections, OS services, notifications, archiving, Objective-C language services, scripting, distributed objects
  - AppKit: Aqua interface
    - Interface, fonts, graphics, color, documents, printing, OS support, international support, InterfaceBuilder support
    - Largest part (over 100) are interface widgets

Cocoa Class Hierarchy

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

- Fairly flat hierarchy
- Reason: Delegates, and categories can be used to mix in functionality
  → no deep subclassing required
- Full hierarchy:
  see Online Help in Xcode

Delegates

- Similar to Listeners in Java
- A delegate is a class whose methods are called from another class that wants to plan for extending its functionality
  - E.g., you can write a delegate class for NSTableView that will get called when the user changes the width of a column
- Delegates solve the fragile base class problem
  - If NSTableView is changed, the delegate class doesn't need to be recompiled

Example: NSTableView Delegate Methods

Moving and resizing columns

– tableView:didDragTableColumn:

– tableViewColumnDidMove:

– tableViewColumnDidResize:

Selecting in table

– selectionShouldChangeInTableView:

– tableView:shouldSelectRow:

– tableView:shouldSelectTableColumn:

– tableViewSelectionIsChanging:

– tableViewSelectionDidChange:

Responding to mouse events

– tableView:didClickTableColumn:

– tableView:
mouseDownInHeaderOfTableColumn:

Editing a cell

– tableView:
shouldEditTableColumn:row:

Displaying a cell

– tableView:
willDisplayCell:forTableColumn:row:

Displaying tooltips

– tableView:
toolTipForCell:rect:tableColumn:
row:mouseLocation:

Allowing variable height rows

– tableView:heightOfRow:

Protocols

- Similar to Java's interfaces
- Mostly replace the need for multiple inheritance

Categories: Extending a class without subclassing

- Example: Add a "find&replace" method to NSString
  - Could subclass "MyNSString"—but then have to change all code to use that new class
  - Could change NSString itself—but that would require access to the source code for that class (and recompiling, rebinding any code using it,…)
  - Instead: Create a category "NSStringExtensions":

```
@interface NSString (NSStringExtensions)
- (NSString *)find:(NSString *)findString
          replaceWith:(NSString *)replaceString;
@end
```

- Any code using NSString can now use the find:replaceWith: method
- An advantage of the Dynamic Loading possible with Objective-C

Demo: Categories

Events and Actions

- Events are generated by user or system (e.g., periodic events)
  - Corresponds to input "I" from our formal widget model
- Actions are generated by objects (e.g., menus) in response to lower-level events
  - Corresponds to actions "A" from our formal widget model
  - InterfaceBuilder lets developer connect actions to custom objects (e.g., from a button to a custom class), using "IBAction" constant in the source

Responders

- Most UI objects are subclasses of NSResponders and can respond to events
- NSApplication can find a responder that can handle an event (respondsToSelector), then call its method directly
- Framework takes care of Responder Chain
  - Events are passed on along the responder chain (key window → main window → application) until they can be handled by some object
- Applications, windows, views, etc. can be extended by adding a delegate without having to subclass them

Outlets

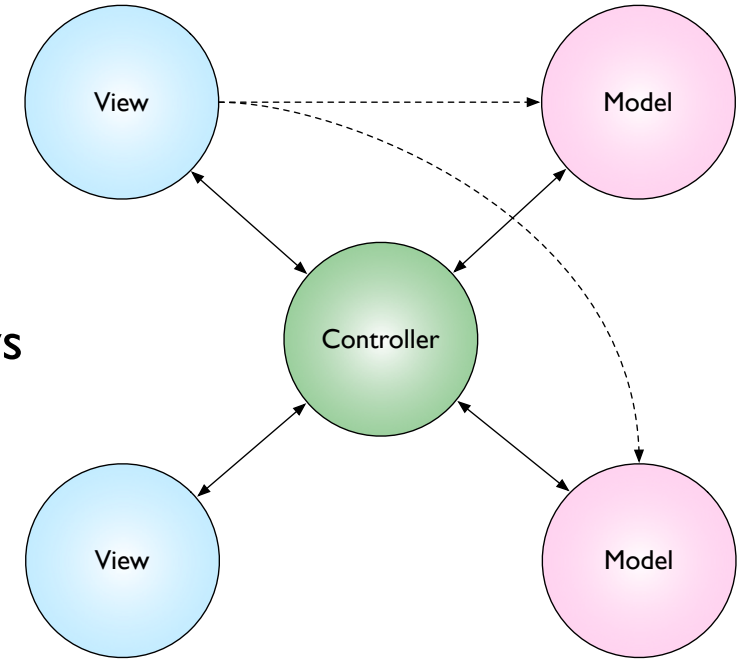
- Outlets are instance variables to refer to other objects
  - InterfaceBuilder knows about them and lets the developer connect outlets graphically ("IBOutlet" constant)
  - Example: A custom class that wants to display a result in a text field needs an outlet

Interface Builder

- Graphical tool to create UIs for Cocoa (and Carbon) applications
- Tied into development environment (Xcode)
- Resources are stored in xib files (XML Interface Builder)
  - used to be nib (NeXTSTEP Interface Builder)

- An application reads its main xib file automatically when it starts up
- Additional xib files can be read when needed (for transient dialogs, etc.)

Aside: MVC



- Model
  - store and change data
  - should never know about specific views
- View
  - parts of the UI
  - sometimes have a reference to models
- Controllers
  - sets up connections
  - translate actions into model specific commands (click ➔ add item)
  - relays changes in the model to appropriate views (disable a button, update a table)

Demo:
Interface Builder Basics

Interface Builder: Defining the Look

- Interface Builder supports the developer when visually laying out the user interface
- Guides (similar to Photoshop) help to adhere to the visual aspects of the Aqua Design Guidelines (the Mac OS X Look and Feel)
- This helps design the View in the MVC (Model–View–Controller) paradigm

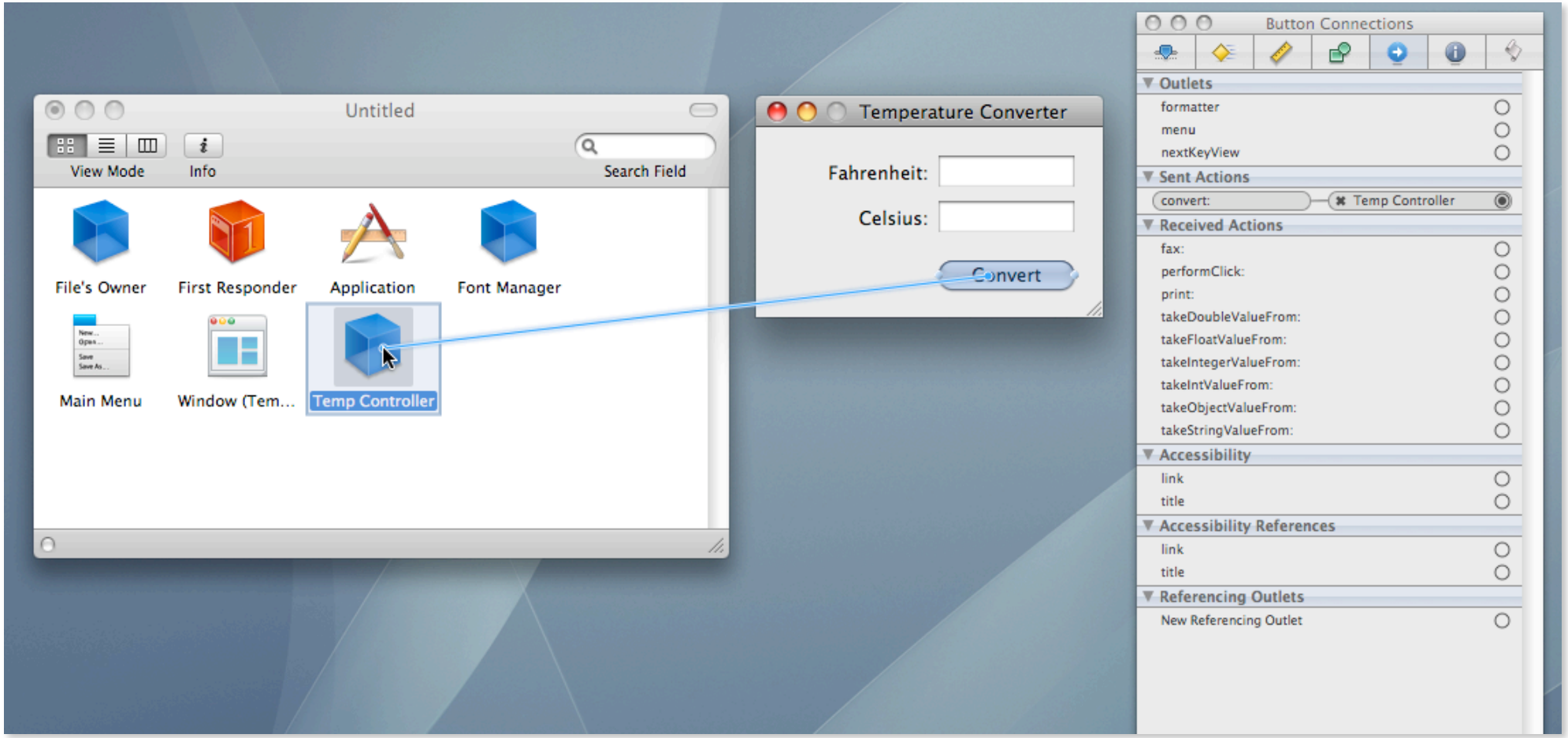
Demo: Interface Builder —Layout Support

Interface Builder: Defining the *Feel*

- Not just visually define the widgets in a UI (specify static UI layout—which is what most UIDS support), but also connections between widgets and custom classes of the application (dynamic UI behavior)
- Linking View and Controller
- Can even synthesize Controller to directly link View and Model
- UI can be tested inside Interface Builder without compiling or writing any code

Example

User input via an NSButton is connected to the convert() method of a custom TempController class in an application.



Demo: Interface Builder Connecting Actions, Testing

Interface Builder: Defining the Feel

- Suggests a more user-centered implementation process that starts with the user interface, not the application functionality
  - Interface Builder synchronizes with source code skeleton that can then be filled in
  - Interface Builder uses special constants to include hints about outlets and actions in the source code

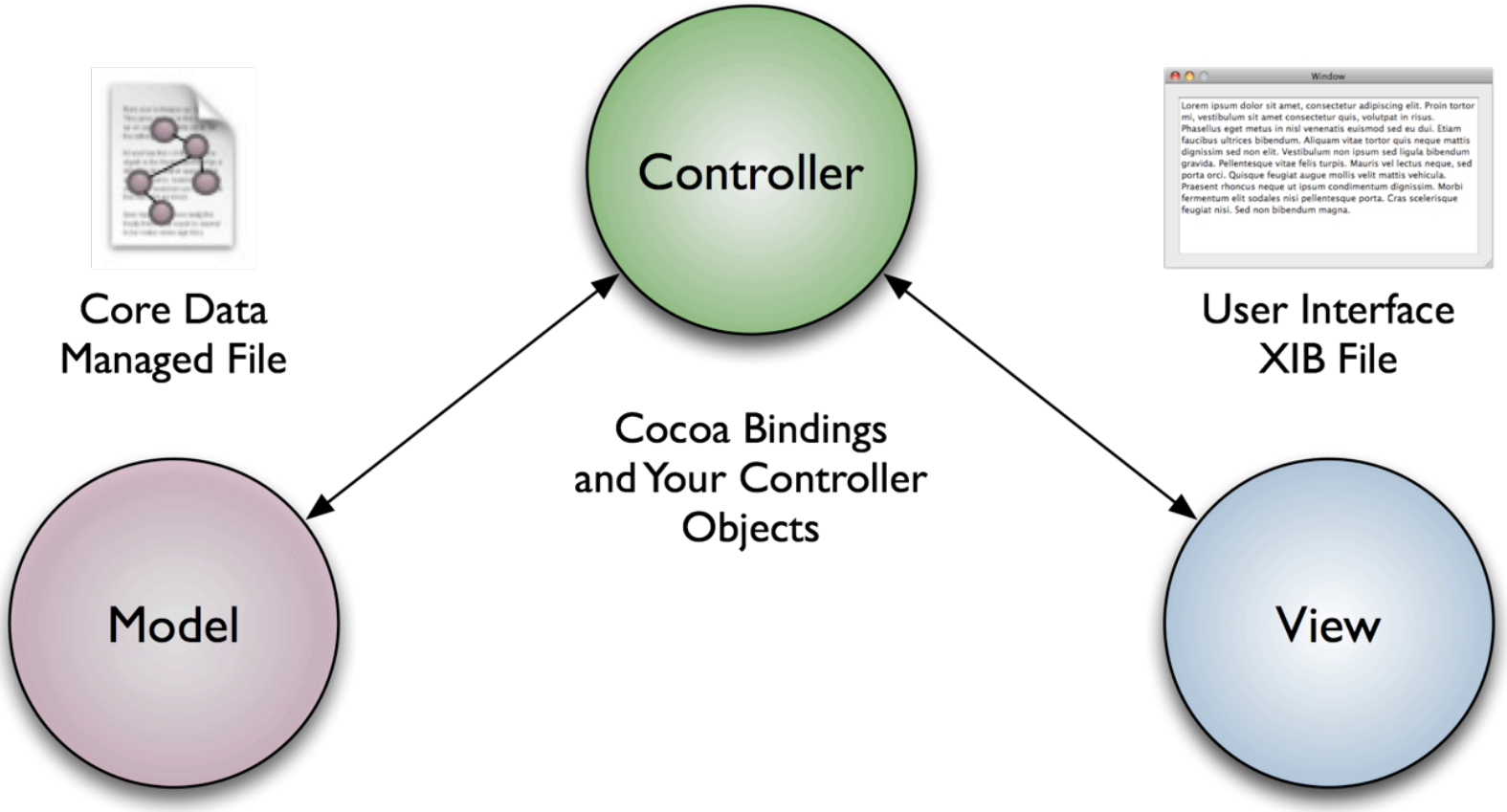
Cocoa Bindings

- Cocoa Bindings are an approach to keep MVC Model and MVC View synchronized without having to write a lot of glue code
- Example: Keeping a displayed table of students (View) synchronized with the corresponding array (Model) of data in memory, and also with a label showing the number of students (another View)
- Cocoa Bindings define the MVC *Controller*

Demo: Cocoa Bindings in Interface Builder

Core Data: Defining the MVC Model

- Object-graph management and persistence framework
- To define application data model graphically
- Provides common functionality
  - Undo, Redo
  - Persistence (save to disk, read from disk in XML or SQLite format)


Controller
Core Data
Managed File
Window
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User Interface
XIB File
Cocoa Bindings
and Your Controller
Objects
Model
View

Demo: Core Data

Core Image, Core Audio, Core Animation

- Core Image: Framework for GPU-accelerated image display, contains a large and extensible set of Image Units (visual effects, transitions, and filters) that can be combined at runtime, and used by any app developer
- Core Audio: toolbox of Audio Units for audio effects and digital audio signal processing
- Core Animation: implicit animation support for the UI

Demo:
Core Image Fun House

Demo: Core Audio—AULab

Demo: Core Animation

Webclips, Dashcode, Automator

- Webclips
  - Windows to websites
  - Updated automatically
- Dashcode
  - Programming environment for Dashboard Widgets
  - Bases on web technology (JavaScript, HTML, Images)
- Automator
  - End user scripting tool
  - Like graphical shell scripts

Demo: Webclips, Dashcode, Automator

More Information

- Apple Developer Documentation: http://developer.apple.com/