

EMBEDDED SYSTEMS PROGRAMMING 2015-16

Introduction to the Platforms

LIBRARY

A collection of resources
(in our context, classes)
used to develop software

- **Examples: the Java Class Library, the C++ Standard Template Library (STL), the C standard library...**

FRAMEWORK

A collection of libraries
organized to provide a key functionality

A framework suggests/imposes a programming model

- Example: Apple's UIKit framework provides the classes needed to construct and manage an application's user interface for iOS

PLATFORM

A collection of software frameworks
(including application frameworks)
that allows software to run

A platform specifies an operating system, a set of programming languages and run-time system libraries.
It may include an hardware architecture

- Examples: Android, iOS, Windows Phone

ECOSYSTEM



ECOSYSTEM



ECOSYSTEM

A platform together with the community developing hardware and software products for that platform

The products and the users are sometimes considered part of the ecosystem as well

- Example: Android together with Android developers, Google Play, etc.

ANDROID, IOS, WP

They share several characteristics.

- They are platforms
- They include an **operating system**, a set of **core applications** (browser, e-mail, ...) and a rich set of **libraries** to develop custom applications
- Libraries for data storage, hardware access, multimedia, 3D graphics... (More on this later)
- They are optimized for embedded devices

OPERATING SYSTEM (1/2)



UNIX

RESEARCH, OPENNESS AND REGULATIONS

- Thompson and Ritchie invented Unix in the 1960s as a **research project** while at Bell Labs, a telecom company
- Under a 1958 antitrust decree, Bell Labs could not sell non-telecom technology: it was required to **license Unix to anyone who asked**
- Unix was made available to universities and firms, under licenses that included **all source code**: this fostered experimentation, innovation, adoption

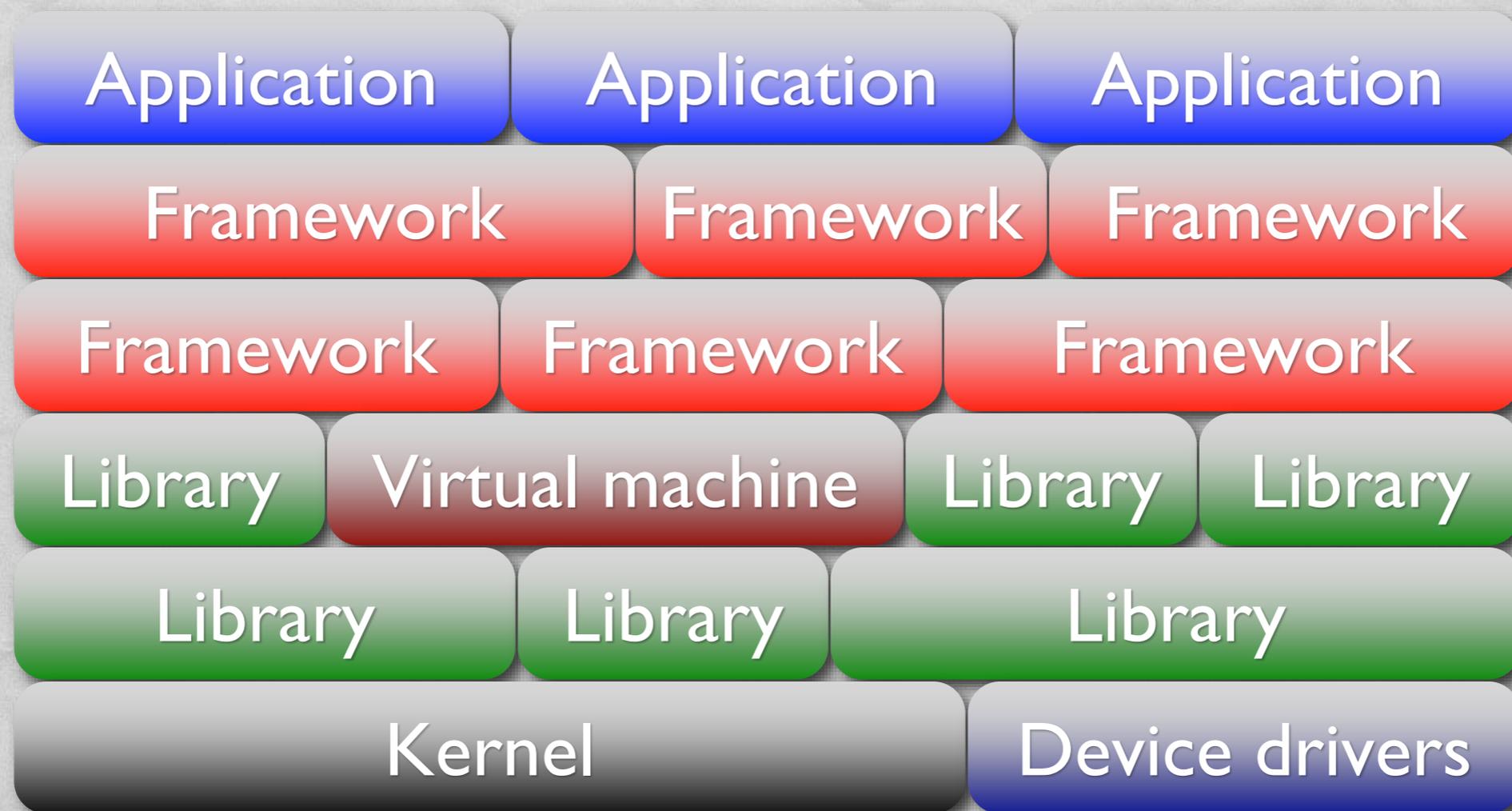
THE ROLE OF UNIX



OPERATING SYSTEM (2/2)

- **Android:** Linux (intemperately customized)
- **iOS:** BSD Unix (heavily modified)
- **Windows Phone:** based on proprietary, closed-source kernels (WinCE for WP7, Win8 for WP8)

ON TOP OF THE OS



- There might be different libraries for the same function, at different levels of abstraction

TYPICAL LIBRARIES AND FRAMEWORKS

- For fonts, 2D and 3D graphic rendering
- For user interface (UI) management
- For network management
- For data storage
- For decoding/encoding multimedia formats
- For geolocation

TYPICAL APPLICATIONS

- Web browser, email, chat
- Calendar / appointments / todo manager
- Contacts / phonebook
- Media (music, video, ...) player
- Application market

LICENSES

- **Android:** open source*, download sources from <http://source.android.com/>
- **iOS:** closed source, copyright aggressively enforced
- **Windows Phone:** closed source



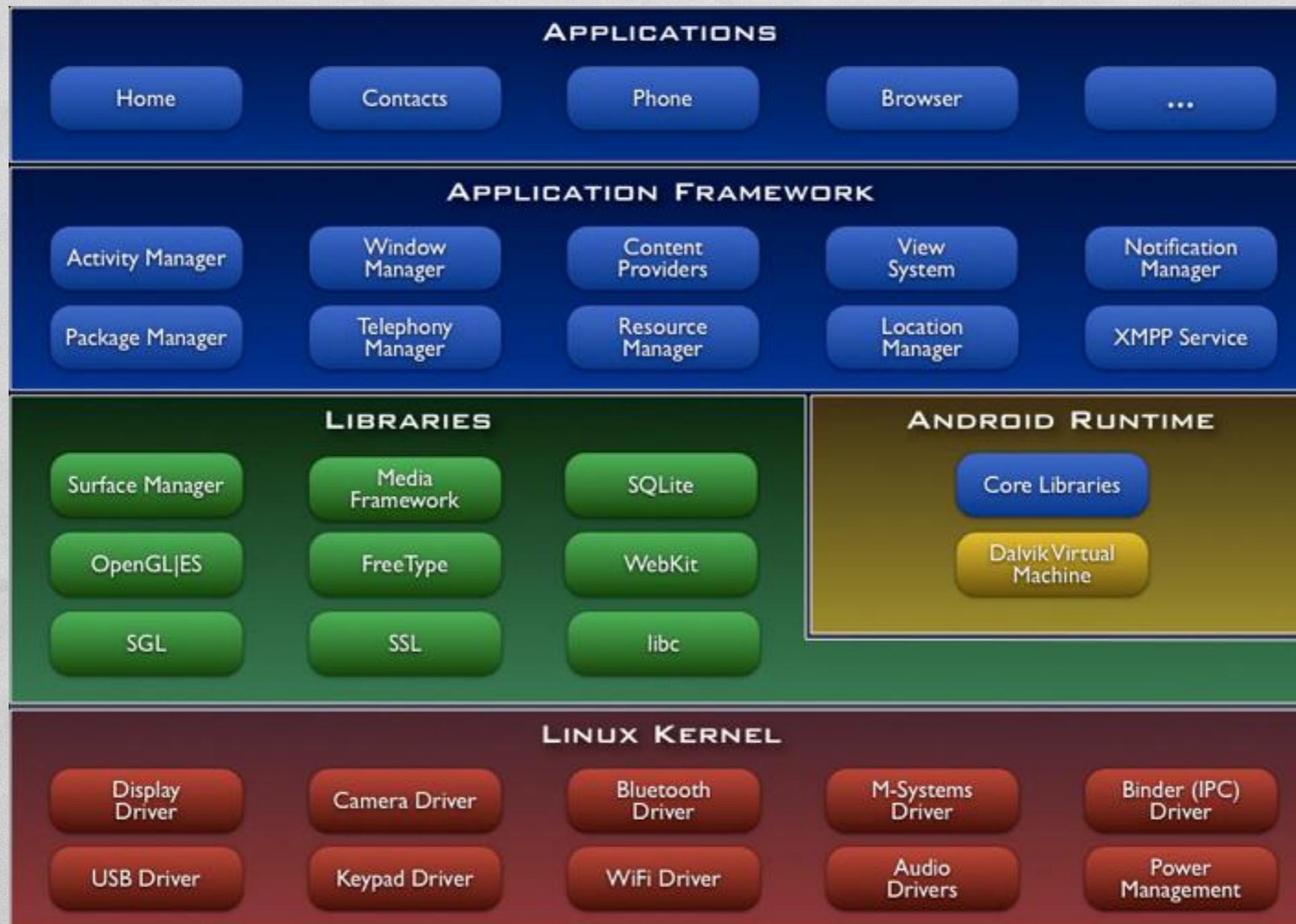
ANDROID

ANDROID: HISTORY

- 2003: Android Inc. founded
- 2005: Android acquired by Google
- 2008: first software release (open source)
- 2008: first product (HTC Dream)



ANDROID: ARCHITECTURE



ANDROID: LIBRARIES (1/2)

- **libc**: BSD-derived implementation of the standard C system library (libc), tuned for embedded Linux-based devices
- **SSL**: Secure Socket abstraction based on the SSL protocol
- **SGL**: 2D graphics engine
- **WebKit**: web browser engine which powers both the Android browser and embeddable web views
- **FreeType**: bitmap and vector font rendering

ANDROID: LIBRARIES (2/2)

- **OpenGL|ES:** 3D graphics engine; uses hardware acceleration where available
- **SQLite:** open-source, lightweight relational database engine
- **Media Framework:** playback and recording of MPEG4, H.264, MP3, AAC, AMR, JPG, PNG... files
- **Surface Manager:** manages access to the display subsystem and seamlessly composites 2D and 3D graphic layers from multiple applications

APPLICATION FRAMEWORK

(1/2)

- **View System:** provides building blocks for UI components
- **Window Manager:** creates windows, dispatch UI events to applications
- **Activity Manager:** manage the lifecycle and stacking of applications
- **Content Providers:** store and retrieve data and make it shareable between applications
- **Package Manager:** handles information on the application packages currently installed on a device

APPLICATION FRAMEWORK

(2/2)

- **Resource Manager:** handles access to resources inside packages
- **Telephony Manager:** provides access to the telephony services on a device
- **Location Manager:** provides access to GPS and other location services
- **Notification Manager:** collects events happening in the background and notifies them to the user

ANDROID RUNTIME

- Android applications are developed in Java, albeit with a custom library (no SE or ME compliance)
- Java sources are compiled into Java bytecode, and then into a proprietary format (DEX)
- DEX files are platform independent and are executed into a proprietary virtual machine (Dalvik or ART)



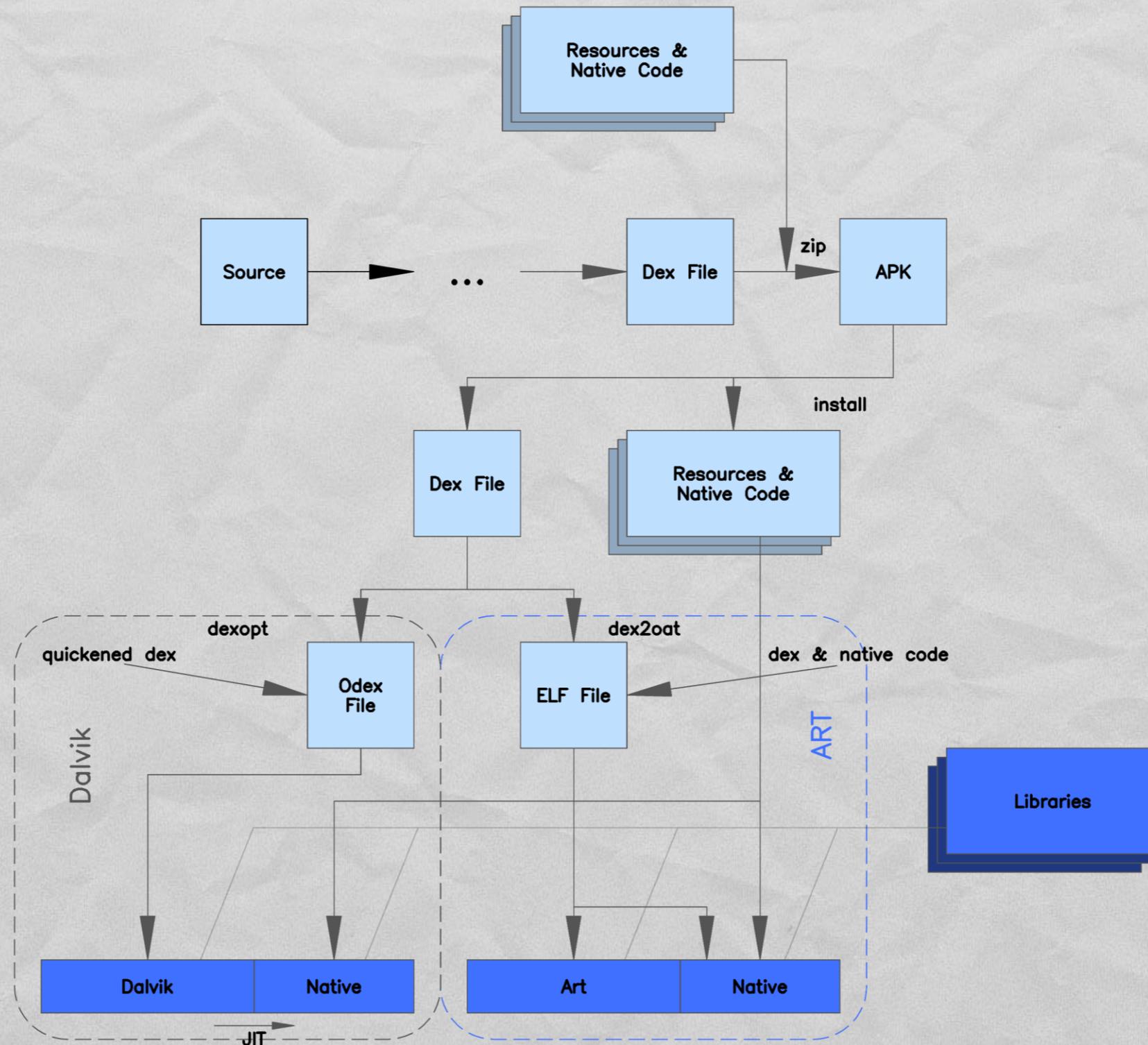
PERFORMANCE (1/3)

- DEX, Dalvik and ART are designed for systems constrained in terms of memory and processor speed
- DEX packs multiple classes into a single file
- Dalvik and ART are register-based machines
 - Smaller bytecode
 - Faster execution

PERFORMANCE (2/3)

- Android 2.2: Just-In-Time (JIT) compiler: introduced in Dalvik. It translates bytecode into machine code at run-time
- Android 4.4: ART introduced. Faster, more predictable garbage collector. **Ahead-Of-Time (AOT) compiler**: it translates bytecode into native assembly code at install time
- A **Native Development Kit (NDK)** is available to compile performance-critical portions of apps from C++ into native code

PERFORMANCE (3/3)



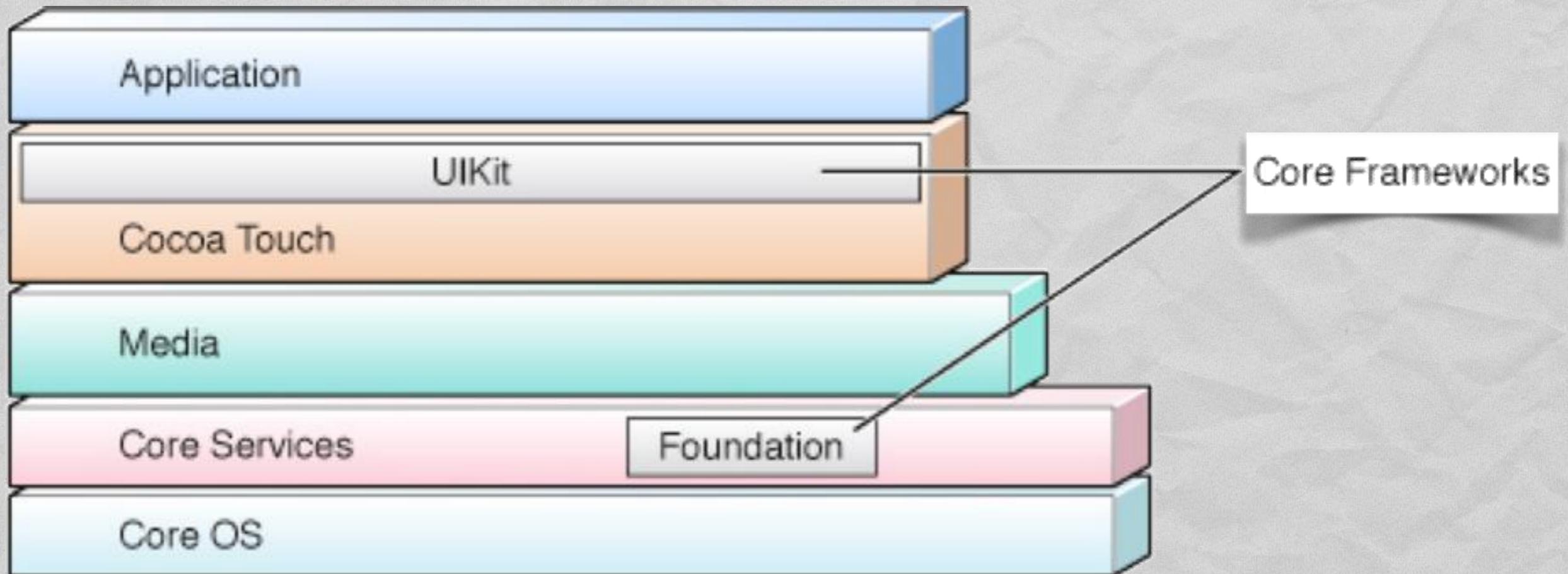
OTHER PLATFORMS

IOS: HISTORY

- 1985: NeXT founded
- 1988: Objective-C licensed
- 1989: NeXTSTEP o.s.
- 1996: Apple acquires NeXT
- 2001: Mac OS X, based on NeXTSTEP via OpenStep
- 2007: iPhone OS (later: iOS), based on OS X
- 2008: iPhone OS SDK, App Store



IOS: ARCHITECTURE

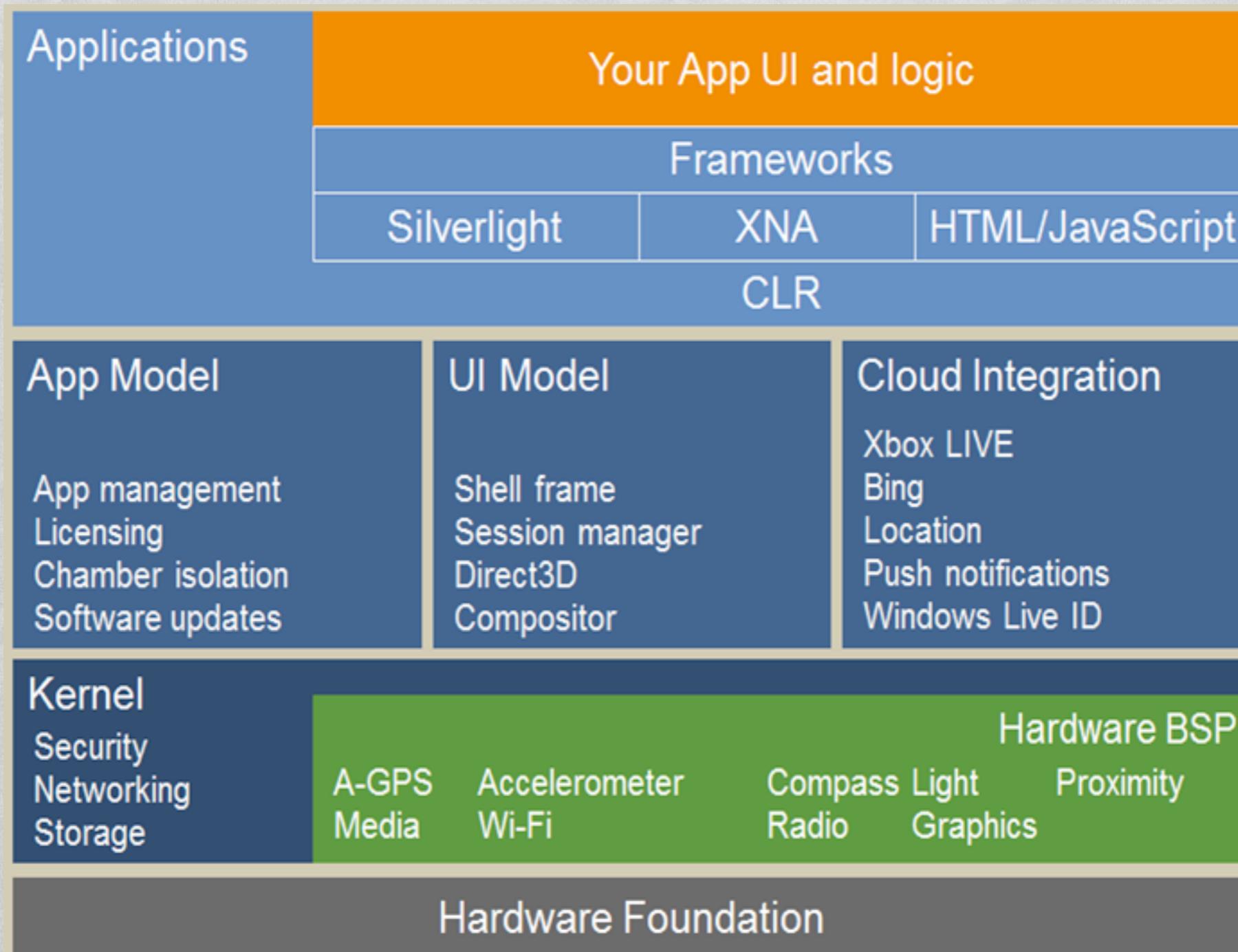


WP: HISTORY

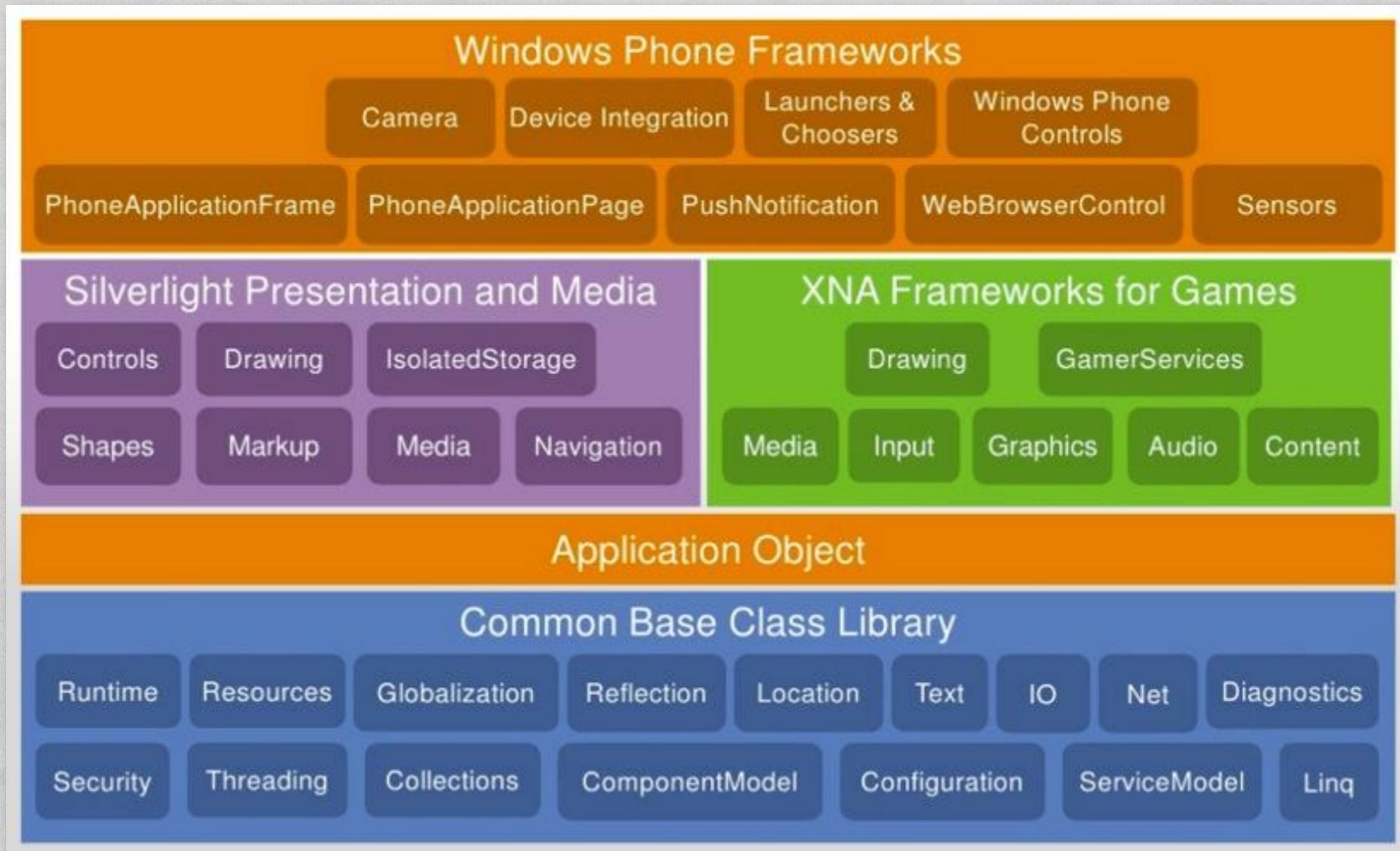
- 1996: Windows CE 1.0, targeted at “handheld PCs”
- 1997: Windows CE 2.0.
UI even more similar to that of Windows 95/98.
First keyboardless devices (“palm-size PCs”)
- 2000: Windows CE 3.0 / Pocket PC 2000.
Different versions for different devices
- 2003-2010: versions proliferating for marketing reasons
- 2010: Windows Phone 7, based on Windows CE. Metro UI
- 2012: Windows Phone 8, incompatible with WP7.
Replaces the Windows CE architecture with one
based on Windows 8 components & the Windows NT Kernel



WINDOWS PHONE 7.X: SOFTWARE ARCHITECTURE



WINDOWS PHONE 7.X: FRAMEWORK DETAILS



DEVELOPING APPLICATIONS

- Apple: “creating applications that do something useful and look nice requires you to spend some time”
- Microsoft: “It is really easy to get started and become comfortable with the development of applications”

**Who to believe?
You decide**

TO LEARN MORE

- <http://developer.android.com/>
- <http://developer.apple.com/library/ios/>
- <http://dev.windows.com/>

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