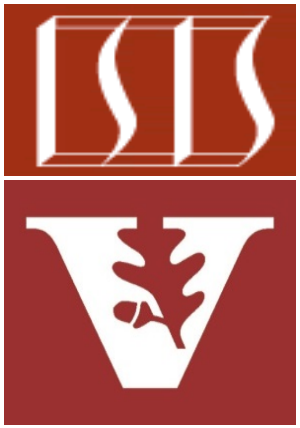
Infrastructure Middleware (Part 3): Android Runtime Core & Native Libraries



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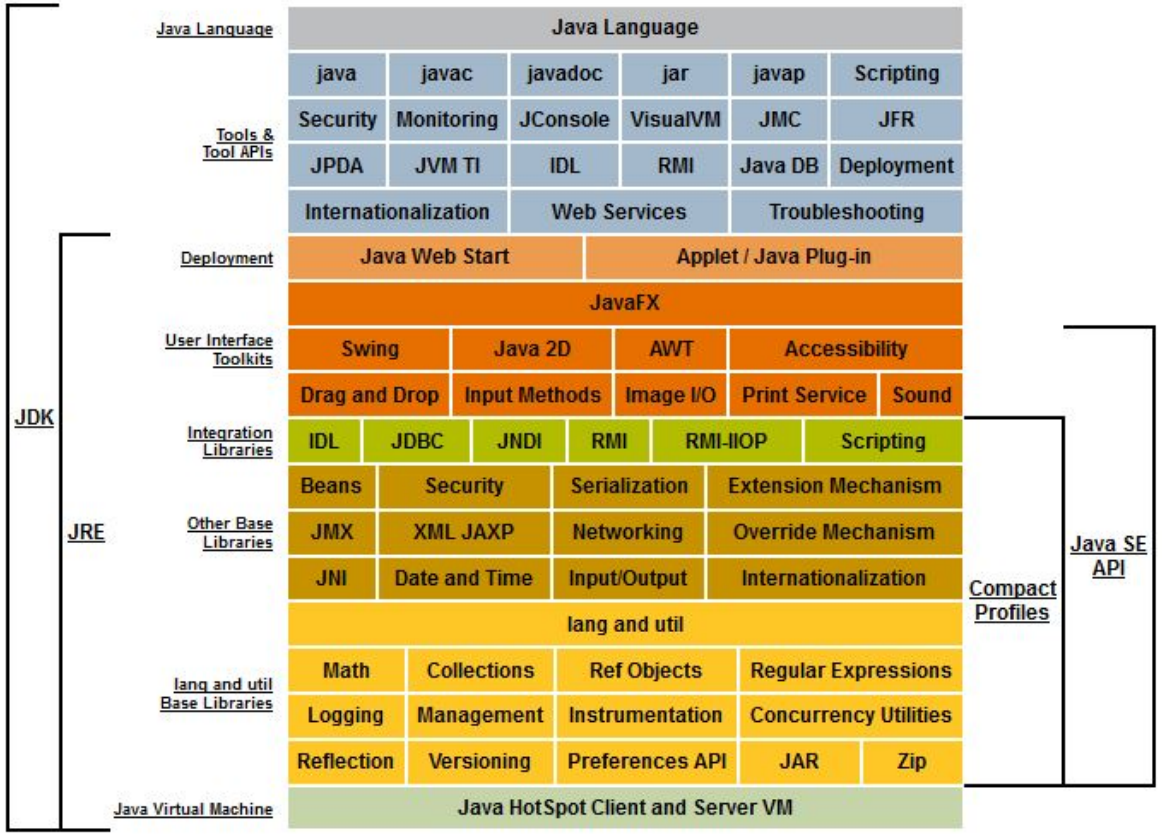
Vanderbilt University
Nashville, Tennessee, USA

Learning Objectives in this Part of the Lesson

- Recognize key core Java libraries that are part of the Android platform



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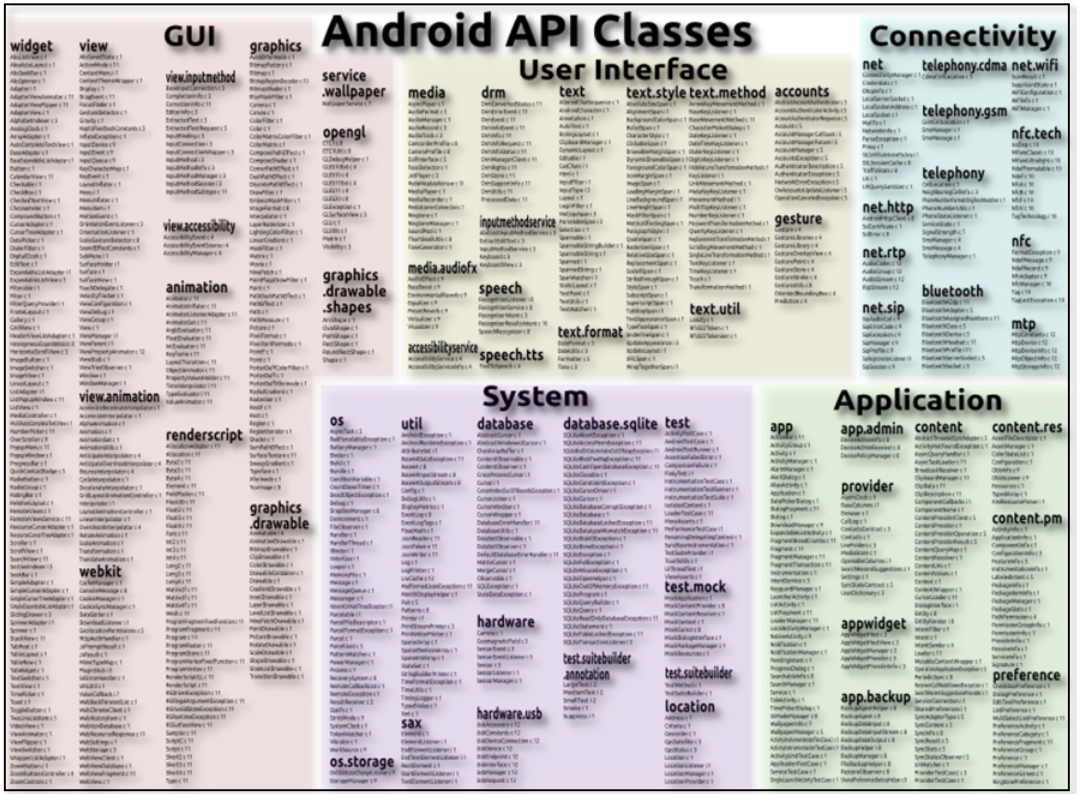

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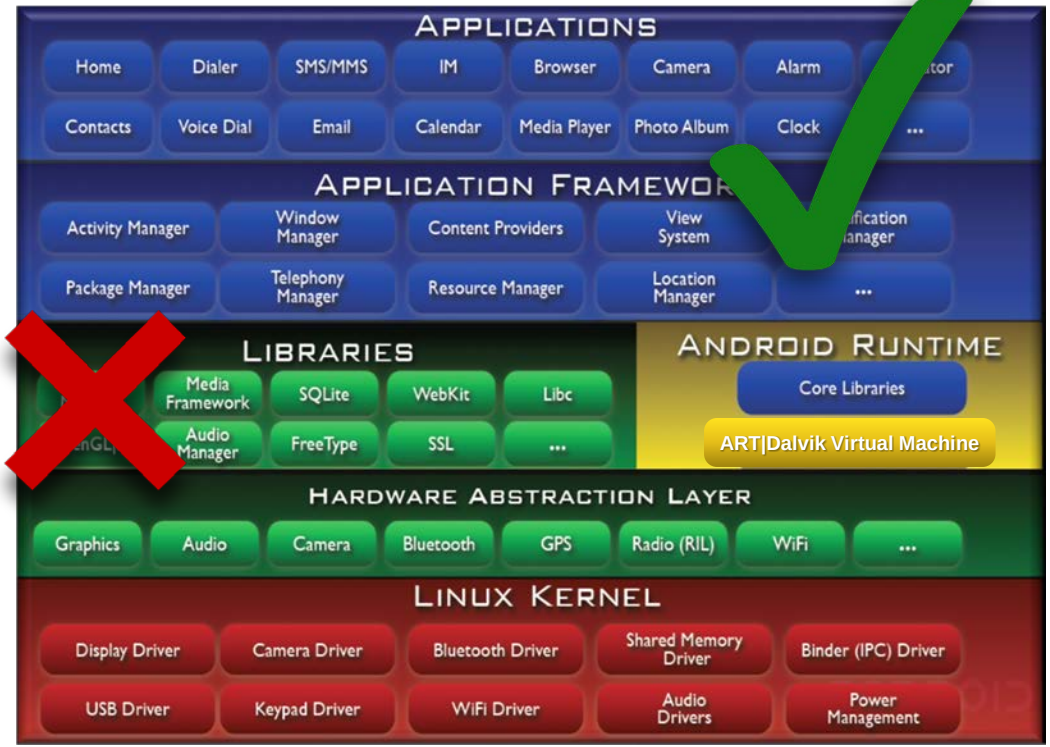
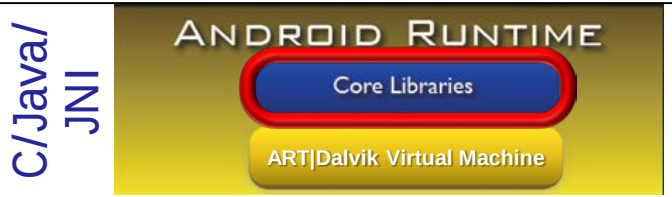


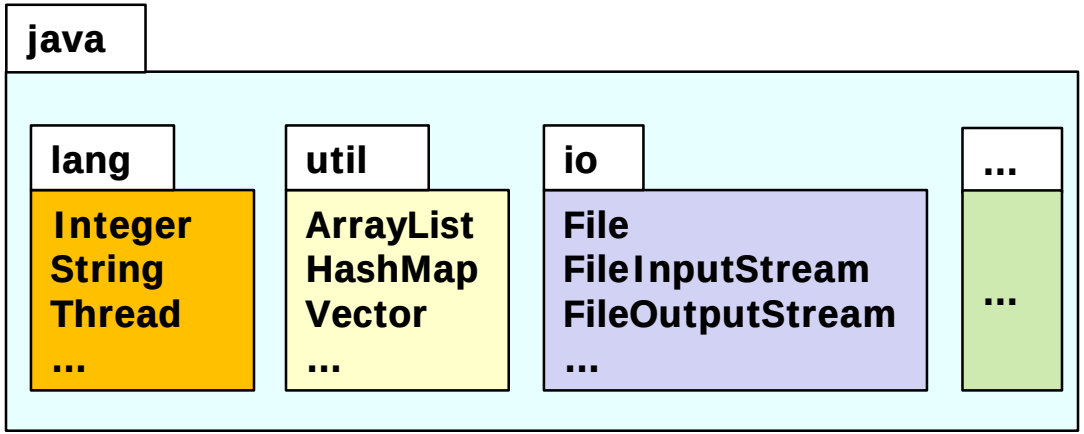
Apps use core Java/Android libraries extensively; native libraries not as much

Overview of the Android Runtime: Core Java Libraries

Android Runtime: Core Java Libraries

- Android contains many (but not all) core Java libraries in the java.* & javax.* packages





See en.wikipedia.org/wiki/Comparison_of_Java_and_Android_API

Android Runtime: Core Java Libraries

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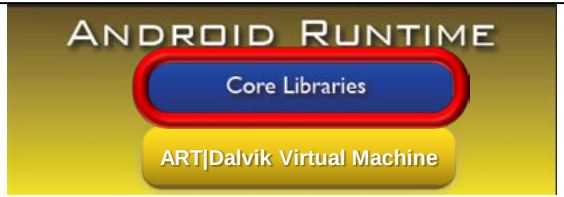
  - Java Thread

C/Java/ JNI



See developer.android.com/reference/java/lang/Thread.html

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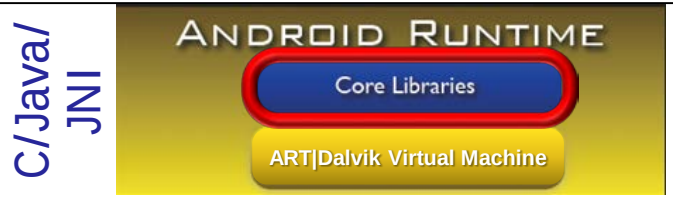

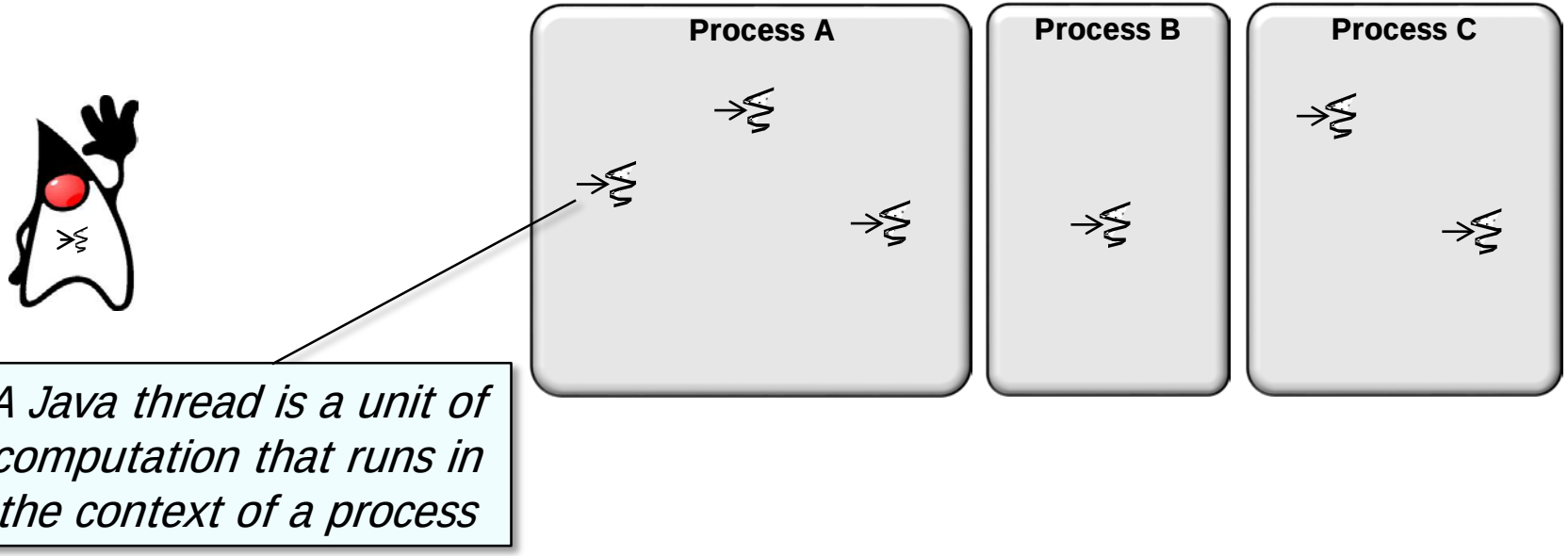

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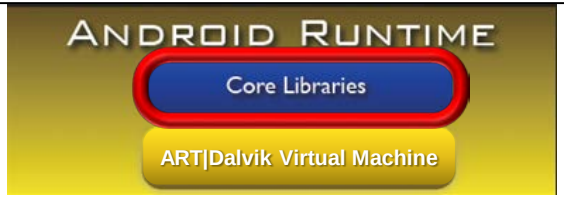

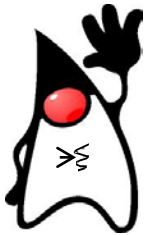

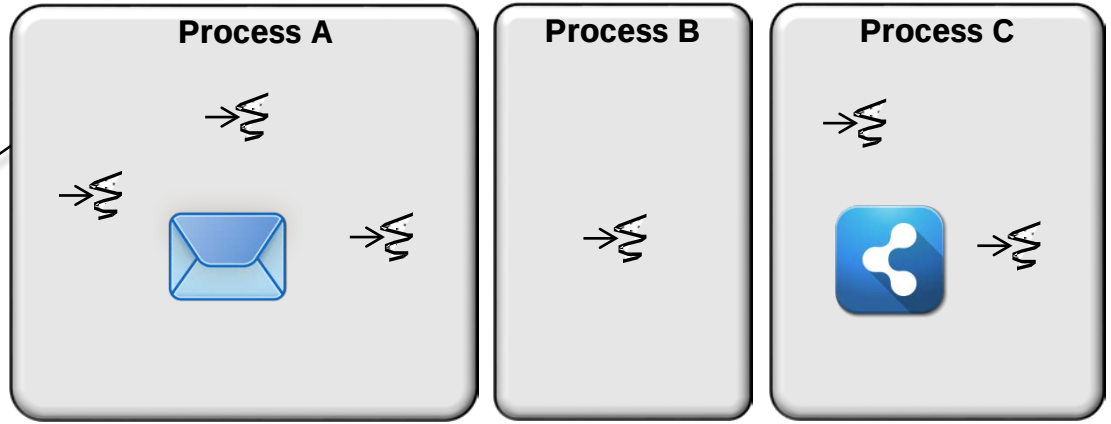

Java threads running in a process can communicate with each other via shared objects or message passing

See en.wikipedia.org/wiki/Thread_(computing)

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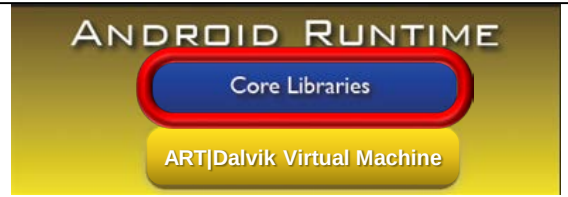

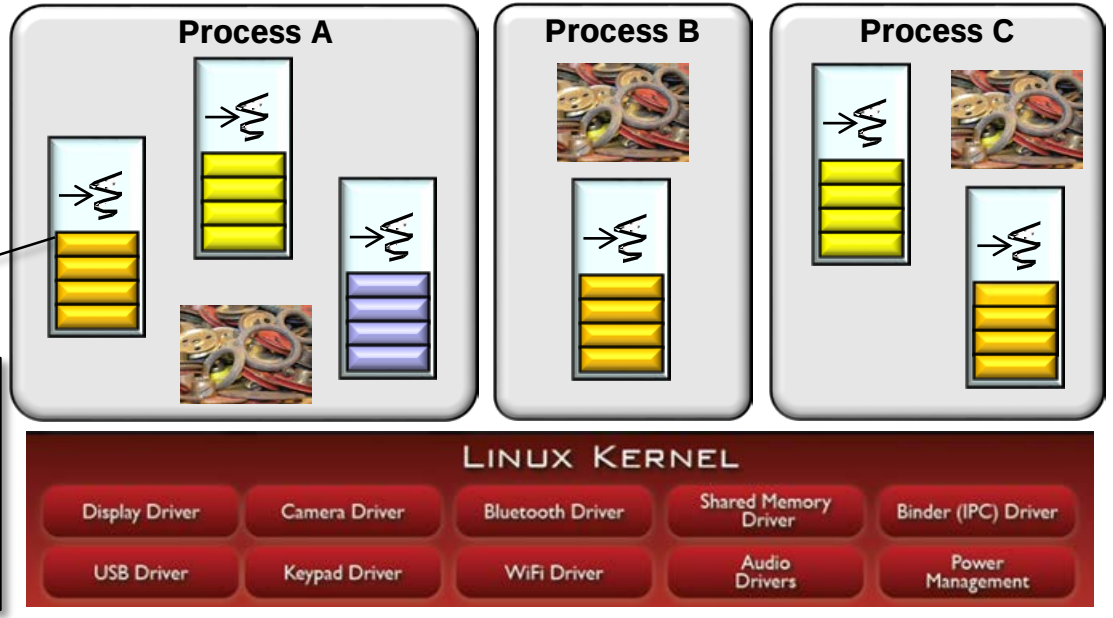

Each Java thread leverages unique "state" from the underlying Linux kernel thread, e.g., a stack, a program counter, & other registers

See en.wikipedia.org/wiki/Thread_(computing)#Processes.2C_kernel_threads.2C_user_threads.2C_and_fibers

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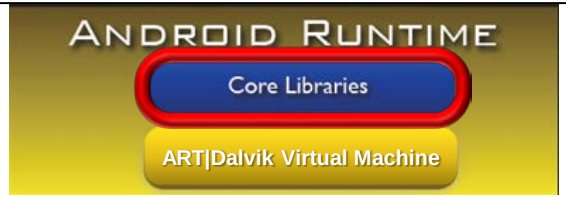
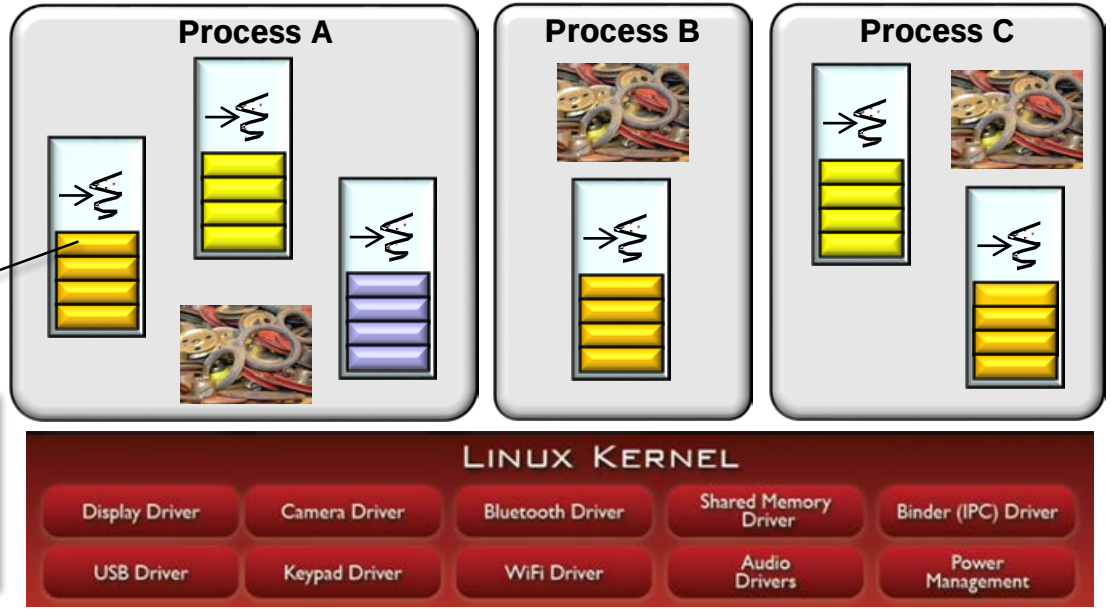




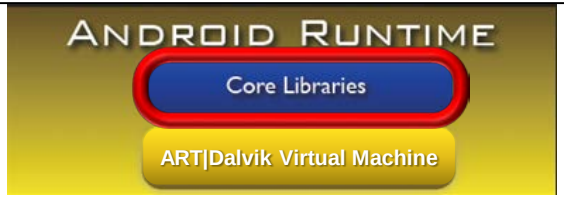
Java dynamic & static objects can be shared across Java threads (i.e., this "state" is common)

See en.wikipedia.org/wiki/Thread_(computing)#Processes.2C_kernel_threads.2C_user_threads.2C_and_fibers

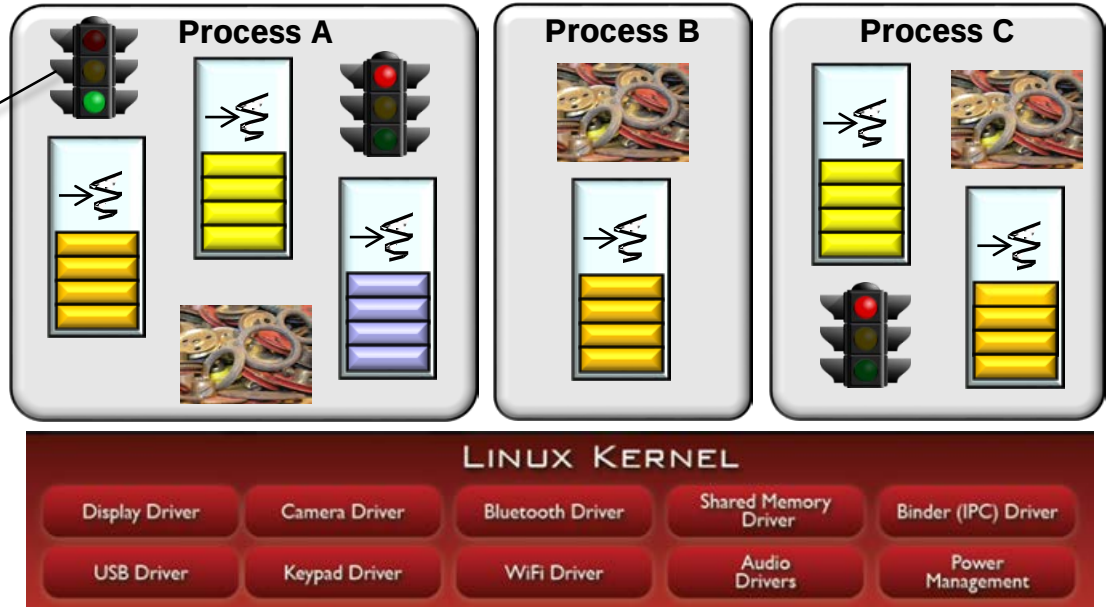
Android Runtime: Core Java Libraries

- Android contains many (but not all) core Java libraries in the java.* & javax.* packages, e.g.
  - Java Thread
  - Java synchronizers

C/Java/ JNI



e.g., reentrant locks, stamped locks, semaphores, condition objects, phasers, etc.



See developer.android.com/reference/java/util/concurrent/package-summary.html

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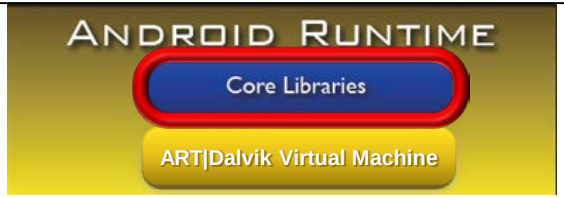
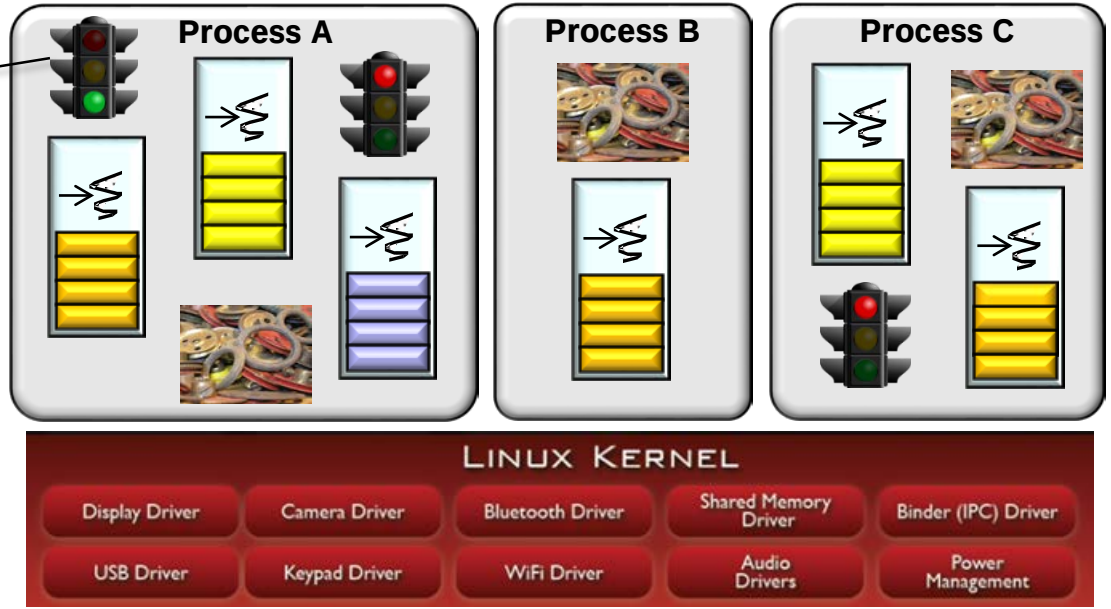


Java synchronizers are used to prevent race conditions



See en.wikipedia.org/wiki/Race_condition

Android Runtime: Core Java Libraries

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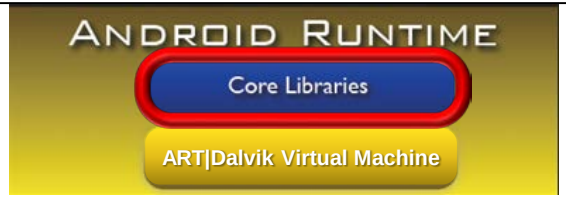
  - Java synchronizers
  - Java networking

C/Java/ JNI



Java network programming mechanisms can exchange data between Android devices & remote servers

Network

java.net

See developer.android.com/reference/java/net/HttpURLConnection.html

Android Runtime: Core Java Libraries

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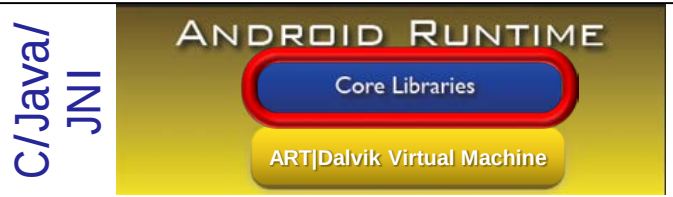
  - Java Thread
  - Java synchronizers
  - Java networking
  - Java I/O & files



Java file mechanisms can store data persistently on Android devices

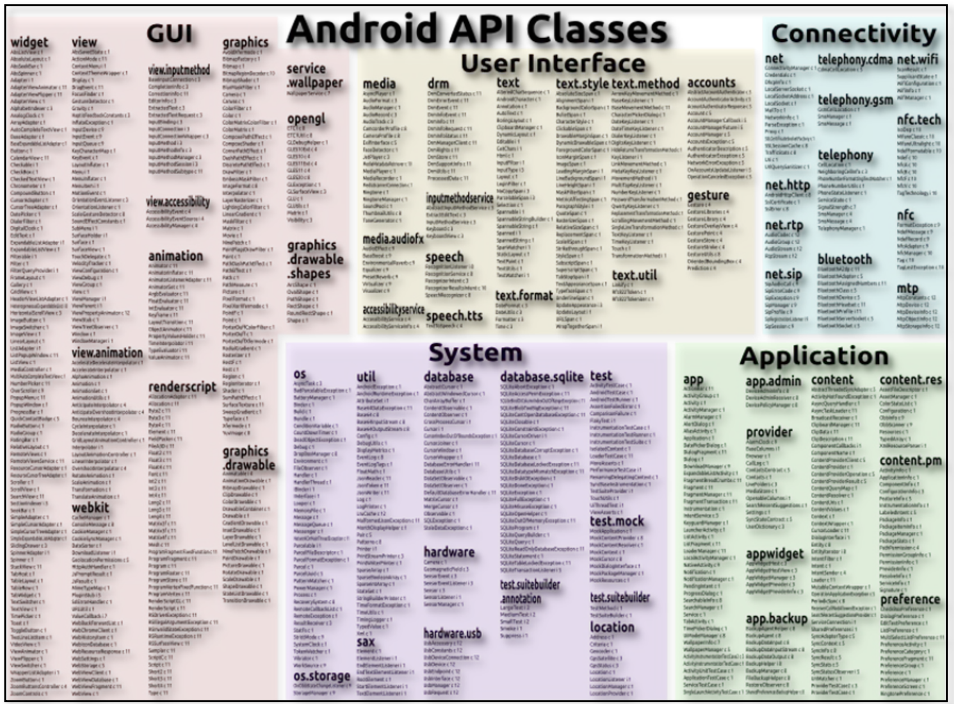
See docs.oracle.com/javase/8/docs/api/java/nio/file/Files.html

Overview of the Android Runtime: Core Android Libraries

Android Runtime: Core Android Libraries

- Android contains thousands of classes in the android.* packages

C/Java/JNI



See www.makelinux.net/android/classes

Android Runtime: Core Android Libraries

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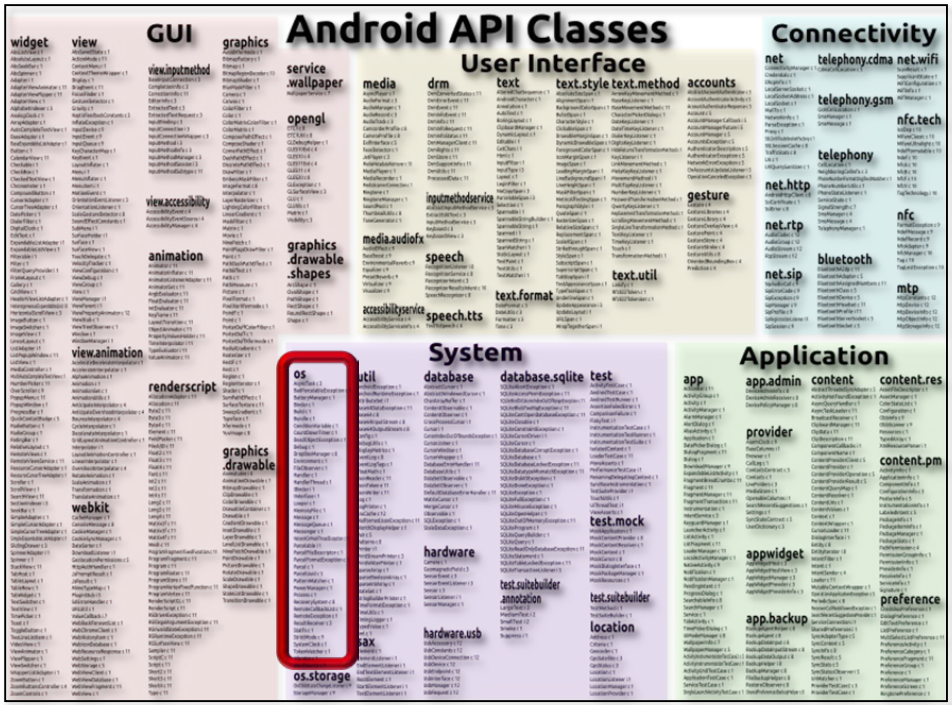
  - Concurrency

C/Java/JNI



See www.vogella.com/tutorials/AndroidBackgroundProcessing/article.html

Android Runtime: Core Android Libraries

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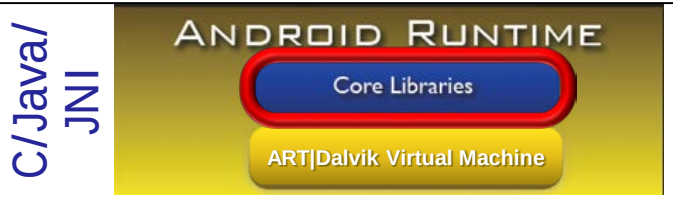
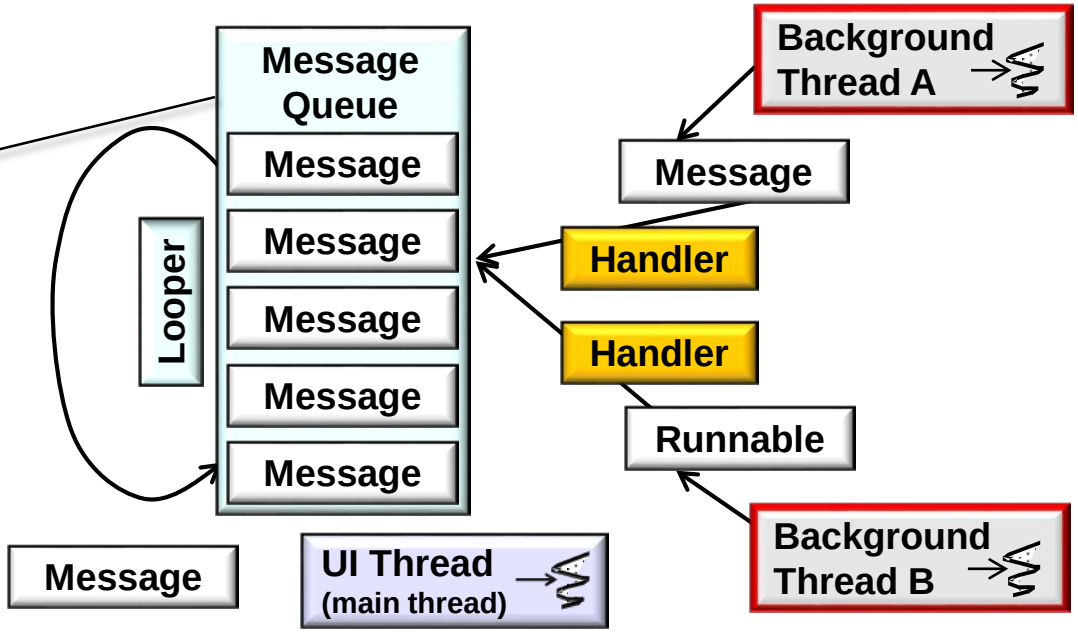
    - *Handlers, Messages, & Runnables (HaMeR)*



Operations run in one or more threads & publish their results to the UI thread



See developer.android.com/training/multiple-threads/communicate-ui.html

Android Runtime: Core Android Libraries

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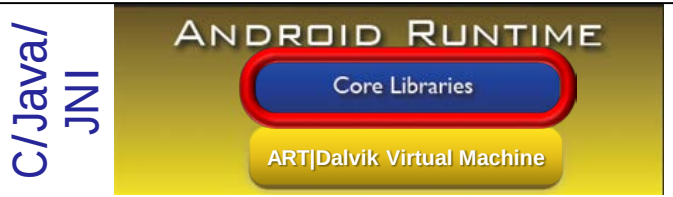
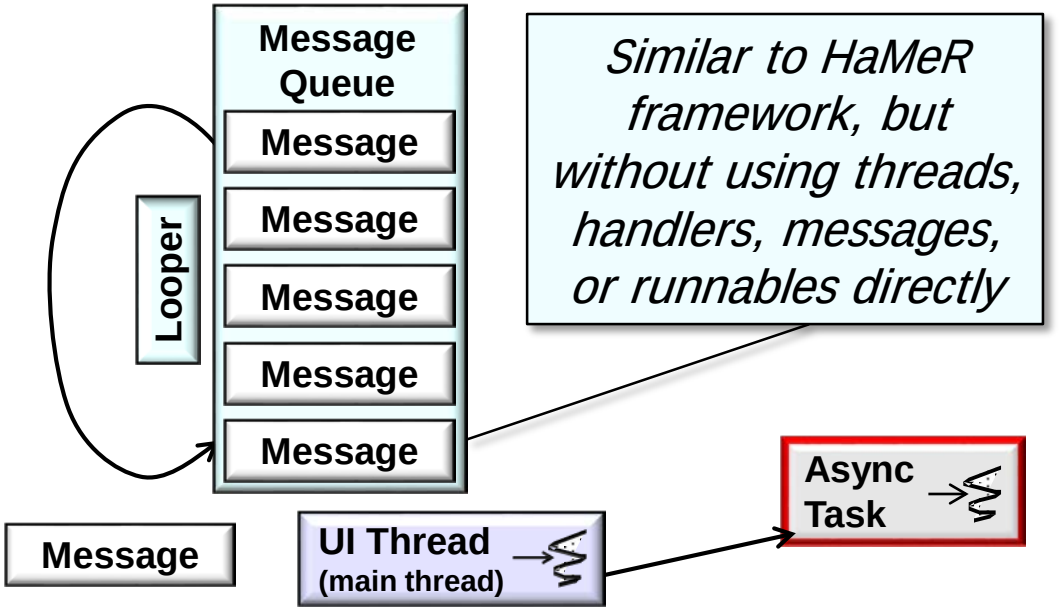
    - *Handlers, Messages, & Runnables (HaMeR)*
    - *AsyncTask*

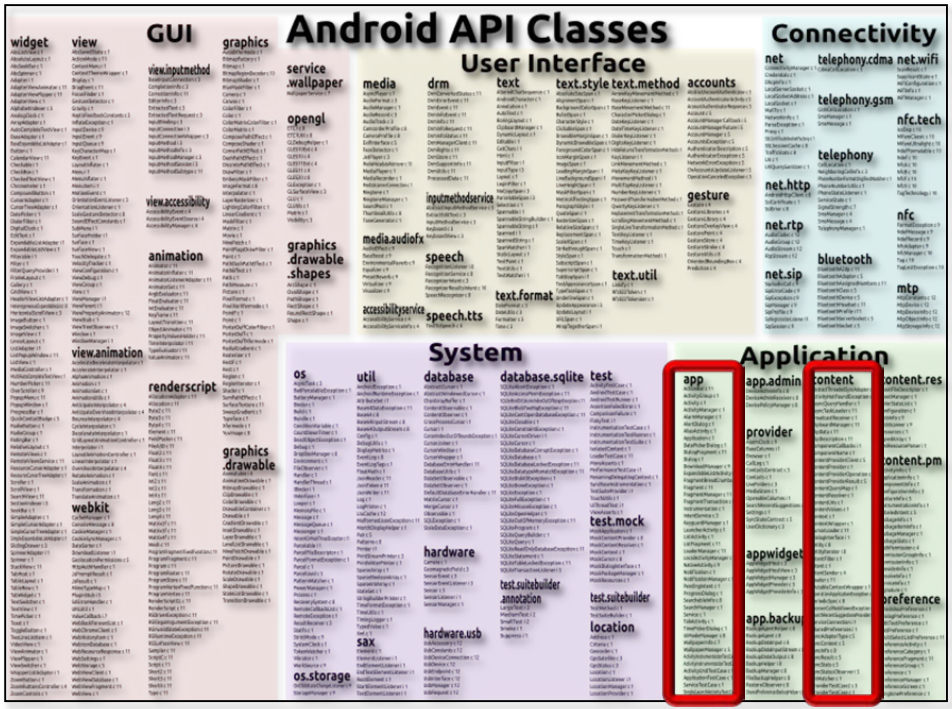




See developer.android.com/reference/android/os/AsyncTask.html

Android Runtime: Core Android Libraries

- Android contains thousands of classes in the android.* packages, e.g.
  - Concurrency
  - App components



Android Runtime: Core Android Libraries

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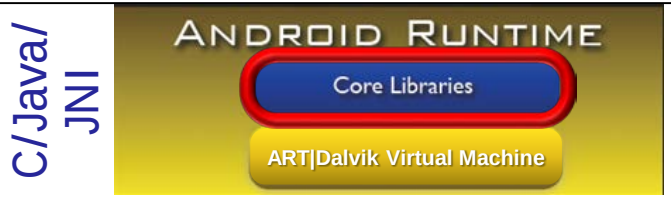
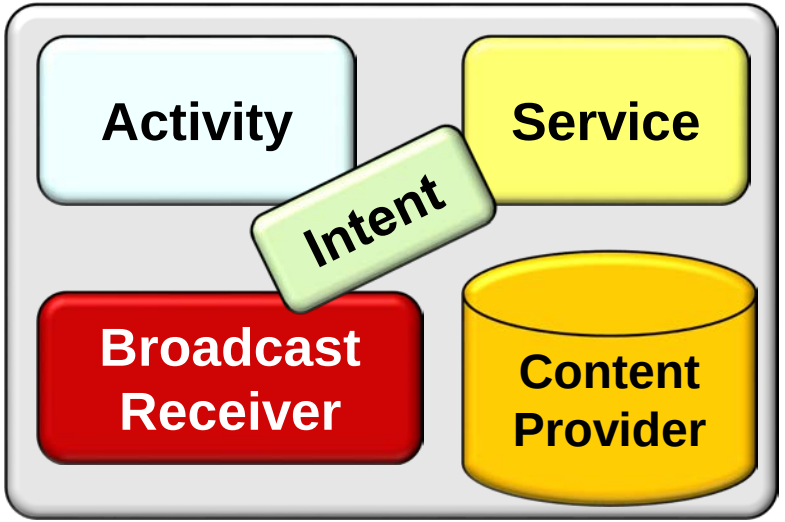
  - App components
    - Building blocks of mobile apps that provide hooks that Android uses to control an app's lifecycle





See developer.android.com/guide/components/fundamentals.html#Components

Android Runtime: Core Android Libraries

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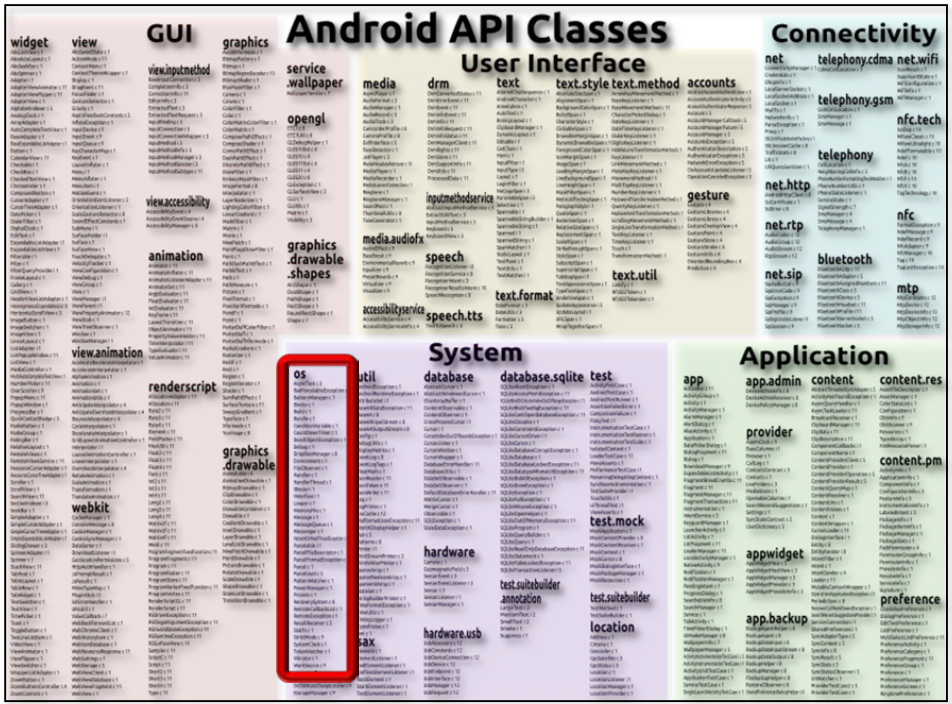
  - App components
  - Binder IPC framework

C/Java/JNI



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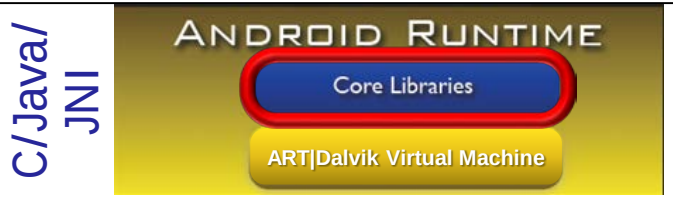
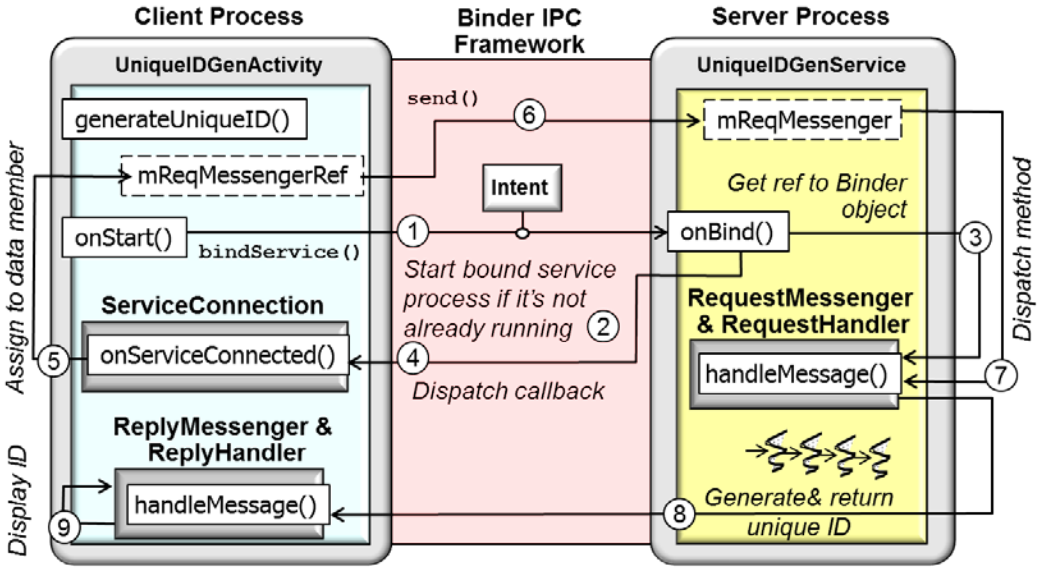
  - App components
  - Binder IPC framework
    - Enables sync & async communication between components on a device

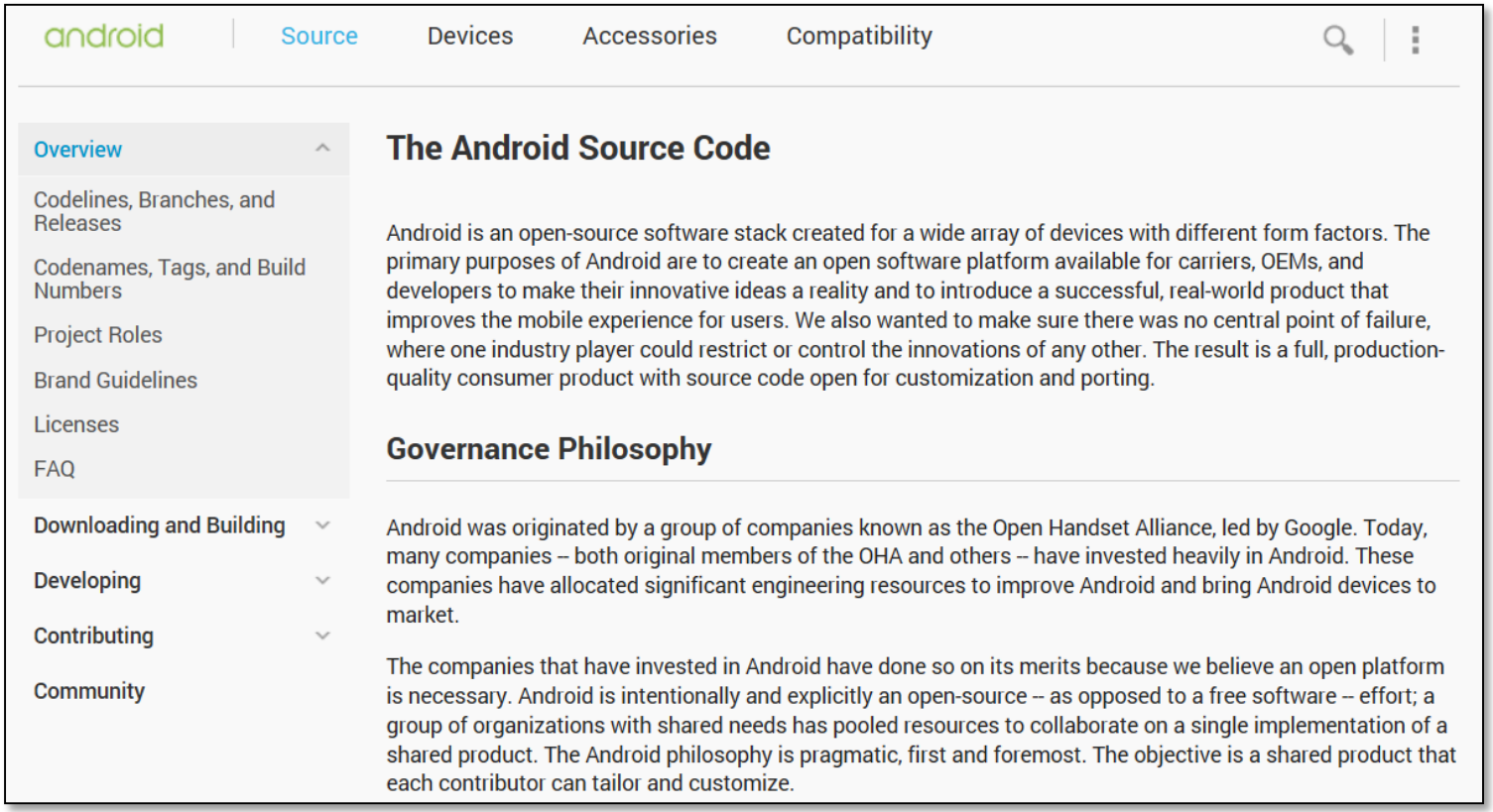




See elinux.org/Android_Binder

Android Runtime: Core Android Libraries

- The source code for all the core Java & Android libraries is available online



See source.android.com

Overview of Android Native C/C++ Libraries

Android Native C/C++ Libraries

- Although Android apps are written using Java APIs, *implementations* of these APIs are often written in C/C++

Goal is to enhance system performance w/out sacrificing developer productivity

Android Native C/C++ Libraries

C++/C

- Although Android apps are written using Java APIs, *implementations* of these APIs are often written in C/C++
  - Java & C/C++ are combined via the Java Native Interface (JNI)

JNI Tips

JNI is the Java Native Interface. It defines a way for managed code (written in the Java programming language) to interact with native code (written in C/C++). It's vendor-neutral, has support for loading code from dynamic shared libraries, and while cumbersome at times is reasonably efficient.

If you're not already familiar with it, read through the Java Native Interface Specification to get a sense for how JNI works and what features are available. Some aspects of the interface aren't immediately obvious on first reading, so you may find the next few sections handy.

See developer.android.com/training/articles/perf-jni.html

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  - JNI defines a standard way for managed Java code to interact with native code written in C/C++

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- Android's Native Development Kit (NDK) allows the implementation of apps & services using native C/C++ code

See developer.android.com/ndk

Android Native C/C++ Libraries

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  - Using the NDK on *portions* of code can help enhance performance by minimizing latency, maximizing throughput, & conserving key system resources

Resist the urge to develop all of your apps using the NDK!

Android Native C/C++ Libraries

- Android's Native Development Kit (NDK) allows the implementation of apps & services using native C/C++ code
  - Using the NDK on *portions* of code can help enhance performance by minimizing latency, maximizing throughput, & conserving key system resources

- It can also be used to integrate existing C/C++ libraries into Android apps

Android Native C/C++ Libraries

C++/C

- **System C library**
  - bionic libc
- **Surface Manager**
  - display management
- **Media Framework**
  - audio/video streaming
- **FreeType**
  - library for rendering fonts
- **Webkit**
  - web browser engine
- **OpenGL ES, SGL**
  - graphics engines
- **SQLite**
  - relational database engine
- **SSL**
  - secure sockets layer

Android native libraries are open source & often have Java wrapper facades

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Enables developers to write native system services for Android

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Composites 2D & 3D graphic layers from multiple apps

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Supports audio-video streaming in the background

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Renders bitmap & vector fonts

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Framework used on mobile & non-mobile platforms for web browsing

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Supports 2D & 3D vector graphics, e.g., often used for gaming apps

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Relational database engine that performs CRUD operations on persistent data

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  - library for rendering fonts
- **Webkit**
  - web browser engine
- **OpenGL ES, SGL**
  - graphics engines
- **SQLite**
  - relational database engine
- **SSL**
  - secure sockets layer

Ensures confidentiality & integrity for web interactions (e.g., e-commerce)

Android Native C/C++ Libraries

C++/C

- **System C library**
  - bionic libc
- **Surface Manager**
  - display management
- **Media Framework**
  - audio/video streaming
- **FreeType**
  - library for rendering fonts
- **Webkit**
  - web browser engine
- **OpenGL ES, SGL**
  - graphics engines
- **SQLite**
  - relational database engine
- **SSL**
  - secure sockets layer

Native C/C++ libraries use non-Java concurrency libraries, e.g., POSIX pthreads

End of Infrastructure Middleware (Part 3): the Android Runtime Core & Native Libraries