Embedded Android Workshop

Embedded Linux Conference 2012

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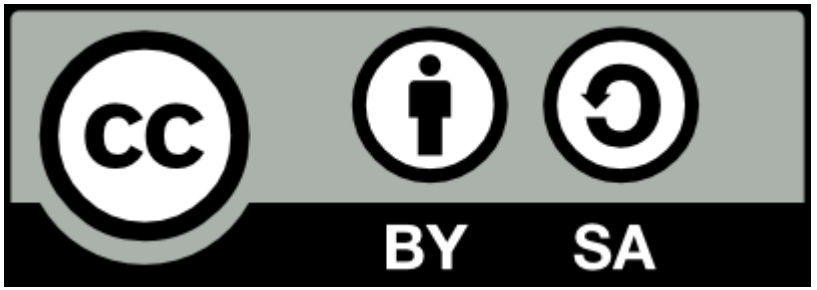

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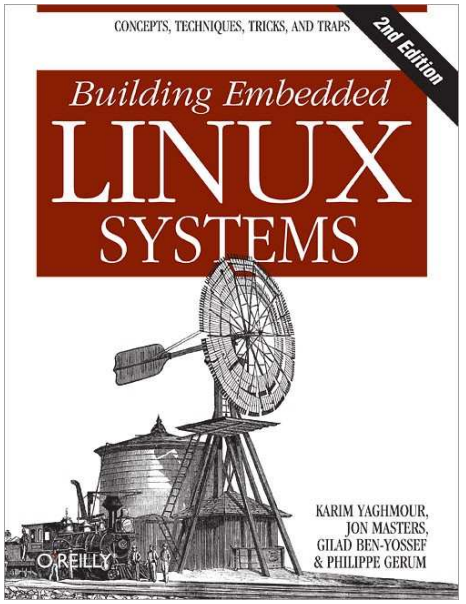
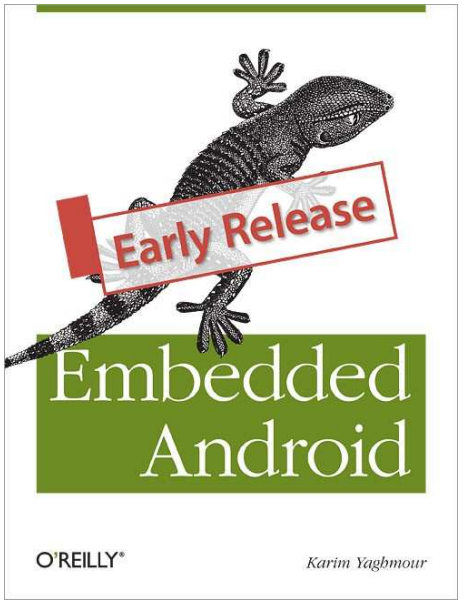
About

- Author of:





- Introduced Linux Trace Toolkit in 1999
- Originated Adeos and relayfs (kernel/relay.c)
- Training, Custom Dev, Consulting, ...

About Android

- Huge
- Fast moving
- Stealthy

Introduction to Embedded Android

- Basics
- History
- Ecosystem
- Legal framework
- Platform and hardware requirements
- Development tools

1. Basics

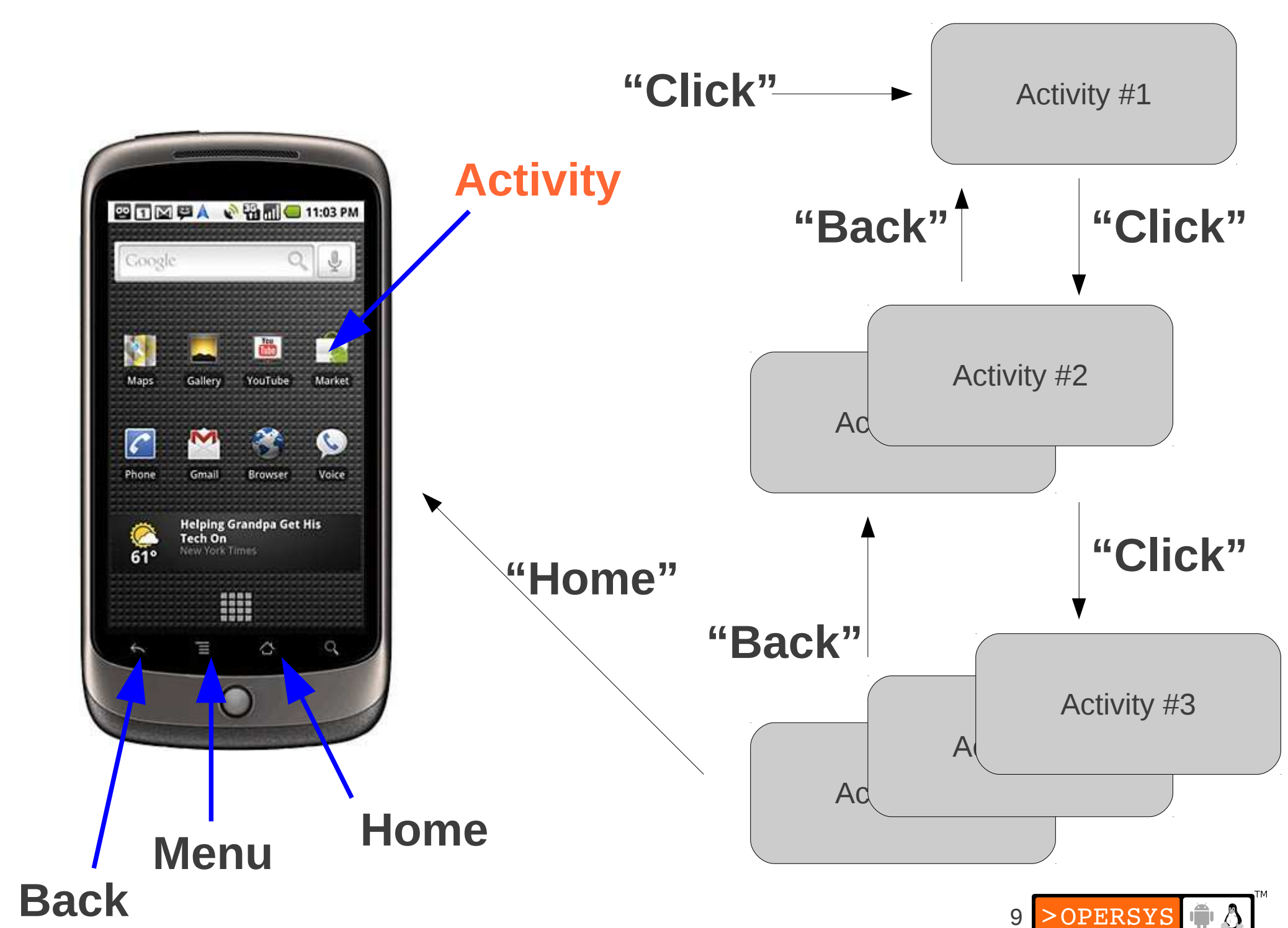
- Features
- UX Concepts
- App Concepts

1.1. Features

- Application framework enabling reuse and replacement of components
- Dalvik virtual machine optimized for mobile devices
- Integrated browser based on the open source WebKit engine
- Optimized graphics powered by a custom 2D graphics library; 3D graphics based on the OpenGL ES 1.0 specification (hardware acceleration optional)
- SQLite for structured data storage
- Media support for common audio, video, and still image formats (MPEG4, H.264, MP3, AAC, AMR, JPG, PNG, GIF)
- GSM Telephony (hardware dependent)
- Bluetooth, EDGE, 3G, and WiFi (hardware dependent)
- Camera, GPS, compass, and accelerometer (hardware dependent)
- Rich development environment including a device emulator, tools for debugging, memory and performance profiling, and a plugin for the Eclipse IDE

1.2. UX Concepts

- Browser-like
- iPhone-ish
- No user-concept of “task”
- Main keys:
  - HOME
  - SEARCH
  - BACK
  - MENU
- App-model allows users to safely install/test almost anything


“Click”
Activity #1
Activity
“Back”
“Click”
Activity #2
“Home”
“Click”
“Back”
Activity #3
Back
Menu
Home
11:03 PM
Google
Maps
Gallery
YouTube
Market
Phone
Gmail
Browser
Voice
Helping Grandpa Get His Tech On
New York Times
61°

1.3. App Concepts

- No single entry point (No main() !?!?)
- Unlike Windows or Unix API/semantics in many ways
- Processes and apps will be killed at random: developer must code accordingly
- UI disintermediated from app “brains”
- Apps are isolated, very
- Behavior predicated on low-memory conditions

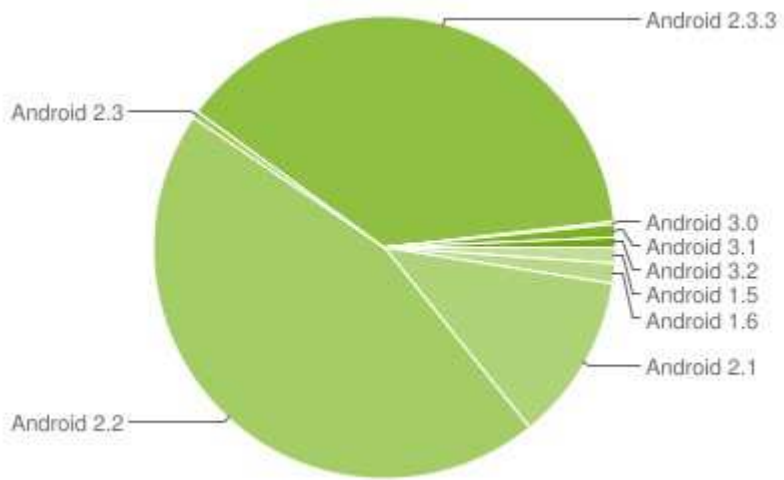
2. History

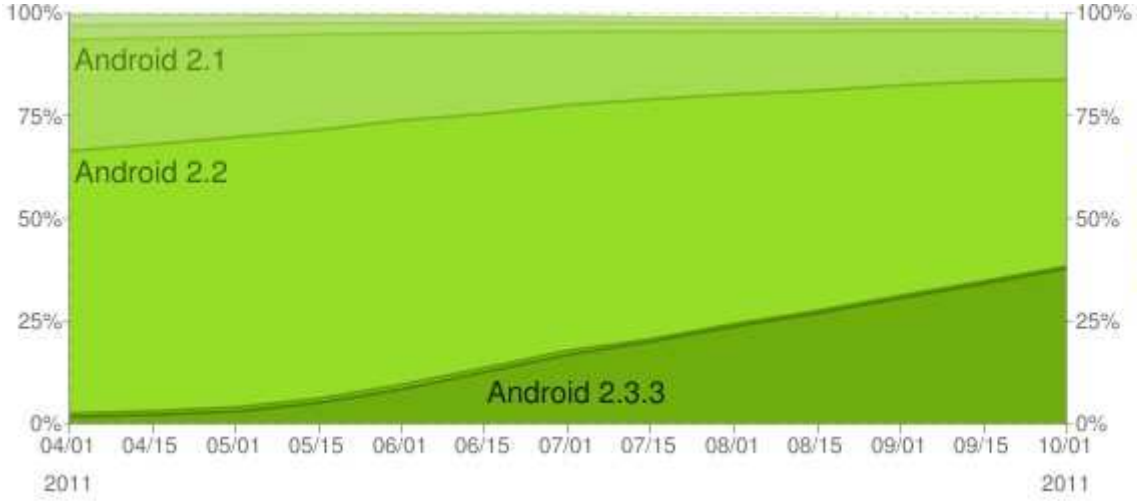
- 2002:
  - Sergey Brin and Larry Page started using Sidekick smartphone
  - Sidekick one of 1st smartphones integrating web, IM, mail, etc.
  - Sidekick was made by Danger inc., co-founded by Andy Rubin (CEO)
  - Brin/Page met Rubin at Stanford talk he gave on Sidekick's development
  - Google was default search engine on Sidekick
- 2004:
  - Despite cult following, Sidekick wasn't making $
  - Danger inc. board decided to replace Rubin
  - Rubin left. Got seed $. Started Android inc. Started looking for VCs.
  - Goal: Open mobile hand-set platform
- 2005 - July:
  - Got bought by Google for undisclosed sum :)
- 2007 - November:
  - Open Handset Alliance announced along with Android

- 2008 - Sept.: Android 1.0 is released
- 2009 - Feb.: Android 1.1
- 2009 - Apr.: Android 1.5 / Cupcake
- 2009 - Sept.: Android 1.6 / Donut
- 2009 - Oct.: Android 2.0/2.1 / Eclair
- 2010 - May: Android 2.2 / Froyo
- 2010 - Dec.: Android 2.3 / Gingerbread
- 2011 - Jan : Android 3.0 / Honeycomb – Tablet-optimized
- 2011 – May: Android 3.1 – USB host support
- 2011 – Nov: Android 4.0 / Ice-Cream Sandwich – merge Gingerbread and Honeycomb

3. Ecosystem

- 350k phone activations per day
- 150k apps (vs. 350k for Apple's app store)
- 1/3 of new smartphones sold in US
- ...





3.1. Who's playing?

- Leading IP:
  - Google
- Semiconductor manufacturers:
  - ARM, Intel, Freescale, TI, Qualcomm, NVIDIA, ...
- Handset manufacturers:
  - Motorola, Samsung, HTC, LG, Sony-Ericsson, ...
- Tablet manufacturers:
  - Motorola, Samsung, Archos, DELL, ASUS, ...
- Special-purpose devices:
  - Nook, Joint Battle Command-Platform, ...
- App stores:
  - Android Market, Amazon App Store, V CAST Apps, B&N NOOK Apps, ...

3.2. Open Handset Alliance

- “... a group of 80 technology and mobile companies who have come together to accelerate innovation in mobile and offer consumers a richer, less expensive, and better mobile experience. Together we have developed Android™, the first complete, open, and free mobile platform.”
- Unclear what OHA does or what benefits, if any, members derive
- Not an organization with board members, staff, etc. ... just an “Alliance”
- Google's Android team are the lead on all bleeding edge dev, all else tag along
- OHA is largely inactive / absent
- Comprised of:
  - Mobile Operators: Sprint, T-Mobile, Vodafone, NTT Docomo, ...
  - Handset Manufacturers: HTC, Motorola, LG, Samsung, Sony Ericsson, ...
  - Semiconductor Companies: ARM, Freescale, Intel, NVIDIA, Qualcomm, TI, ...
  - Software Companies: Google, ...
  - Commercialization Companies: ...

4. Legal Framework

- Code access
- Code licenses
- Branding use
- Google's own Android Apps
- Alternative App stores
- Oracle v. Google

4.1. Code Access

- Parts:
  - Kernel
  - Android Open Source Project (AOSP)
- Kernel:
  - Should have access to latest shipped version => GPL requirement
  - Google-maintained forks at android.git.kernel.org
- AOSP:
  - *Usually* Code-drops every 6 months
  - Official AOSP branches at android.git.kernel.org
  - Managed by “repo” tool, an overlay to “git”
- Honeycomb (3.0) code requires talking to Google
  - ... which hasn't precluded moders from lifting binaries off the SDK and putting Honeycomb on all sorts of devices, including B&N's Nook ...

4.2. Code Licenses

- Kernel:
  - GNU General Public License (a.k.a. GPL)
- AOSP:
  - Mostly Apache License 2.0 (a.k.a. ASL)
  - Having GPL-free user-space was a design goal
  - A few GPL and LGPL parts: mainly BlueZ and DBUS
  - Some key components in BSD: Bionic and Toolbox
  - “external/” directory contains a mixed bag of licenses, incl. lots of GPL
- May be desirable to add GPL/LGPL components:
  - BusyBox
  - uClibc / eglibc / glibc

4.3. Branding Use

- Android Robot:
  - Very much like the Linux penguin

- Android Logo (A-N-D-R-O-I-D w/ typeface):
  - Cannot be used
- Android Custom Typeface:
  - Cannot be used
- Android in Official Names:
  - As descriptor only: “for Android”
  - Most other uses require approval
- Android in Messaging:
  - Allowed if followed by a generic: “Android Application”
- Compliance through CDD/CTS involved in “approval”

4.4. Google's own Android Apps

- The non-AOSP apps:
  - Android Market
  - YouTube
  - Maps and Navigation
  - Gmail
  - Voice
  - SkyMap
  - ...
- Require:
  - CTS/CDD Compliance
  - Signed agreement w/ Google
- Inquiries: android-partnerships@google.com

4.5. Alternative “App Stores”

- A couple of stores are already public:
  - Android Market
  - Amazon App Store
  - V CAST Apps
  - B&N NOOK Apps
  - ...
- Nothing precluding you from having your own

4.6. Oracle v. Google

- Filed August 2010
- Patent infringement:
  - 6,125,447; 6,192,476; 5,966,702; 7,426,720; RE38,104; 6,910,205; and 6,061,520
- Copyright infringement:
- Android does not use any Oracle Java libraries or JVM in the final product.
- Android relies on Apache Harmony and Dalvik instead.
- In October 2010, IBM left Apache Harmony to join work on Oracle's OpenJDK, leaving the project practically orphaned.
- In May 2011, judge orders claims cut from 132 to 3 and prior art references cut from hundreds to 8

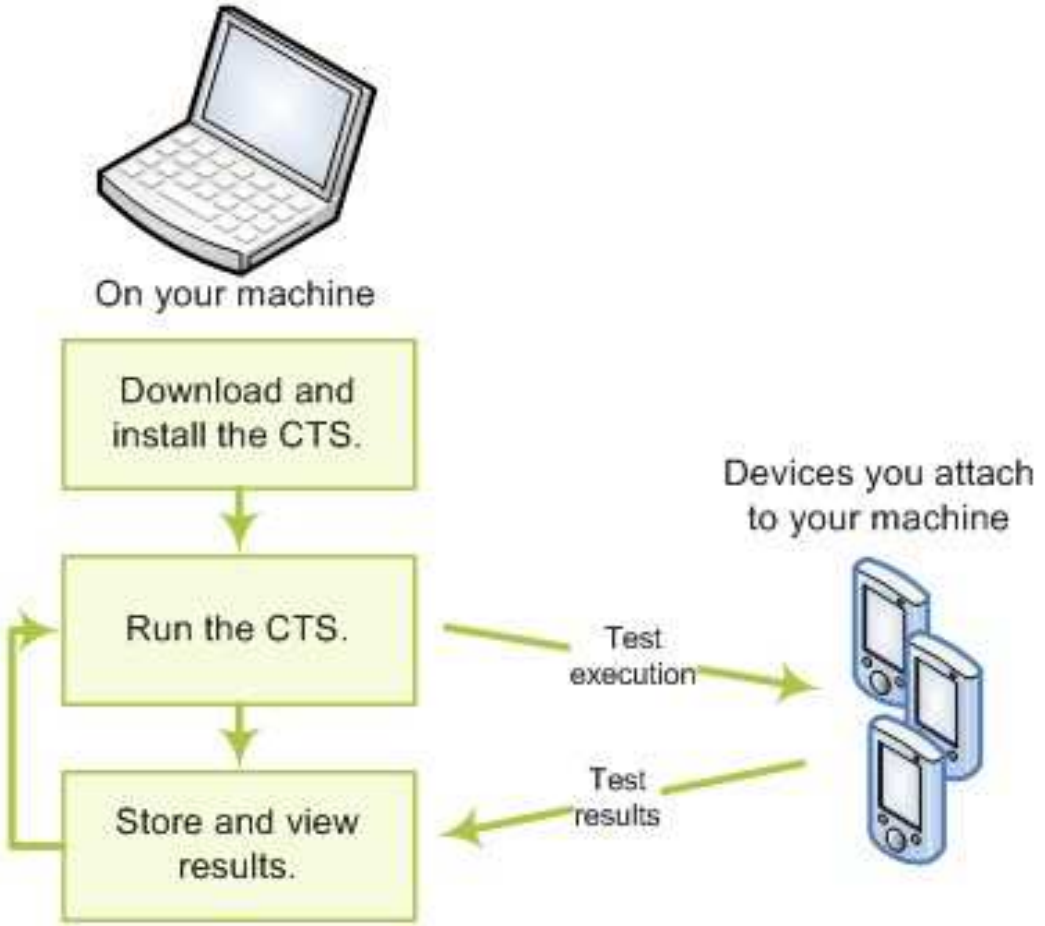
5. Platform and Hardware requirements

- In principle:
  - Android runs on top of Linux
  - Therefore: if it runs Linux, it can run Android
- Known to have been made to work on:
  - ARM
  - x86
  - MIPS
  - SuperH
- Put in all sort of devices:
  - Washers, micro-wave ovens, car systems, etc.

5.1. Compliance Definition Document

- Software: MUST conform to AOSP
- Application Packaging Compatibility: support “.apk” files
- Multimedia Compatibility: decoders, encoders, recording, ...
- Developer Tool Compatibility: adb, ddms, Monkey
- Hardware compatibility:
  - Display and Graphics
  - Input Devices
  - Data Connectivity
  - Cameras
  - Memory and Storage
  - USB
- Performance Compatibility
- Security Model Compatibility
- Software Compatibility Testing
- Updatable Software: MUST include mechanism to update

5.2. Compatibility Test Suite



6. Development tools

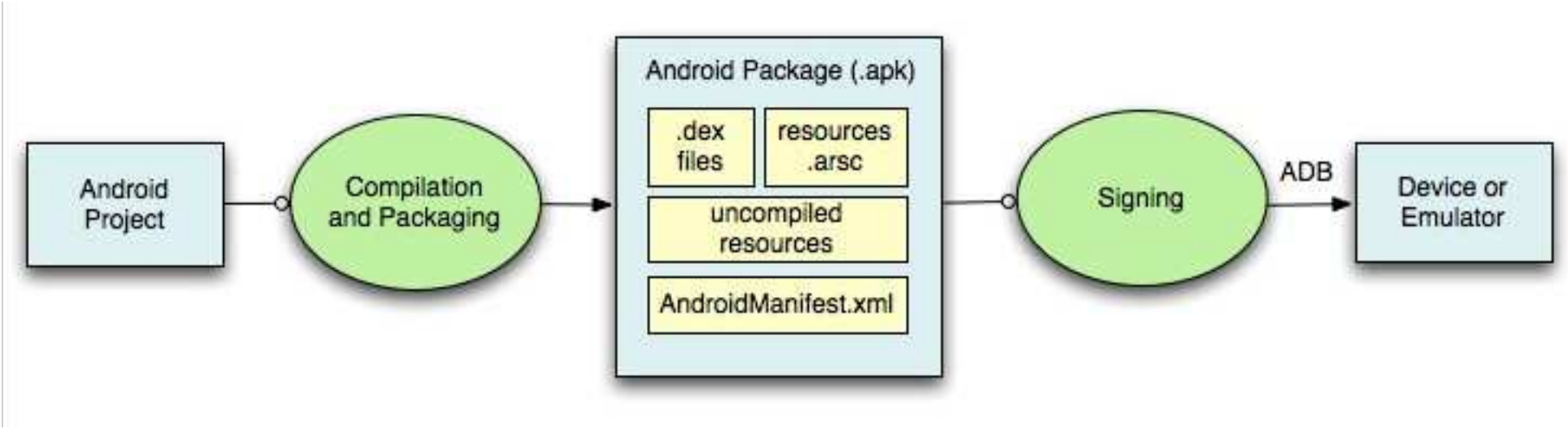
- Requirements
- App dev tools and resources
- App debugging

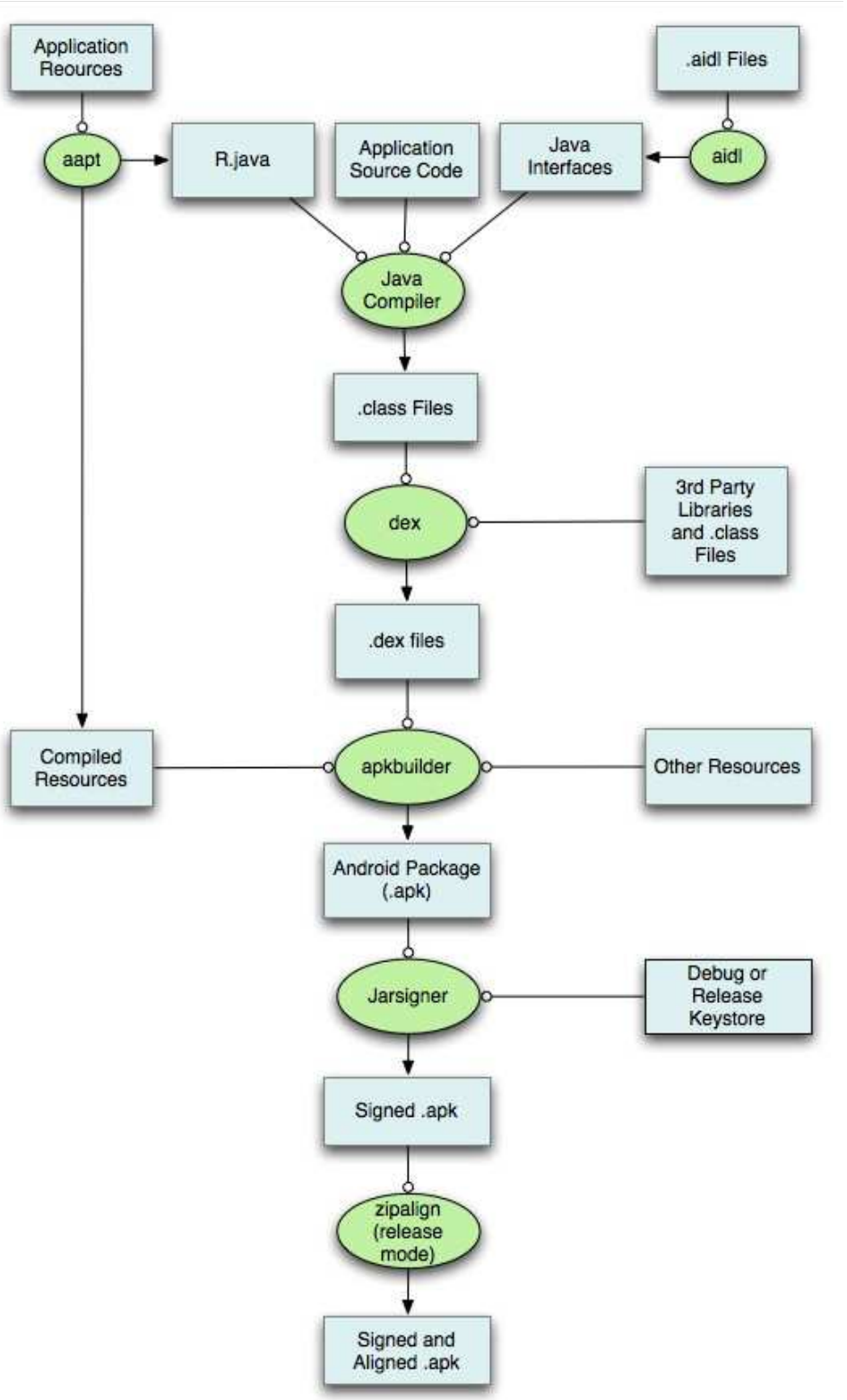
6.1. Requirements

- App development and debugging:
  - Windows / Mac / Linux workstation
  - JDK
  - Eclipse w/ ADT plugin
  - Highly recommended: real device(**S**)
- Platform development:
  - GNU cross-dev toolchain
  - JTAG debugger
  - ... more on this later

6.2. App dev tools and resources

- SDK:
  - android – manage AVDs and SDK components
  - apkbuilder – creating .apk packages
  - dx – converting .jar to .dex
  - adb – debug bridge
  - ...
- Emulator – QEMU-based ARM emulator
  - Use KVM for x86 instead
- NDK: GNU toolchain for native binaries
- Documentation: developer.android.com


Android Project
Compilation and Packaging
Android Package (.apk)
.dex files
resources .arsc
uncompiled resources
AndroidManifest.xml
Signing
ADB
Device or Emulator


Application Reources
.aidl Files
aapt
R.java
Application Source Code
Java Interfaces
aidl
Java Compiler
.class Files
dex
3rd Party Libraries and .class Files
.dex files
Compiled Resources
apkbuilder
Other Resources
Android Package (.apk)
Jarsigner
Debug or Release Keystore
Signed .apk
zipalign (release mode)
Signed and Aligned .apk

6.3. App debugging

- adb
- ddms
- monkeyrunner
- traceview
- logcat
- Eclipse integration (ADT plugin)

Concepts and Internals

1. Android Concepts
2. Framework Intro
3. Native Development
4. Overall Architecture
5. System startup
6. Linux Kernel
7. Hardware Support
8. Native User-Space
9. Dalvik
10. JNI
11. System Server
12. Calling on Services
13. Activity Manager
14. Binder
15. Stock AOSP Apps

1. Android Concepts

- Components
- Intents
- Component lifecycle
- Manifest file
- Processes and threads
- Remote procedure calls

1.1. Components

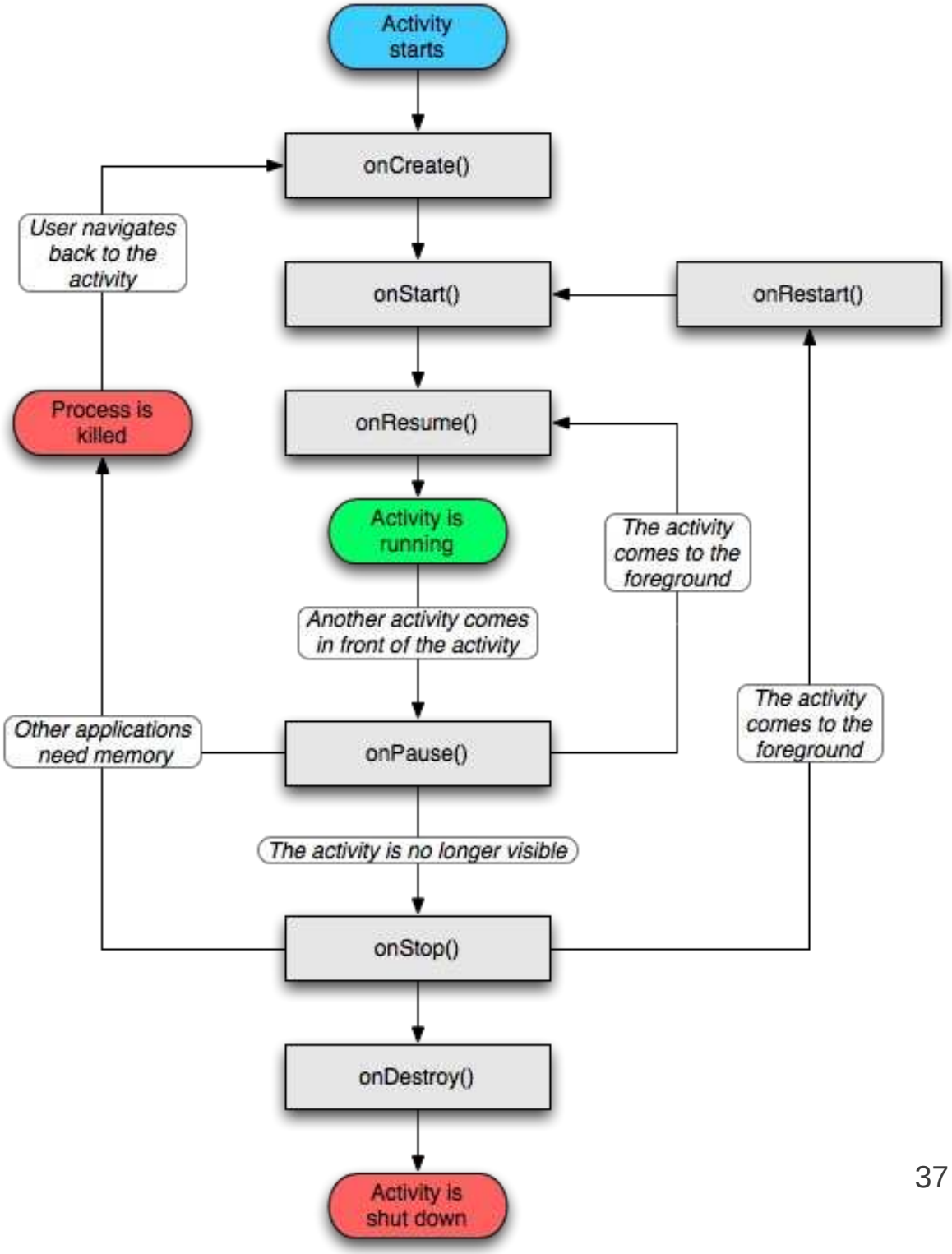
- 1 App = N Components
- Apps can use components of other applications
- App processes are automagically started whenever any part is needed
- Ergo: N entry points, !1, and !main()
- Components:
  - Activities
  - Services
  - Broadcast Receivers
  - Content Providers

1.2. Intents

- Intent = asynchronous message w/ or w/o designated target
- Like a polymorphic Unix signal, but w/o required target
- Intents “payload” held in Intent Object
- Intent Filters specified in Manifest file

1.3. Component lifecycle

- System automagically starts/stops/kills processes:
  - Entire system behaviour predicated on low memory
- System triggers Lifecycle callbacks when relevant
- Ergo: Must manage Component Lifecycle
- Some Components are more complex to manage than others


Activity starts
onCreate()
User navigates back to the activity
onStart()
onRestart()
Process is killed
onResume()
Activity is running
The activity comes to the foreground
Another activity comes in front of the activity
Other applications need memory
onPause()
The activity comes to the foreground
The activity is no longer visible
onStop()
onDestroy()
Activity is shut down

1.4. Manifest file

- Informs system about app's components
- XML format
- Always called AndroidManifest.xml
- Activity = <activity> ... static
- Service = <service> ... static
- Broadcast Receiver:
  - Static = <receiver>
  - Dynamic = Context.registerReceiver()
- Content Provider = <provider> ... static

1.5. Processes and threads

- Processes
  - Default: all callbacks to any app Component are issued to the main process thread
  - <activity>—<service>—<recipient>—<provider> have process attribute to override default
  - Do NOT perform blocking/long operations in main process thread:
    - Spawn threads instead
  - Process termination/restart is at system's discretion
  - Therefore:
    - Must manage Component Lifecycle
- Threads:
  - Create using the regular Java Thread Object
  - Android API provides thread helper classes:
    - Looper: for running a message loop with a thread
    - Handler: for processing messages
    - HandlerThread: for setting up a thread with a message loop

1.6. Remote procedure calls

- Android RPCs = Binder mechanism
- No Sys V IPC due to in-kernel resource leakage
- Binder is a low-level functionality, not used as-is
- Instead: must define interface using Interface Definition Language (IDL)
- IDL fed to aidl Tool to generate Java interface definitions

2. Framework Introduction

- UI
- Data storage
- Security/Permissions
- ... and much more ... :
  - Graphics
  - Audio and Video
  - Location and Maps
  - Bluetooth
  - NFC

2.1. UI

- Everything based on hierarchy of Views and ViewGroups (layouts)
- Declared in XML or dynamically through Java
- UI components:
  - Widgets
  - Event handlers
  - Menus
  - Dialogs
  - Notifications
  - ...

2.2. Data storage

- Shared preferences
  - Private primitive key-pair values
- Internal storage
  - Private data on device memory
- External storage
  - Public data on shared external device (SD)
- SQLite DB
  - Private DB
- Network connection
  - Web-based storage (REST)

2.3. Security/Permissions

- Most security enforced at process level: UID, GID
- Permissions enforce restrictions on:
  - Per-process operations
  - Per-URI access
- Applications are sandboxed
- Specific permissions required to “exit” sandbox
- Decision to grant access based on:
  - Certificates
  - User prompts
- All permissions must be declared statically

3. Native development

- What it can and cannot do
- Getting and installing the NDK
- Using the NDK
- Implementing fully native apps

3.1. What it can and cannot do

- Useful for:
  - Porting existing body of code to Android
  - Developing optimized native apps, especially for gaming
- Provides:
  - Tools and build files to generate native code libraries from C/C++
  - Way to embed native libs into .apk
  - Set of stable (forward-compatible) native libs
  - Documentation, samples and tutorials
- Enables:
  - Calling native code from Java using JNI
  - Implementing fully native apps (since 2.3)
- Doesn't allow you to:
  - Compile traditional Linux/Unix apps as-is

3.2. Getting and installing the NDK

- What's in the NDK?
  - Development tools
  - Stable native APIs system headers
  - Documentation - IMPORTANT
  - Samples
- Getting the NDK
  - http://developer.android.com/sdk/ndk/index.html
- Prerequisites
  - Windows, Mac or Linux
  - Complete SDK
  - make (GNU's) and awk
  - For Windows, Cygwin 1.7 or higher
- NDK set up:
  - Make sure prerequisites are installed
  - Download and install NDK

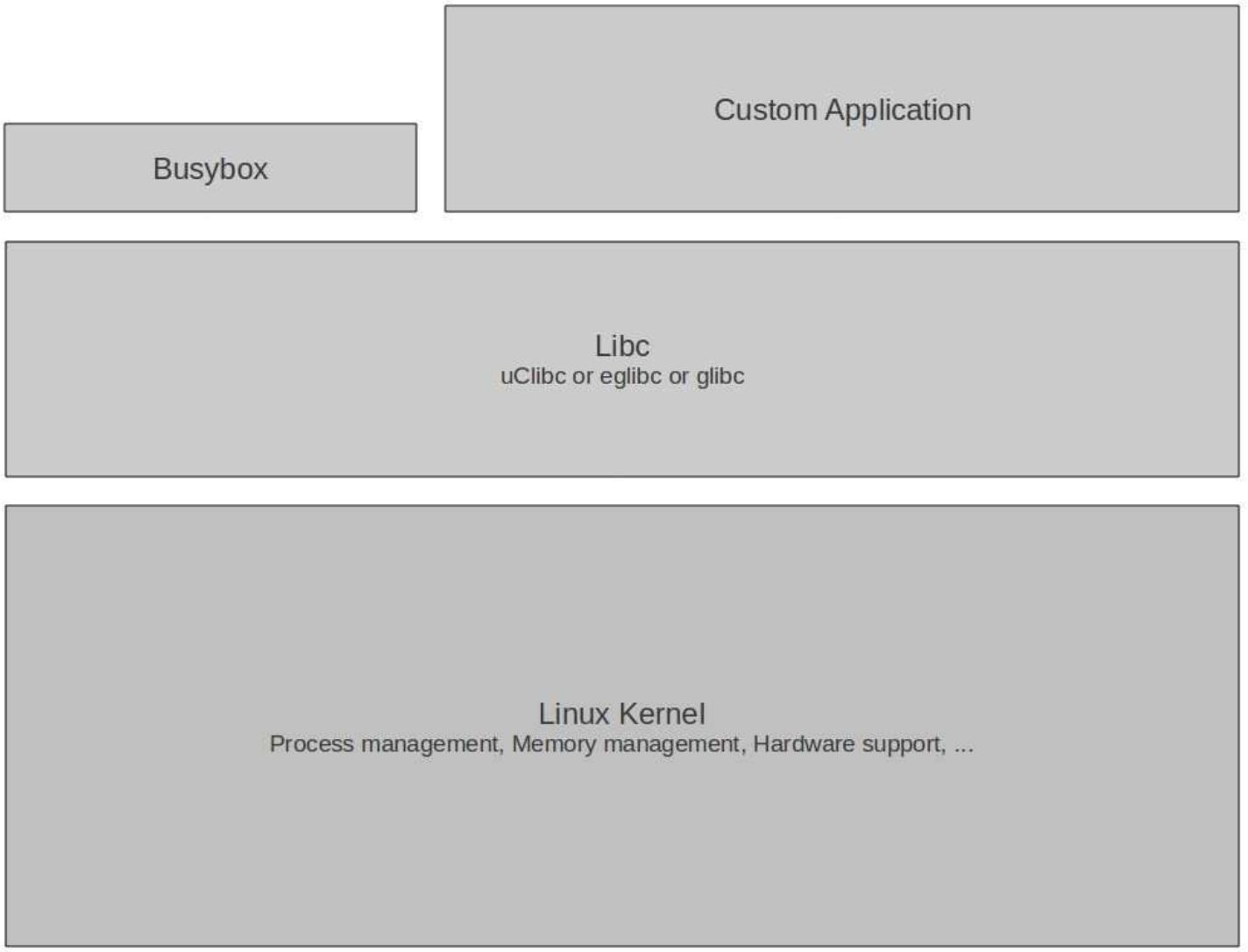
3.3. Using the NDK

1. Place native code under <project>/jni/...
2. Create <project>/jni/Android.mk to describe native code to NDK
3. Optional: create <project>/jni/Application.mk for describing which natives sources are required by app
4. Build native code:
   - cd <project>
   - <ndk>/ndk-build
5. Compile app with SDK. Native code will be shared lib in .apk file.

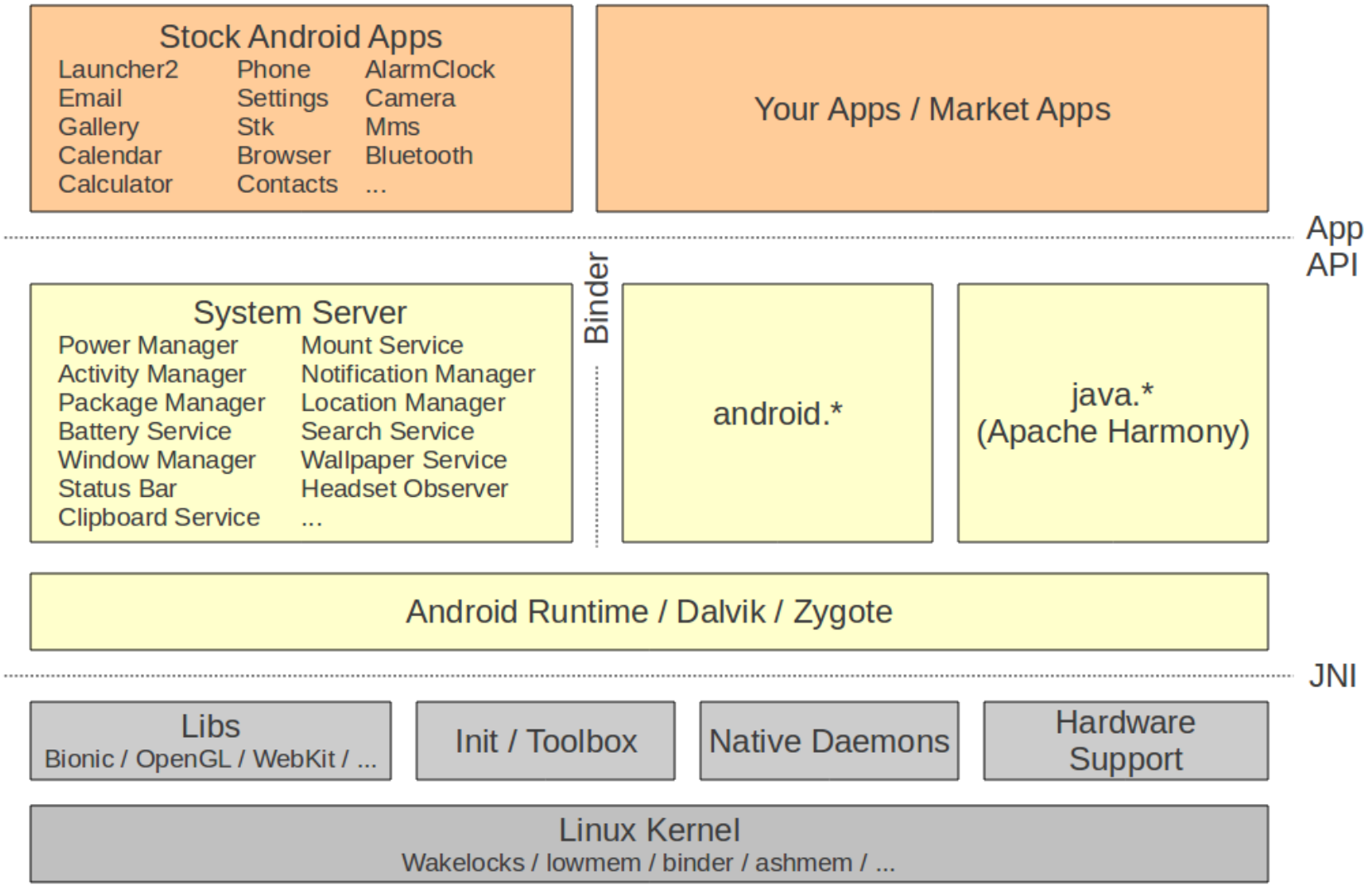
3.4. Implementing fully native apps

- Android 2.3 and up
- Native lifecycle management
- Still runs within context of dedicated Dalvik VM
- Can use JNI to call on Java functions
- Limited API:
  - Activity lifecycle management
  - Input events and sensors
  - Window management
  - Direct access to assets
- Make sure your activity is called: “android.app.NativeActivity”

4.1. Overall Architecture - EL



4.2. Overall Architecture - Android



5. System Startup

- Bootloader
- Kernel
- Init
- Zygote
- System Server
- Activity Manager
- Launcher (Home)

5.1. Bootloader

- aosp/bootable/bootloader
  - Custom bootloader for Android
  - USB-based
  - Implements the “fastboot” protocol
  - Controlled via “fastboot” cli tool on host
- aosp/bootable/recovery
  - UI-based recovery boot program
  - Accessed through magic key sequence at boot
  - Usually manufacturer specific variant

- Flash layout:

```
0x000003860000-0x000003900000 : "misc"
0x000003900000-0x00003e00000 : "recovery"
0x00003e00000-0x00004300000 : "boot"
0x00004300000-0x0000c300000 : "system"
0x0000c300000-0x0000183c0000 : "userdata"
0x0000183c0000-0x00001dd20000 : "cache"
0x00001dd20000-0x00001df20000 : "kpanic"
0x00001df20000-0x00001df60000 : "dinfo"
0x00001df60000-0x00001dfc0000 : "setupdata"
0x00001dfc0000-0x00001e040000 : "splash1"
0x000000300000-0x000001680000 : "modem"
```

Kernel
/system
/data
/cache

From Acer Liquid-E

5.2. Kernel

- Early startup code is very hardware dependent
- Initializes environment for the running of C code
- Jumps to the architecture-independent start_kernel() function.
- Initializes high-level kernel subsystems
- Mounts root filesystem
- Starts the init process

5.3. Android Init

- Open, parses, and runs /init.rc:
  - Create mountpoints and mount filesystems
  - Set up filesystem permissions
  - Set OOM adjustments properties
  - Start daemons:
    - adbd
    - servicemanager (binder context manager)
    - vold
    - netd
    - rild
    - app_process -Xzygote (Zygote)
    - mediaserver
    - ...

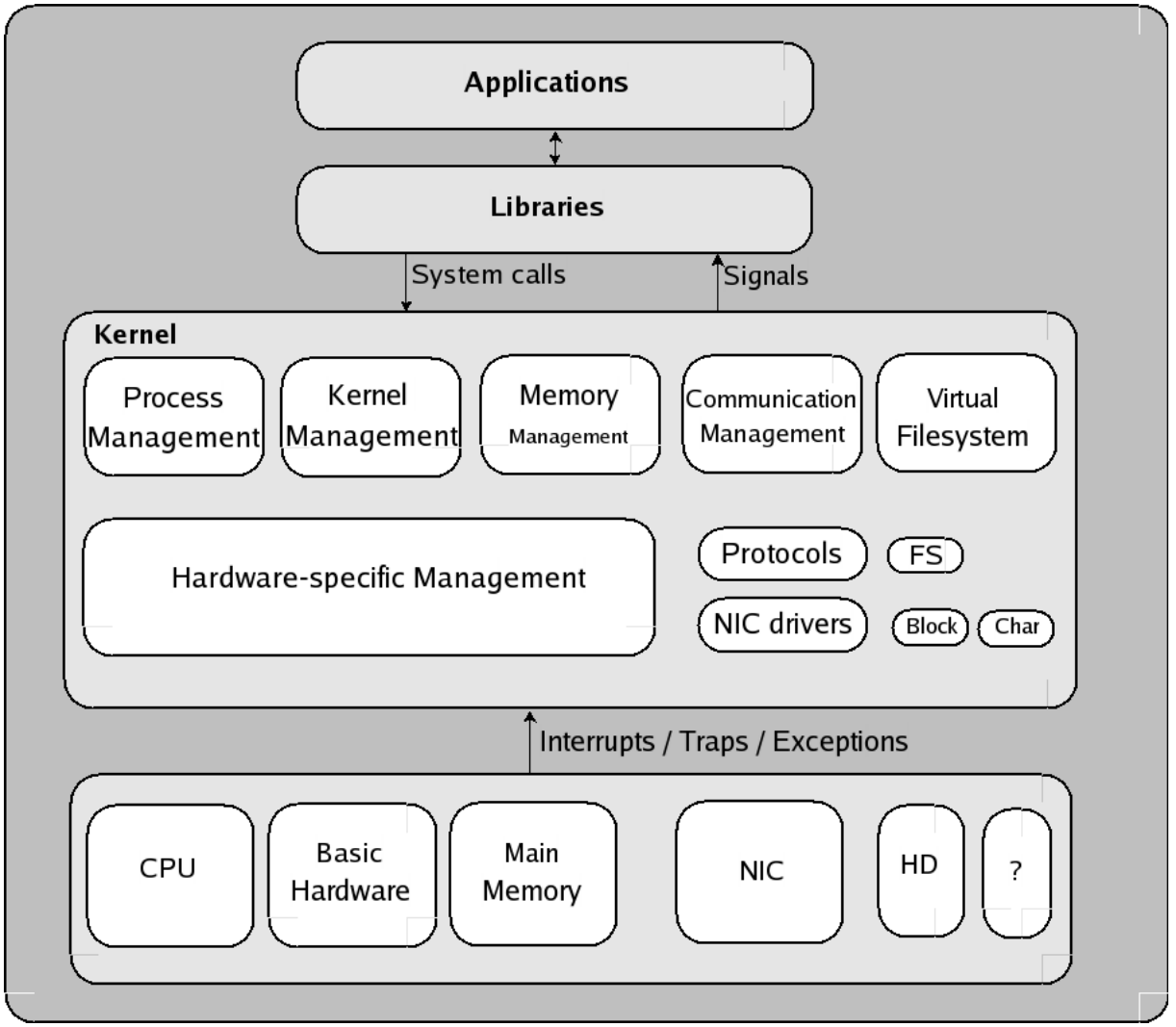
5.4. Zygote, etc.

- Init:
  - app_process -Xzygote (Zygote)
- frameworks/base/cmds/app_process/app_main.cpp:
  - runtime.start(“com.android.internal.os.Zygote”, ...
- frameworks/base/core/jni/AndroidRuntime.cpp:
  - startVM()
  - Call Zygote's main()
- frameworks/base/core/java/com/android/internal/os/ZygoteInit.java:
  - ...

- preloadClasses()
- startSystemServer()
- ... magic ...
- Call SystemServer's run()

- frameworks/base/services/java/com/android/server/SystemServer.java:
  - Start **all** system services/managers
  - Start ActivityManager:
    - Send Intent.CATEGORY_HOME
    - Launcher2 kicks in

6. Linux Kernel



6.1. Androidisms

- Wakelocks
- lowmem handler
- Binder
- ashmem – Anonymous Shared Memory
- RAM console
- Logger
- ...

7. Hardware support

Bluetooth	BlueZ through D-BUS IPC (to avoid GPL contamination it seems)
GPS	Manufacturer-provided libgps.so
Wifi	wpa_supplicant
Display	Std framebuffer driver (/dev/fb0)
Keymaps and Keyboards	Std input event (/dev/event0)
Lights	Manufacturer-provided liblights.so
Backlight	
Keyboard	
Buttons	
Battery	
Notifications	
Attention	
Audio	Manufacturer-provided libaudio.so (could use ALSA underneath ... at least as illustrated in their porting guide)
Camera	Manufacturer-provided libcamera.so (could use V4L2 kernel driver underneath ... as illustrated in porting guide)
Power Management	“Wakelocks” kernel patch
Sensors	Manufacturer-provided libsensors.so
Accelerometer	
Magnetic Field	
Orientation	
Gyroscope	
Light	
Pressure	
Temperature	
Proximity	
Radio Layer Interface	Manufacturer-provided libril-<companyname>-<RIL version>.so

8. Native User-Space

- Mainly
  - /data => User data
  - /system => System components
- Also found:
  - /dev
  - /proc
  - /sys
  - /sbin
  - /mnt
  - /cache
  - Etc.

- Libs:

  Bionic, SQLite, SSL, OpenGL|ES,

  Non-Posix: limited Pthreads support, no SysV IPC
- Toolbox
- Daemons:

  servicemanager, vold, rild, netd, adbd, ...

9. Dalvik

- Sun-Java =

  Java language + JVM + JDK libs
- Android Java =

  Java language + Dalvik + Apache Harmony
- Target:
  - Slow CPU
  - Relatively low RAM
  - OS without swap space
  - Battery powered
- Now has JIT

9.1. Dalvik's .dex files

- JVM munches on “.class” files
- Dalvik munches on “.dex” files
- .dex file = .class files post-processed by “dx” utility
- Uncompressed .dex = 0.5 * Uncompressed .jar

10. JNI – Java Native Interface

- Call gate for other languages, such as C, C++
- Equivalent to .NET's pinvoke
- Usage: include and call native code from App
- Tools = NDK ... samples included
- Check out *“JNI Programmer's Guide and Specification”* - freely available PDF

11. System Server

Entropy Service
Power Manager
Activity Manager
Telephone Registry
Package Manager
Account Manager
Content Manager
System Content Providers
Battery Service
Lights Service
Vibrator Service
Alarm Manager
Init Watchdog
Sensor Service
Window Manager
Bluetooth Service
Device Policy
Status Bar
Clipboard Service
Input Method Service
NetStat Service
NetworkManagement Service
Connectivity Service
Throttle Service
Accessibility Manager
Mount Service
Notification Manager
Device Storage Monitor
Location Manager
Search Service
DropBox Service
Wallpaper Service
Audio Service
Headset Observer
Dock Observer
UI Mode Manager Service
Backup Service
AppWidget Service
Recognition Service
Status Bar Icons
DiskStats Service
ADB Settings Observer

12. Calling on System Services

- Use getSystemService
- Ex: NotificationManager Object reference:

```
String ns = Context.NOTIFICATION_SERVICE;

NotificationManager mNotificationManager = (NotificationManager) \
getSystemService(ns);
```

- Prepare your content
- Call on the object:

```
mNotificationManager.notify(HELLO_ID, notification);
```

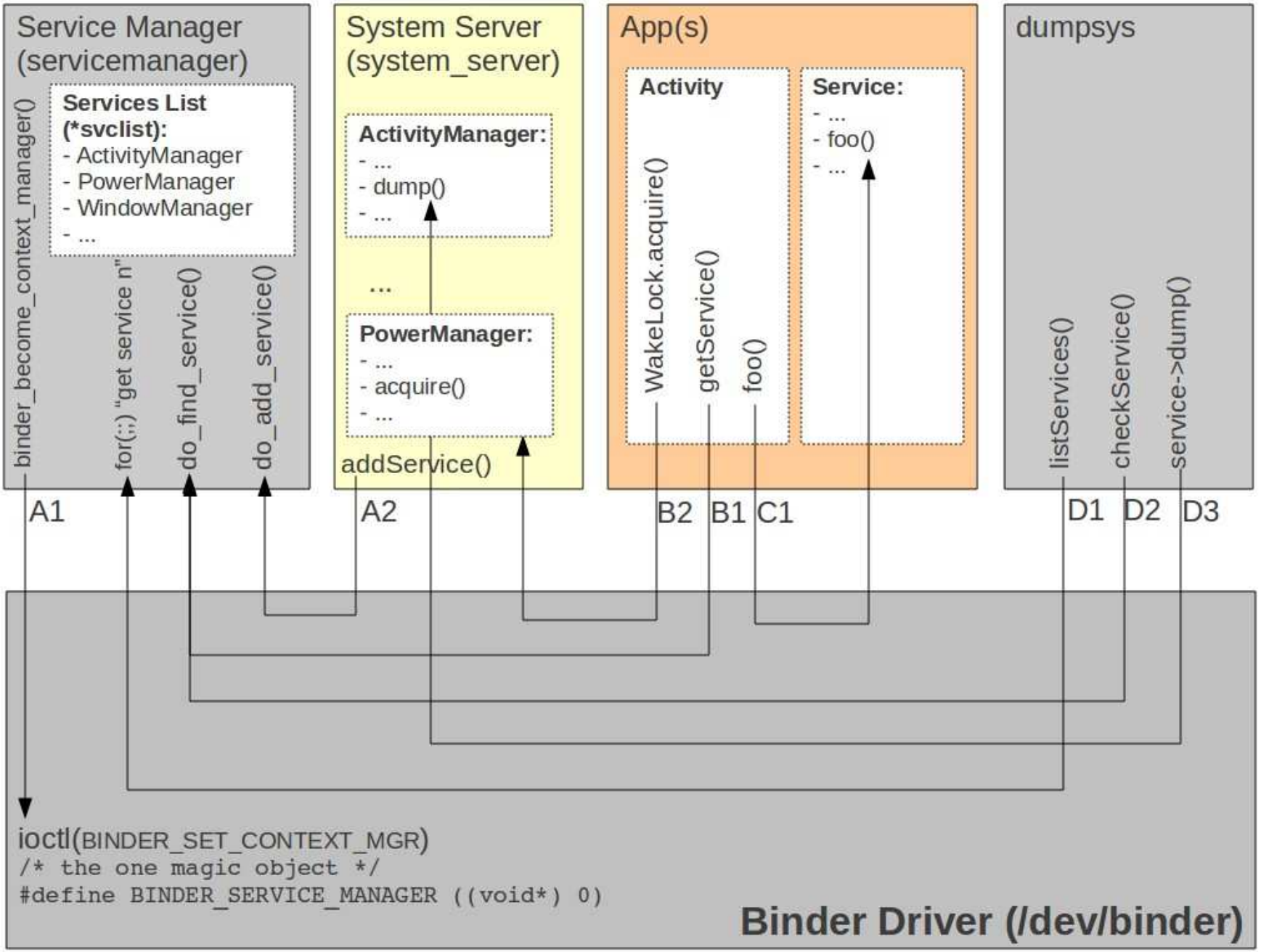
13. ActivityManager

- Start new Activities, Services
- Fetch Content Providers
- Intent broadcasting
- OOM adj. maintenance
- Application Not Responding
- Permissions
- Task management
- Lifecycle management

- Ex. starting new app from Launcher:
  - onClick(Launcher)
  - startActivity(Activity.java)
  - <*Binder*>
  - ActivityManagerService
  - startViaZygote(Process.java)
  - <*Socket*>
  - Zygote

14. Binder

- CORBA/COM-like IPC
- Data sent through “parcels” in “transactions”
- Kernel-supported mechanism
- /dev/binder
- Check /proc/binder/*
- android.* API connected to System Server through binder.


Service Manager
(servicemanager)
Services List
(*svclist):
- ActivityManager
- PowerManager
- WindowManager
- ...
binder_become_context_manager()
for(;;) "get service n"
do_find_service()
do_add_service()
System Server
(system_server)
ActivityManager:
- ...
- dump()
- ...
...
PowerManager:
- ...
- acquire()
- ...
addService()
App(s)
Activity
WakeLock.acquire()
getService()
foo()
Service:
- ...
- foo()
- ...
dumpsys
listServices()
checkService()
service->dump()
A1
A2
B2
B1
C1
D1
D2
D3
ioctl(BINDER_SET_CONTEXT_MGR)
/* the one magic object */
#define BINDER_SERVICE_MANAGER ((void*) 0)
Binder Driver (/dev/binder)

15. Stock AOSP Apps

/packages/apps

AccountsAndSettings
AlarmClock
Bluetooth
Browser
Calculator
Calendar
Camera
CertInstaller
Contacts
DeskClock
Email
Gallery
HTMLViewer
Launcher2
Mms
Music
PackageInstaller
Protips
Provision
QuickSearchBox
Settings
SoundRecorder
SpeechRecorder
Stk
VoiceDialer

/packages/providers

ApplicationProvider
CalendarProvider
ContactsProvider
DownloadProvider
DrmProvider
GoogleContactsProvider
MediaProvider
TelephonyProvider
UserDictionaryProvider

/packages/inputmethods

LatinIME
OpenWnn
PinyinIME

Android Open Source Project

- Tools and location
- Content
- Building
- Build system
- Adding new applications
- Images
- Using adb

1. Tools and location

- Location:
  - http://android.git.kernel.org/
- Get “repo”:

  $ curl https://dl-ssl.google.com/dl/googlesource/git-repo/repo > ~/bin/repo

  $ chmod a+x ~/bin/repo
- Fetch the AOSP:
  - Make sure you fetch a tagged release
  - Gingerbread:

    $ repo init -u https://android.googlesource.com/platform/manifest -b android-2.3.7_r1

    $ repo sync

2. Content

bionic	C library replacement
bootable	Reference bootloader
build	Build system
cts	Compatibility Test Suite
dalvik	Dalvik VM
development	Development tools
device	Device-specific files and components
external	Copy of external projects used by AOSP
frameworks	System services, android.*, Android-related cmds, etc.
hardware	Hardware support libs
libcore	Apache Harmony
ndk	The NDK
packages	Stock Android apps, providers, etc.
prebuilt	Prebuilt binaries
sdk	The SDK
system	pieces of the world that are the core of the embedded linux platform at the heart of Android.

3. Building

- Requires 64-bit Ubuntu 10.04
- Packages required:

```
$ sudo␣apt-get␣install␣build-essential␣libc6-dev␣\
> ia32-libs␣lib32z1␣bison␣flex␣gperf␣git-core␣\
> g++␣libc6-dev-i386␣libz-dev␣libx11-dev␣\
> libstdc++6␣lib32ncurses5␣lib32ncurses5-dev␣\
> g++-multilib
```

- Possibly fix a few symbolic links:

```
$ sudo ln␣-s␣/usr/lib32/libstdc++.so.6␣/usr/lib32/libstdc++.so

$ sudo ln␣-s␣/usr/lib32/libz.so.1␣/usr/lib32/libz.so
```

- Set up build environment:

  $. build/envsetup.sh

  $ lunch

- Launch build and go watch tonight's hockey game:

  $ make -j2

- ... though you should check your screen at breaks ...
- Just launch emulator when it's done:

  $ emulator &

- Some nice tricks:
  - See build/envsetup.sh for commands
  - Do use ccache (compiler cache):

    $ export USE_CCACHE=1
  - Use “lunch” from AOSP root to set env vars
    - You'll need that if you come back later and want to relaunch emulator from AOSP root:

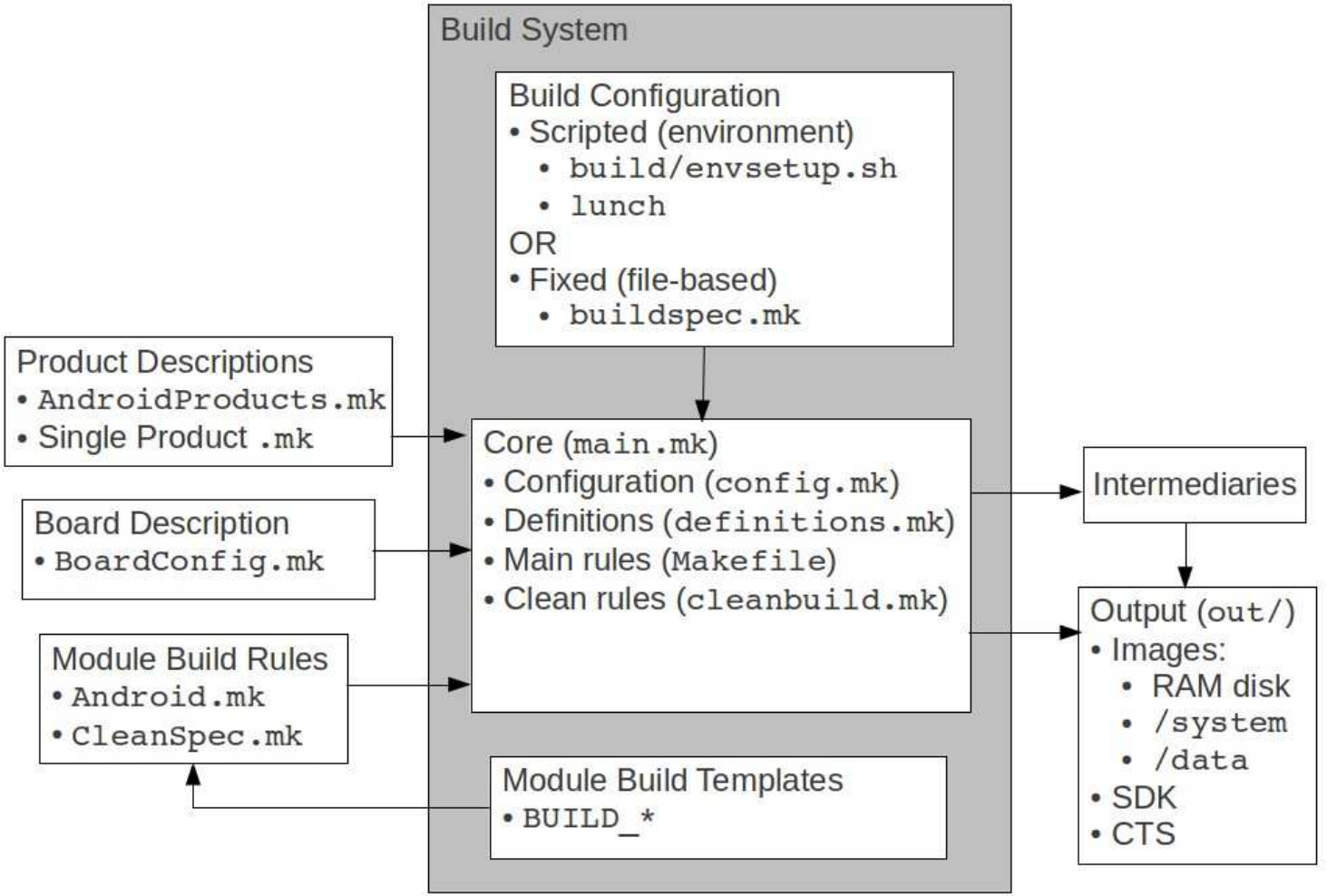
    $. build/envsetup.sh

    $ lunch

    $ emulator

4. Build system

- Non-Recursive
- “Modules” build predicated on Android.mk



5. Adding new applications

- Add application in [aosp]/packages/apps
- Can use Eclipse to create initial version
- Copy Eclipse project to packages/apps
- Add an appropriate Android.mk file to project
- Add project to PRODUCT_PACKAGES in [aosp]/build/target/product/core.mk

6. Images

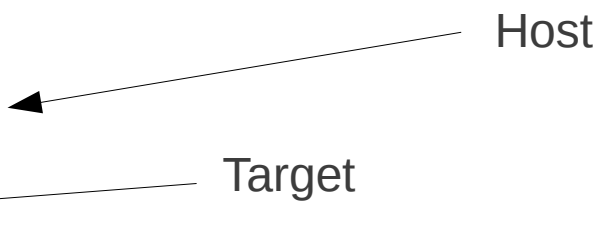
- All output and build in [aosp]/out/
- Images at [aosp]/out/target/product/generic/:
  - ramdisk.img
  - system.img
  - userdata-qemu.img
- Kernel is in:
  - prebuilt/android-arm/kernel/kernel-qemu
- Emulator overrides:
  - -kernel
  - -initrd

7. Using adb

- Can use to control/interface w/ running AOSP, including emulator.
- Shell:

  $ adb shell

  #



- Dumping the log:

  $ adb logcat

- Copying files to/from target:

  $ adb push foo /data/local

  $ adb pull /proc/config.gz

Kernel Selection

- Google:
  - http://android.git.kernel.org/
- Vanilla:
  - http://www.kernel.org
- Either way ... you're screwed:
  - Android kernel is a fork
  - No resolution in sight
  - **Cannot** use vanilla kernel as-is ... androidisms

Native Android User-Space

- Filesystem layout
- Bionic
- Toolbox
- Init
- Native daemons
- Power tools

1. Filesystem layout

- /acct => Control Group mount point (Documentation/cgroups.txt)
- /cache => cache flash partition
- /d => Symlink to /sys/kernel/debug
- /data => Android's “/data” filesystem
- /dev => Device nodes
- /etc => Symlink to /system/etc
- /mnt => Temporary mount point
- /proc => procfs
- /root => unused
- /sbin => eventd and adbd
- /sdcard => SD card mountpoint
- /sys => sysfs
- /system => Android's “/system” filesystem
- /vendor => Symlink to /system/vendor

1.1. /system

- /app => Stock apps installed
- /bin => Native binaries and daemons
- /etc => Configuration files
- /fonts => TTFs
- /framework => Android framework .jar files
- /lib => Native libraries
- /usr => Miniature “/usr”
- /xbin => Optional/Extra binaries

1.2. /data

- /anr => ANR traces
- /app => App install location
- /app-private => Protected apps
- /backup => For Backup Manager
- /dalvik-cache => Dalvik DEX cache
- /data => App data
- /dontpanic => Last panic output (console + threads) for “dumpstate”
- /local => Shell-writable space
- /misc => Misc. data (wifi, vpn, bluetooth, ...)
- /property => Persistent system properties (country, lang., ...)
- /secure => Secure Android data available
- /system => System data

2. Bionic

- In aosp:
  - /bionic
- In filesystem:
  - /system/lib
- Provides:
  - libc
  - libm
  - libdl
  - libstd++
  - libthread_db
  - linker

3. Toolbox

- In aosp:
  - /system/core/toolbox
- In filesystem:
  - /system/bin/toolbox
- Provides

  alarm date getevent insmod ls mv powerd renice schedtop smd top dd getprop ioctl lsmod nandread printenv rm sendevent start umount cat hd ionice lsof netstat ps rmdir setconsole stop uptime chmod df id kill mkdir newfs_msdos r rmmod setkey sync vmstat chown dmesg ifconfig ln readtty rotatefb setprop syren watchprops cmp exists iftop log mount notify reboot route sleep wipe

4. Init

- In aosp:
  - /system/core/init
- In filesystem:
  - /init
- Relies on:
  - /init.rc
  - /init.[board].rc
  - /ueventd.rc
  - /ueventd.[board].rc
  - /system/etc/init.[board].sh

5. Native daemons

- servicemanager
- vold
- rild
- netd
- adbd
- installd

5.1. servicemanager

- In aosp:
  - /frameworks/base/cmds/servicemanager/
- In filesystem:
  - /system/bin/
- Provides:
  - Context management for binder
  - Service index for entire system

5.2. vold

- In aosp:
  - /system/vold/
- In filesystem:
  - /system/bin/
- Provides:
  - Volume mounter
  - Auto-mount
  - Auto-format mounted devices

5.3. rild

- In aosp:
  - /hardware/ril/mock-ril/
- In filesystem:
  - /system/bin/
- Provides:
  - “Radio Interface Layer” to phone hardware

5.4. netd

- In aosp:
  - /system/netd/
- In filesystem:
  - /system/bin/
- Provides:
  - Management of aspects of networking
  - Interfaces with Network Management service

5.5. adbd

- In aosp:
  - /system/core/adb/
- In filesystem:
  - /sbin
- Provides:
  - Interfaces with host “adb” command
  - Remote debugging capabilities
  - Access to shell
  - Package install/uninstall
  - ... see “adb help” on host for full detail

5.6. installd

- In aosp:
  - /frameworks/base/cmds/installd
- In filesystem:
  - /system/bin/
- Provides:
  - Package install/uninstall
  - Sanity checks and verifications
  - Interfaces with Package Manager service

6. Power tools

- dumpstate
- dumpsys
- service
- logcat

System Server

- Services run by System Server
- Observing the System Server
- Calling on system services
- Inside a few system services
- Creating your own system service

1. Services run by the System Server

Entropy Service
Power Manager
Activity Manager
Telephone Registry
Package Manager
Account Manager
Content Manager
System Content Providers
Battery Service
Lights Service
Vibrator Service
Alarm Manager
Init Watchdog
Sensor Service
Window Manager
Bluetooth Service
Device Policy
Status Bar
Clipboard Service
Input Method Service
NetStat Service
NetworkManagement Service
Connectivity Service
Throttle Service
Accessibility Manager
Mount Service
Notification Manager
Device Storage Monitor
Location Manager
Search Service
DropBox Service
Wallpaper Service
Audio Service
Headset Observer
Dock Observer
UI Mode Manager Service
Backup Service
AppWidget Service
Recognition Service
Status Bar Icons
DiskStats Service
ADB Settings Observer

1.1. Some stats

- frameworks/base/services/java/com/android/server:
  - 3.5 M
  - ~100 files
  - 85 kloc
- Activity manager:
  - 920K
  - 30+ files
  - 20 kloc

2. Observing the System Server

- Logcat
- dumpsys

2.1. logcat

- Find the System Server's PID

  $ adb shell ps | grep system_server

  system 63 32 120160 35408 ffffffff afd0c738 S system_server

- Look for its output:

  $ adb logcat | grep “63)”

```
...
D/PowerManagerService(   63): bootCompleted
I/TelephonyRegistry(   63): notifyServiceState: 0 home Android Android 310260  UMTS CSS not supp...
I/TelephonyRegistry(   63): notifyDataConnection: state=0 isDataConnectivityPossible=false reason=null
interfaceName=null networkType=3
I/SearchManagerService(   63): Building list of searchable activities
I/WifiService(   63): WifiService trying to setNumAllowed to 11 with persist set to true
I/ActivityManager(   63): Config changed: { scale=1.0 imsi=310/260 loc=en_US touch=3 keys=2/1/2 nav=3/1 ...
I/TelephonyRegistry(   63): notifyMessageWaitingChanged: false
I/TelephonyRegistry(   63): notifyCallForwardingChanged: false
I/TelephonyRegistry(   63): notifyDataConnection: state=1 isDataConnectivityPossible=true reason=simL...
I/TelephonyRegistry(   63): notifyDataConnection: state=2 isDataConnectivityPossible=true reason=simL...
D/Tethering(   63): MasterInitialState.processMessage what=3
I/ActivityManager(   63): Start proc android.process.media for broadcast
com.android.providers.downloads/.DownloadReceiver: pid=223 uid=10002 gids={1015, 2001, 3003}
I/RecoverySystem(   63): No recovery log file
W/WindowManager(   63): App freeze timeout expired.
...
```

2.2. dumpsys

```
Currently running services:
  SurfaceFlinger
  accessibility
  account
  activity
  alarm
  appwidget
  audio
  backup
...
  wifi
  window
---------------------------------------------------------------------------
DUMP OF SERVICE SurfaceFlinger:
+ Layer 0x396b90
      z=    21000, pos=(   0,   0), size=( 480, 800), needsBlending=1, needsDithering=1, invalidat ...
0]
      name=com.android.launcher/com.android.launcher2.Launcher
      client=0x391e48, identity=6
      [ head= 1, available= 2, queued= 0 ] reallocMask=00000000, inUse=-1, identity=6, status=0
      format= 1, [480x800:480] [480x800:480], freezeLock=0x0, dq-q-time=53756 us
...
```

3. Calling on System Services

- Use getSystemService
- Ex: NotificationManager Object reference:

```
String ns = Context.NOTIFICATION_SERVICE;

NotificationManager mNotificationManager = (NotificationManager) \
getSystemService(ns);
```

- Prepare your content
- Call on the object:

```
mNotificationManager.notify(HELLO_ID, notification);
```

4. Inside a few System Services

- Get the AOSP ... repo, etc.
- Tricks:
  - Import into Eclipse and collapse methods
  - Use reverse-engineering tools:
    - Imagix
    - Rationale
    - Lattix
    - Scitools
    - ...
- Be patient, this isn't documented anywhere ...

4.1. ActivityManager

- Start new Activities, Services
- Fetch Content Providers
- Intent broadcasting
- OOM adj. maintenance
- Application Not Responding
- Permissions
- Task management
- Lifecycle management

- Ex. starting new app from Launcher:
  - onClick(Launcher)
  - startActivity(Activity.java)
  - <*Binder*>
  - ActivityManagerService
  - startViaZygote(Process.java)
  - <*Socket*>
  - Zygote

4.2. Package Manager

- 10 kloc
- 450 K
- Installation / removal
- Permissions
- Intent resolution (also IntentResolver.java)
- Called by Activity Manager

4.3. Window Manager

- Main thread
- Window manipulation
- Wallpaper handling
- Orientation
- Focus
- Layering
- Input event management

4.4. Notification Manager

- Toasts
- Notifications
- Sound playback (see NotificationPlayer.java)

4.5. Power Manager

- Wakelocks
- Sleep
- Brightness
- Lock

4.6. Network Management Service

- Talks to “netd” /system/netd
- Interface configuration
- Tethering
- DNS

4.7. Mount Service

- Mount / Unmount
- Format
- USB mass storage
- OBB

4.8. Location Manager

- Manage location providers
- getBestProvider()
- Proximity alerts
- Last known location

4.9. Status Bar Manager

- Expand / collapse
- Icon visibility
- Reveal callbacks
- Callbacks for notification manager

4.10. Backup Manager

- Enable / disable
- Transport management
- backupNow()
- ...

5. Creating your own System Service

- Add your code to: frameworks/base/services/java/com/android/server/
- Have the SystemServer.java init+reg. your service
- Define hardware API for apps
- Expose through:
  - frameworks/base/core/java/android/os/[server].aidl
- Call on native “driver” code through JNI
- Implement or connect to appropriate driver
- Create an app that calls on service
- May need to create new SDK ...

5.1. OpersysService.java

```
package com.android.server;

import android.content.Context;
import android.os.Handler;
import android.os.IOpersysService;
import android.os.Looper;
import android.os.Message;
import android.os.Process;
import android.util.Log;

public class OpersysService extends IOpersysService.Stub {
    private static final String TAG = "OpersysService";
    private OpersysWorkerThread mWorker;
    private OpersysWorkerHandler mHandler;
    private Context mContext;

    public OpersysService(Context context) {
        super();
        mContext = context;
        mWorker = new OpersysWorkerThread("OpersysServiceWorker");
        mWorker.start();
        Log.i(TAG, "Spawned worker thread");
    }

    public void setValue(int val) {
        Log.i(TAG, "setValue " + val);
        Message msg = Message.obtain();
        msg.what = OpersysWorkerHandler.MESSAGE_SET;
        msg.arg1 = val;
        mHandler.sendMessage(msg);
    }
```

```
    private class OpersysWorkerThread extends Thread{
    public OpersysWorkerThread(String name) {
        super(name);
    }

    public void run() {
        Looper.prepare();
        mHandler = new OpersysWorkerHandler();
        Looper.loop();
        }
    }

    private class OpersysWorkerHandler extends Handler {
    private static final int MESSAGE_SET = 0;

    @Override
    public void handleMessage(Message msg) {
        try {
        if (msg.what == MESSAGE_SET) {
            Log.i(TAG, "set message received: " + msg.arg1);
            }
        }
        catch (Exception e) {
        // Log, don't crash!
        Log.e(TAG, "Exception in OpersysWorkerHandler.handleMessage:", e);
            }
        }
    }
}
```

5.2. IOpersysService.aidl

```
package android.os;
interface IOpersysService {
/**
* {@hide}
*/
void setValue(int val);
}
```

5.3. frameworks/base/Android.mk

...

```
    core/java/android/os/IPowerManager.aidl \
    core/java/android/os/IOpersysService.aidl \
    core/java/android/os/IRemoteCallback.aidl \
```

...

5.4. SystemServer.java

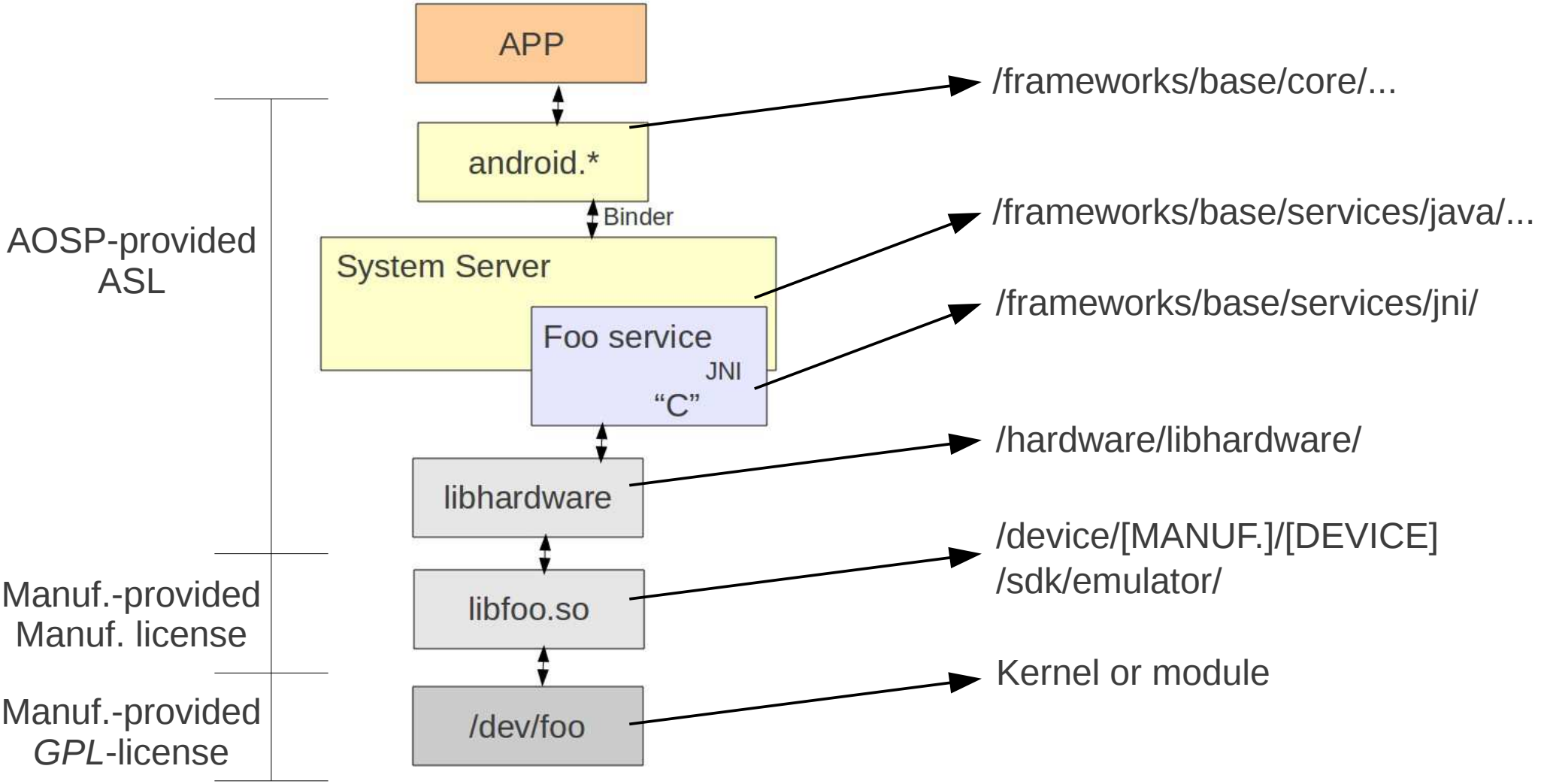
Should eventually be Context.OPERSYS_SERVICE

```
...
        try {
            Slog.i(TAG, "Opersys Service");
            ServiceManager.addService(“opersys”, new OpersysService(context));
        } catch (Throwable e) {
            Slog.e(TAG, "Failure starting OpersysService Service", e);
        }
...
```

5.5. HelloServer.java

```
package com.opersys.helloserver;

import android.app.Activity;
import android.os.Bundle;
import android.os.ServiceManager;
import android.os.IOpersysService;
import android.util.Log;

public class HelloServer extends Activity {
    private static final String DTAG = "HelloServer";

    /** Called when the activity is first created. */
    @Override
    public void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.main);

        IOpersysService om =
IOpersysService.Stub.asInterface(ServiceManager.getService("opersys"));
        try {
        Log.d(DTAG, "Going to call service");
        om.setValue(20);
        Log.d(DTAG, "Service called succesfully");
        }
        catch (Exception e) {
        Log.d(DTAG, "FAILED to call service");
        e.printStackTrace();
        }
    }
}
```

Hardware Abstraction Layer



- [aosp]/hardware/libhardware/include/hardware
  - gps.h
  - lights.h
  - sensors.h
- [aosp]/hardware/ril/include/telephony/
  - ril.h
- Examples in [aosp]/device/samsung/crespo/
  - libaudio
  - libcamera
  - liblight
  - libsensors
- Using JNI to call C functions

1. Call to JNI

```
public class HelloJni extends Activity
{
    /** Called when the activity is first created. */
    @Override
    public void onCreate(Bundle savedInstanceState)
    {
        super.onCreate(savedInstanceState);

        /* Create a TextView and set its content.
         * the text is retrieved by calling a native
         * function.
         */
        TextView  tv = new TextView(this);
        tv.setText( stringFromJNI() + " " + pid() );
        setContentView(tv);
    }

    /* A native method that is implemented by the
     * 'hello-jni' native library, which is packaged
     * with this application.
     */
    public native String  stringFromJNI();
...
    /* this is used to load the 'hello-jni' library on application
     * startup. The library has already been unpacked into
     * /data/data/com.example.HelloJni/lib/libhello-jni.so at
     * installation time by the package manager.
     */
    static {
        System.loadLibrary("hello-jni");
    }
}
```

2. JNI function in C

```
jstring
Java_com_example_hellojni_HelloJni_stringFromJNI( JNIEnv* env,
                                                  jobject thiz )
{
    return (*env)->NewStringUTF(env, "Hello from JNI !");
}
```

Android Framework

- Location and components
- android.*
- Customization

1. Location and components

- [aosp]/frameworks/base
  - /cmds => native cmds and daemons
  - /core => android.* and com.android.*
  - /data => Fonts and sounds
  - /graphics => 2D & Renderscript
  - /include => “C” includes
  - /keystore => security key store
  - /libs => “C” libraries
  - /location => Location provider
  - /media => Stagefright, codecs, etc.
  - /native => Native code for some frameworks components
  - /obex => Bluetooth obex
  - /opengl => GL library and java code
  - /packages => A few core packages (Status Bar)
  - /services => System server
  - /telephony => Phone related functionality
  - /tools => A few core tools (aapt, aidl, ...)
  - /voip => RTP & SIP interfaces
  - /vpn => VPN functionality
  - /wifi => Wifi manager, monitor, etc.

2. android.*

```
accessibilityservice  content   hardware             pim          speech
accounts              database  inputmethodservice   preference   test
annotation            ddm       net                  provider     text
app                   debug     nfc                  security     util
appwidget             emoji     os                   server       view
bluetooth             gesture   service              webkit       widget
```

3. Customization

- Extending API
- Boot screen
- Status bar
- Network
- Preloaded apps
- Browser bookmarks
- Email provider customization
- Themes

3.1. Extending API – System service

- frameworks/base/core/java/android/
  - app/ContextImpl.java
  - content/Context.java
  - os/OpersysManager.java

3.1.1. app/ContextImpl.java

```
...
import android.os.IOpersysService;
import android.os.OpersysManager;
...
    private DownloadManager mDownloadManager = null;
    private NfcManager mNfcManager = null;
    private OpersysManager mOpersysManager = null;
...
            return getDownloadManager();
        } else if (NFC_SERVICE.equals(name)) {
            return getNfcManager();
        } else if (OPERSYS_SERVICE.equals(name)) {
            return getOpersysManager();
        }
...
```

```
private OpersysManager getOpersysManager() {
    synchronized (mSync) {
        if (mOpersysManager == null) {
            IBinder b = ServiceManager.getService(OPERSYS_SERVICE);
            IOpersysService service = IOpersysService.Stub.asInterface(b);
            mOpersysManager = new OpersysManager(service);
        }
    }
    return mOpersysManager;
}
```

3.1.2. content/Context.java

```
...
    /**
     * Use with {@link #getSystemService} to retrieve a
     * {@link android.nfc.NfcManager} for using NFC.
     *
     * @see #getSystemService
     */
    public static final String NFC_SERVICE = "nfc";

    /** The Opersys service **/
    public static final String OPERSYS_SERVICE = "opersys";
...
```

3.1.3. os/OpersysManager.java

```
package android.os;

import android.os.IOpersysService

public class OpersysManager
{
    public void setValue(int value)
    {
        try {
            mService.setValue(value);
        } catch (RemoteException e) {
        }
    }

    public OpersysManager(IOpersysService service)
    {
        mService = service;
    }

    IOpersysService mService;
}
```

3.2. Boot screen

- Create 320x480 image
- Install imagemagick

  $ sudo apt-get install imagemagick
- Convert image to .r format

  $ convert screen.jpg screen.r
- Convert image to 565 format

  $ rgb2565 < screen.r > screen.565
- Write image to flash

  $ fastboot flash splash1 screen.565

3.3. Status bar

- Location:
  - frameworks/base/packages/SystemUI/src/com/android/systemui/statusbar
- Look for:
  - mService.setIcon(...)
- Disable icons with:
  - mService.setIconVisibility(“[ICON_NAME]", false);

3.4. Network

- Locations:
  - Global static:
    - frameworks/base/core/res/res/xml/apns.xml
  - Device static:
    - PRODUCT_COPY_FILES := vendor/acme/etc/apns-conf-us.xml:system/etc/apns-conf.xml
  - Dynamic:
    - system/etc/apns-conf.xml
- Format:

```
<apn carrier="T-Mobile US"
        mcc="310"
        mnc="260"
        apn=" wap.voicestream.com"
        user="none"
        server="*"
        password="none"
        proxy=" 216.155.165.50"
        port="8080"
        mmsc="http://216.155.174.84/servlets/mms"
/>
```

3.5. Preloaded apps

- See build/target/products

```
PRODUCT_PACKAGES := \
    bouncycastle \
    com.android.location.provider \
    com.android.location.provider.xml \
    core \
    core-junit \
    create_test_dmtrace \
    dalvikvm \
    dexdeps \
...
```

3.6. Browser bookmarks

- See packages/apps/Browser/res/values/strings.xml

```
<!-- Bookmarks -->
<string-array name="bookmarks">
    <item>Google</item>
    <item>http://www.google.com/</item>
    <item>Yahoo!</item>
    <item>http://www.yahoo.com/</item>
    <item>MSN</item>
    <item>http://www.msn.com/</item>
    <item>MySpace</item>
    <item>http://www.myspace.com/</item>
...
```

3.7. Email provider customization

- See packages/apps/Email/res/xml/providers.xml

```
<!-- Gmail variants -->
    <provider id="gmail" label="Gmail" domain="gmail.com">
        <incoming uri="imap+ssl+://imap.gmail.com" username="$email"/>
        <outgoing uri="smtp+ssl+://smtp.gmail.com" username="$email"/>
    </provider>
    <provider id="googlemail" label="Google Mail" domain="googlemail.com">
        <incoming uri="imap+ssl+://imap.googlemail.com" username="$email"/>
        <outgoing uri="smtp+ssl+://smtp.googlemail.com" username="$email"/>
    </provider>
...
    <!-- Common US providers -->

    <provider id="aim" label="AIM" domain="aim.com">
        <incoming uri="imap://imap.aim.com" label="IMAP" username="$email"/>
        <outgoing uri="smtp://smtp.aim.com:587" username="$email"/>
    </provider>
    <provider id="aol" label="AOL" domain="aol.com">
        <incoming uri="imap://imap.aol.com" label="IMAP" username="$email"/>
        <outgoing uri="smtp://smtp.aol.com:587" username="$email"/>
    </provider>
...
```

3.8. Themes

- See framework/base/core/res/res/values/styles.xml

Custom Toolchains and Dev Kits

- Rationale
- SDK generation
- NDK generation
- Creating a cross-dev toolchain

1. Rationale

- SDK:
  - Providing other internal teams or external developers access to your modified/custom Android APIs.
- NDK:
  - Same as SDK rationale
- Custom cross-dev toolchain:
  - To avoid having to use a binary toolchain from 3rd party.
  - To control the build parameters used to create the toolchain. Ex.: use uClibc instead of glibc.

2. SDK generation

- Building the SDK:

  $. build/envsetup.sh

  $ lunch sdk-eng

  $ make sdk

- If API modified, do this before make:

  $ make update-api

- Location: [aosp]/out/host/linux-x86/sdk/
- Using a custom SDK:
  - Eclipse->Window->Preferences->Android->”SDK Location”
  - Eclipse->Window->"Android SDK and AVD Manager"->"Installed Packages"->"Update All..."

3. NDK generation

- Build

  $ cd ndk/build/tools

  $ export ANDROID_NDK_ROOT=[aosp]/ndk

  $ ./make-release --help

  $ ./make-release

  IMPORTANT WARNING !!

  This script is used to generate an NDK release package from scratch
  for the following host platforms: linux-x86

  This process is EXTREMELY LONG and may take SEVERAL HOURS on a dual-core
  machine. If you plan to do that often, please read docs/DEVELOPMENT.TXT
  that provides instructions on how to do that more easily.

  Are you sure you want to do that [y/N]

4. Creating a cross-dev toolchain

- **crosstool-ng**: successor to crosstool
- Available at:
  http://ymorin.is-a-geek.org/projects/crosstool
- Downloads, patches, builds, installs, etc.
- Comprises **23** steps
- Menuconfig-based
- Supports uClibc, glibc and eglibc
- Supports ARM, Blackfin, MIPS, PowerPC, SH, …
- Fairly well maintained

- Must make sure the following are installed on Ubuntu in order to use crosstool-ng:
  - gawk
  - texinfo
  - automake
  - libtool
  - cvs
  - libncurses5-dev
- Use “sudo apt-get install” to get those

- Download and extract to ${PRJROOT}/build-tools
- Configure crosstool:

```
$ cd crosstool-ng-1.10.0/
$ ./configure
```

- Build and install crosstool-ng:

```
$ make
$ make install
```

- Configure crosstool:

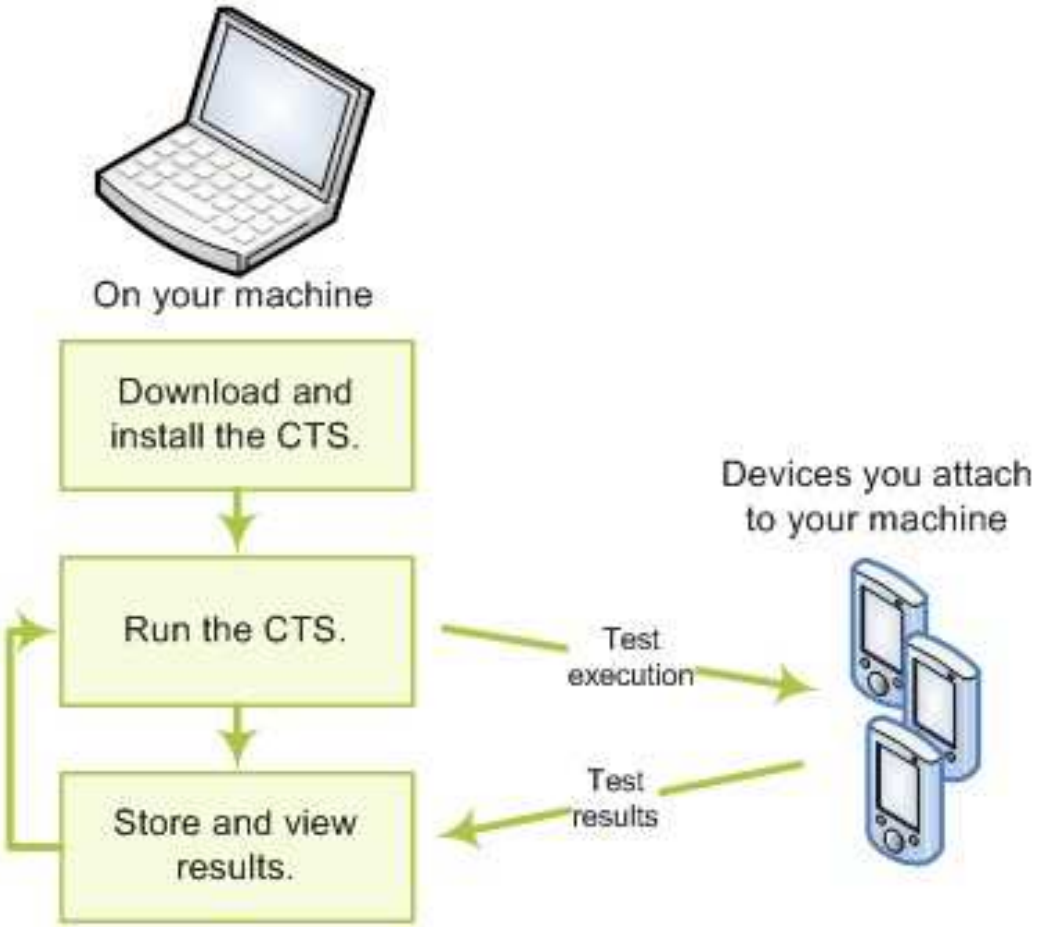
```
$ cd ${PRJROOT}/build-tools
$ ct-ng menuconfig
```

- Options:
  - Paths->Prefix directory: ${PREFIX}/${CT_TARGET}
  - Target options->architecture: powerpc
  - OS->Target OS: linux
  - C library->C library: glibc
  - C library->Extra flags: -U_FORTIFY_SOURCE
  - Debug facilities: gdb & strace
- Build the toolchain:

```
$ ct-ng build
```

Compatibility Test Suite

- Android Compatibility Program:
  - Source code to Android stack
  - Compatibility Definition Document (CDD) – Policy
  - Compatibility Test Suite (CTS) – Mechanism
- Each Android version has own CDD & CTS
- CTS:
  - Part of AOSP
  - Run from host using USB over to attached device
  - Based on JUnit
  - Runs various test apps on target
  - Relies on ADB
  - Provides report to be be analyzed and/or sent back to Google


On your machine
Download and install the CTS.
Run the CTS.
Store and view results.
Test execution
Test results
Devices you attach to your machine

- Report:
  - .zip file containing XML files and screen-shots
  - Sent to: cts@android.com
- Building the CTS:

  $. build/envsetup.sh

  $ make cts
- Launching the CTS:

  $ cd out/host/linux-x86/bin/

  $ ./cts

  $ cts_host >

  $ cts_host > help

  ...

- Using the CTS:

```
$ cts_host > ls --plan
List of plans (8 in total):
Signature
RefApp
VM
Performance
AppSecurity
Android
Java
CTS
```

```
$ ./cts start --plan CTS
```

- Areas covered:
  - Signature tests
  - Platform API tests
  - Dalvik VM tests
  - Platform Data Model
  - Platform Intents
  - Platform Permissions
  - Platform Resources

Thank you ...

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