Porting Android ICS to a custom board
A war story

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Outline

- Android beyond smartphones?
- Why a war story
- Our custom board
- Android building system
- Lessons learned
  - Add device
  - Bootloader/Kernel integration
  - Powersupply
  - Button
  - Touchscreen calibration
  - Wi-Fi
  - Sound
  - HW acceleration

Android beyond smartphones?

- ✔ Easy to implement applications (SDK, API, Java)
- ✔ Human-Machine-Interface
  - ✔ well defined
  - ✔ tested in the wild
- ✔ Reliability of the system
- ► good for HMI centred embedded systems

- ✗ Integrate native application
- ✗ Porting to a new board can be a war story

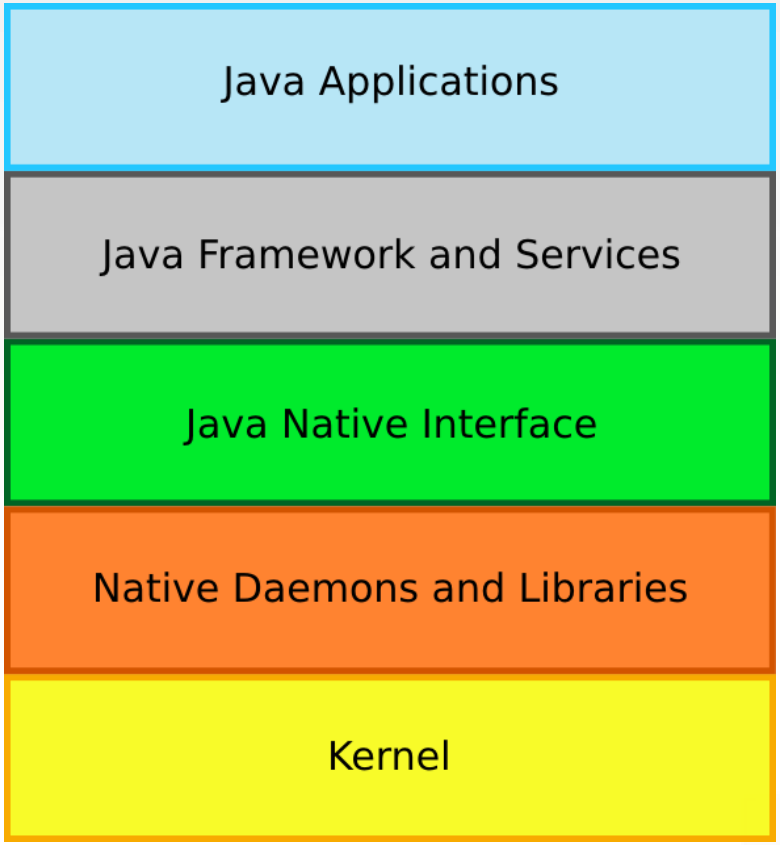
Why is it a war story

- Little documentation
- Small community
- Vendor specific communities
- Developing process of Android
- A huge jungle of programming languages

Why is it a war story

- Android is Linux, but... Android is not Linux!
  - Patched Kernel adds new features
  - Userspace varies widely
    - Own libc (bionic)
    - Lots of basic building blocks are not integrated
      - XWindows
      - Busybox
    - Core system is executed on dalvikVM
    - IPC implementation (binder) varies from SystemV
    - Building blocks are compiled to dynamic libraries which are loaded by the core system in different ways and layers

Why is it a war story



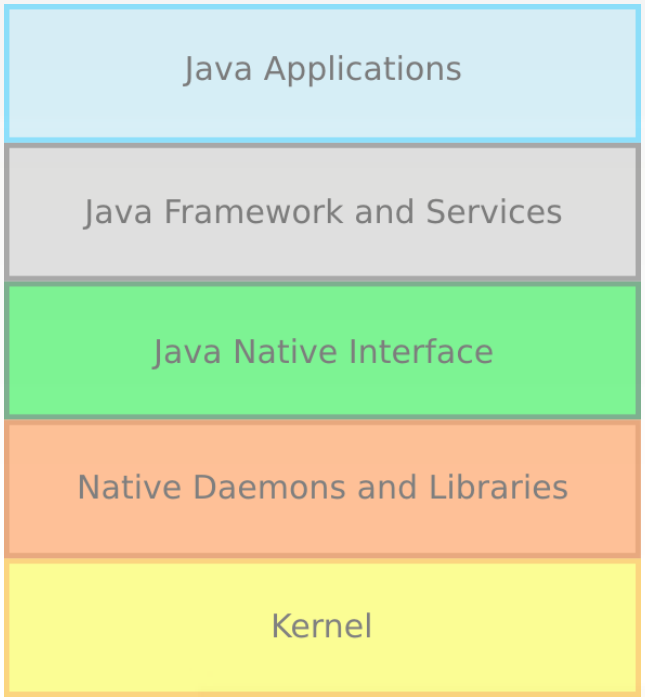
Our custom board

Our custom board

- One button only
- No phone
- No battery monitor
- Ethernet
- Wifi
- Touchscreen
- Sound
- HW acceleration from OMAP3

Android building system

- Important folders
  - build
  - frameworks/base
  - external
  - hardware
  - device
  - out/target/product/<product_name>



Lesson learned I: Add device to our build

- *Devices are found under device/<manufactor>/<board>* folder
  - **<device_name>.mk**
    - Define which basic packages to install for the board
    - Inherit from default product (in *build/target/product*)
    - Add the proper device:
  - **device.mk**
    - Define files that have to be copyed to the rootfs
    - Define where to find the overlay
  - **BoardConfig.mk**
    - Define build flags
  - **vendorsetup.sh**
    - Add lunch menu option

Lessons Learned II: Bootloader/Kernel integration

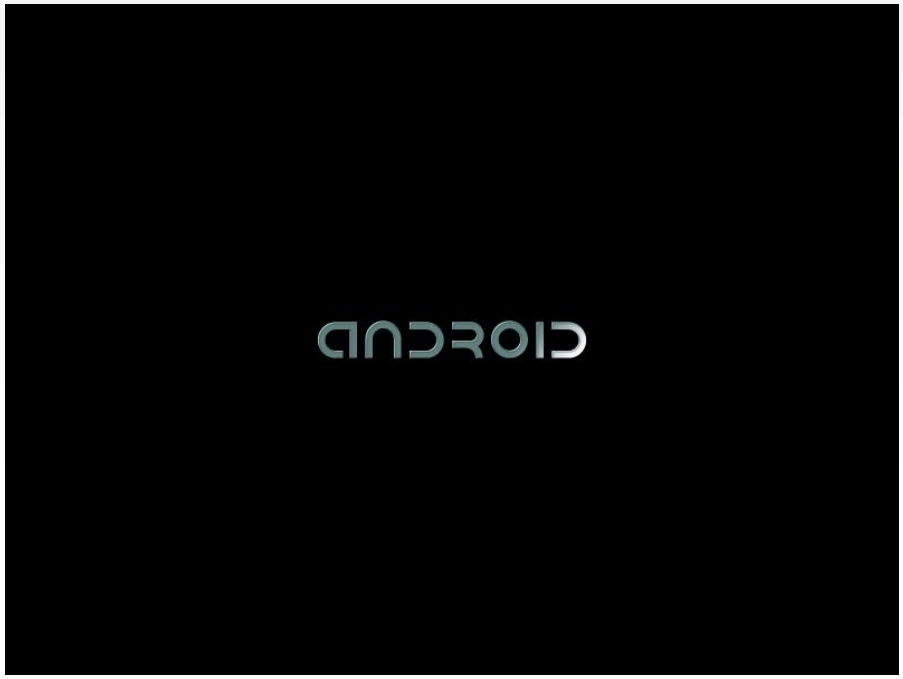
- Problems
  - In AOSP precompiled Kernel image
  - Specific compiler needed?

- Solution
  - We add a “wrapper” in the Makefile
  - After building the android “userspace” build
    - Bootloader
    - Kernel
    - Copy kernel modules to *out/target/product*

- Extra boot parameter:
  - androidboot.console=ttyO2
  - init=/init

Lessons Learned III: Powersupply

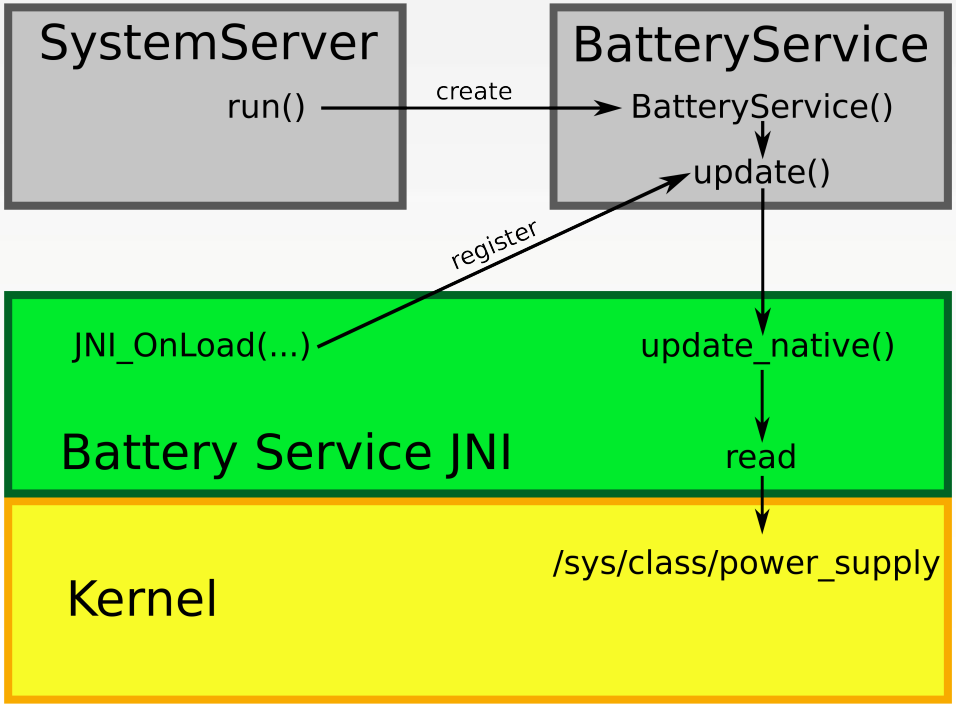
- Boot hangs on splash screen
- Have a look with logcat what's going on



Lessons Learned III: Powersupply

```
E/BatteryService( 1008): Could not open /sys/class/power_supply
(…)
I/SystemServer( 1008): Battery Service
W/dalvikvm( 1008): No implementation found for native Lcom/android/server/BatteryService;.native_update ()V
W/dalvikvm( 1008): threadid=11: thread exiting with uncaught exception (group=0x409e11f8)
I/Process ( 1008): Sending signal. PID: 1008 SIG: 9
E/AndroidRuntime( 1008): *** FATAL EXCEPTION IN SYSTEM PROCESS: android.server.ServerThread
E/AndroidRuntime( 1008): java.lang.UnsatisfiedLinkError: native_update
E/AndroidRuntime( 1008): at com.android.server.BatteryService.native_update(Native Method)
E/AndroidRuntime( 1008): at com.android.server.BatteryService.update(BatteryService.java:233)
E/AndroidRuntime( 1008): at com.android.server.BatteryService.<init>(BatteryService.java:148)
E/AndroidRuntime( 1008): at com.android.server.ServerThread.run(SystemServer.java:196)
I/Zygote  (  967): Exit zygote because system server (1008) has terminated
E/installd(  913): eof
E/installd(  913): failed to read size
I/installd(  913): closing connection
I/installd(  913): new connection
I/ServiceManager(  903): service 'gfxinfo' died
I/ServiceManager(  903): service 'activity' died
I/ServiceManager(  903): service 'cpuinfo' died
I/ServiceManager(  903): service 'sensorservice' died
I/ServiceManager(  903): service 'meminfo' died
I/ServiceManager(  903): service 'account' died
I/ServiceManager(  903): service 'usagestats' died
I/ServiceManager(  903): service 'permission' died
I/ServiceManager(  903): service 'hardware' died
I/ServiceManager(  903): service 'content' died
(...)
```

Lessons Learned III: Powersupply



Lessons Learned III: Powersupply

- What has happened?
  - When JNI is loaded, it registers the low level services (e.g. BatteryService)
    - read values from sysfs
    - BatteryService JNI registers function native_update at BatteryService.java
  - But...
    - BatteryService JNI interface doesn't find “/sys/class/power_supply”
    - Returns error, which is ignored by JNI_OnLoad
  - SystemServer thread creates BatteryService when executed
    - BatteryService tries to update values invoking native_update
    - No JNI interface registered – SystemServer dies...

Lessons Learned III: Powersupply

- Solution
  - No working battery monitor in our system
    → No power supply class in kernel
  - Adding the power supply class
    - Shows battery empty warning in status bar
  - Add the "*test power driver*"
    - Shows Battery at 50% charging fixed

- Has influence on the behaviour of the Power Manager

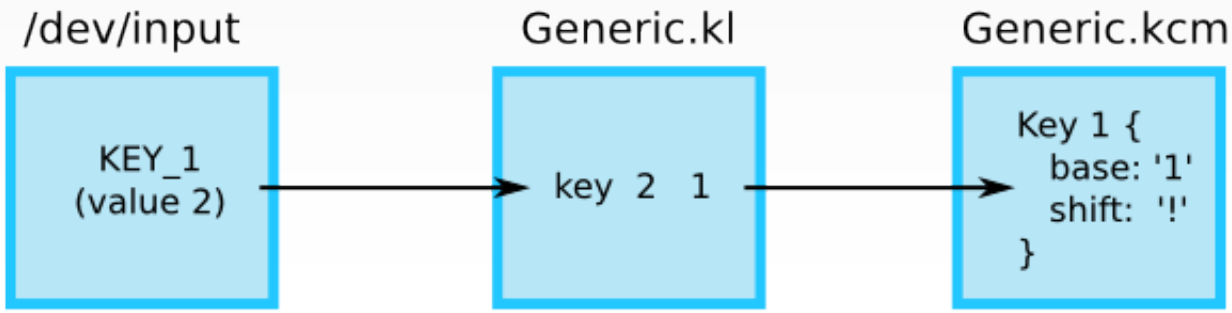
Lessons Learned IV: Button Integration

- Can be found in frameworks/base/services/input:
  - Android scans */dev/input* folder in a loop
  - Polls for events using epoll
  - Identifies touchscreens, joysticks, mice, keyboards automatically

  - Key Layout File (*/system/usr/keylayout*) maps raw input key to internal Android key representation
  - Key Char Map File (*/system/usr/keychars*) describes action for internal Android key

Lessons Learned IV: Button Integration

- Our case
  - Just one button, no external keyboard
- Two alternatives:
  - Define own Key Layout/Key Char Map files
  - Configure key code in kernel appropriately
  - Beware Key Layout File uses numeric number of key code
  - Not all values in Key Layout have a define in *include/linux/input.h*



Lessons Learned V: Touchscreen calibration

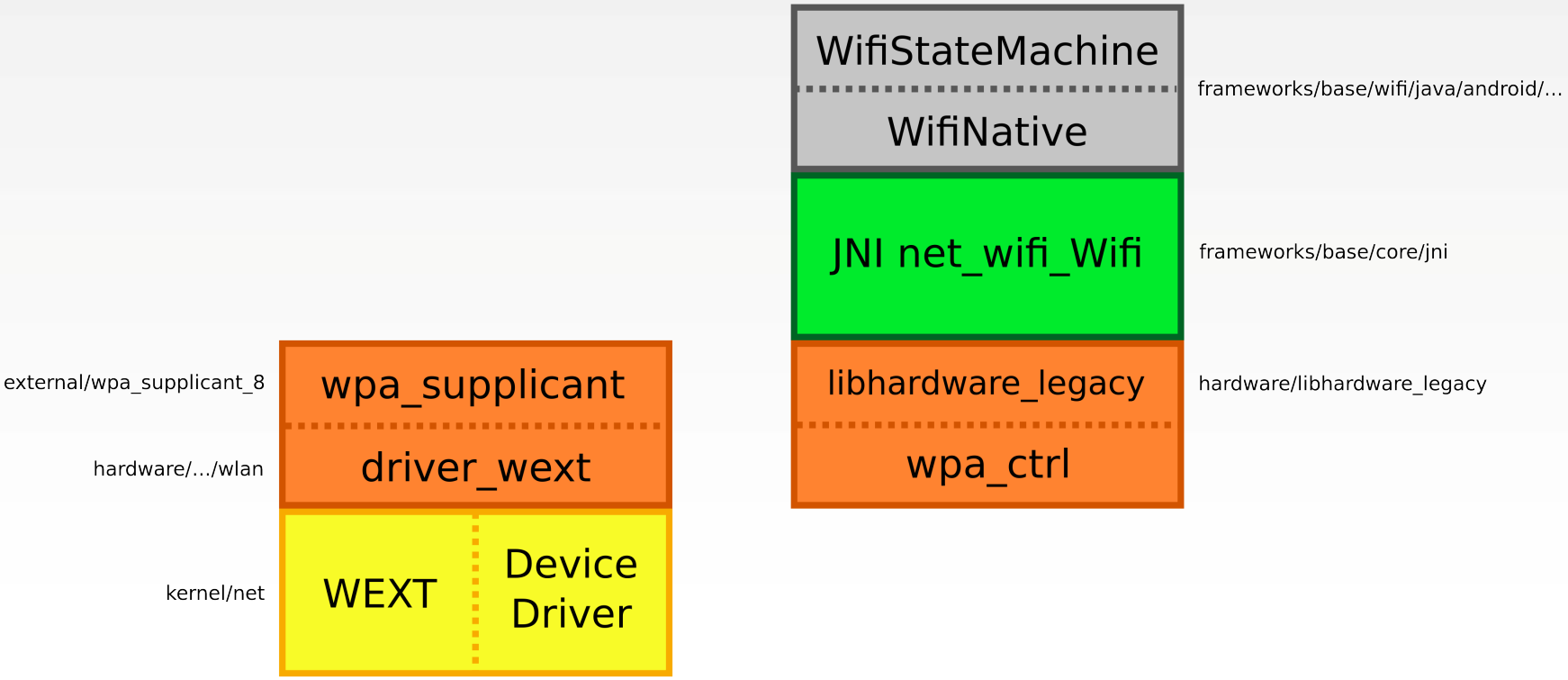
- Detection and input analogous to button integration
- Driver sends X-Y-coordinates

- Callibrate the touchscreen
  - We have to reach all parts of the screen easily
    - Turn on *show touches* in Settings/Developer options
    - Adjust max and min values of your touchscreen in the plattform data

Lessons Learned VI: Wi-Fi

- Example of complexity of Android source code
  - Different libraries and services
  - 5 different folders with userspace code
- Uses wpa_supplicant to connect to a protected WLAN
  - Enhanced with Android specific commands
    - START, STOP, SCAN-ACTIVE, SCAN-PASSIVE, RSSI, LINKSPEED, …

Lessons Learned VI: Wi-Fi

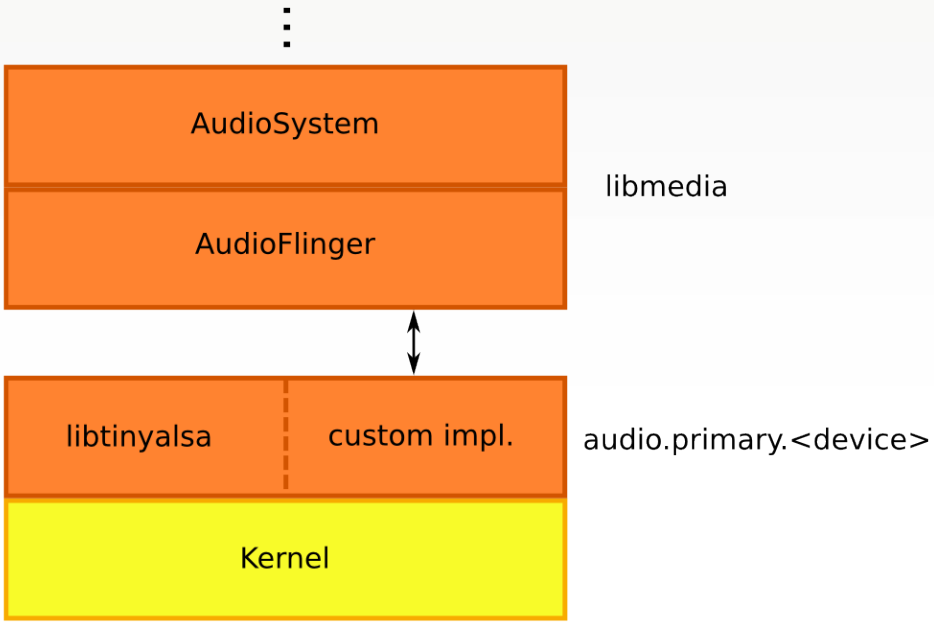


Lessons Learned VI: Wi-Fi

- Integration
  - **Legacy implementation** reads wpa supplicant config file
    - /data/misc/wifi/wpa_supplicant.conf → product specific
    - /system/etc/wifi/wpa_supplicant.conf → template
  - **Kernel and firmware module**
    - In BoardConfig.mk define:
      - WIFI_DRIVER_MODULE_PATH
      - WIFI_DRIVER_MODULE_NAME
      - WIFI_FIRMWARE_LOADER
    - Hardware legacy layer in charge of loading/unloading kernel module and firmware; starts/stops wpa_supplicant
  - **Start wpa_supplicant** and **dhcp** for wlan
    - *service wpa_supplicant /system/bin/wpa_supplicant -Dwext -iwlan0*
    - *service dhcpcd_wlan0 /system/bin/dhcpcd -ABKL*

Lessons Learned VII: Audio

- Audio player is stagefright
- AudioFlinger interfaces hardware abstraction
  - Uses struct audio_hw_device in hardware/libhardware/include
- audio.primary.<device_name>
  - Encapsulates the hardware - custom implementation

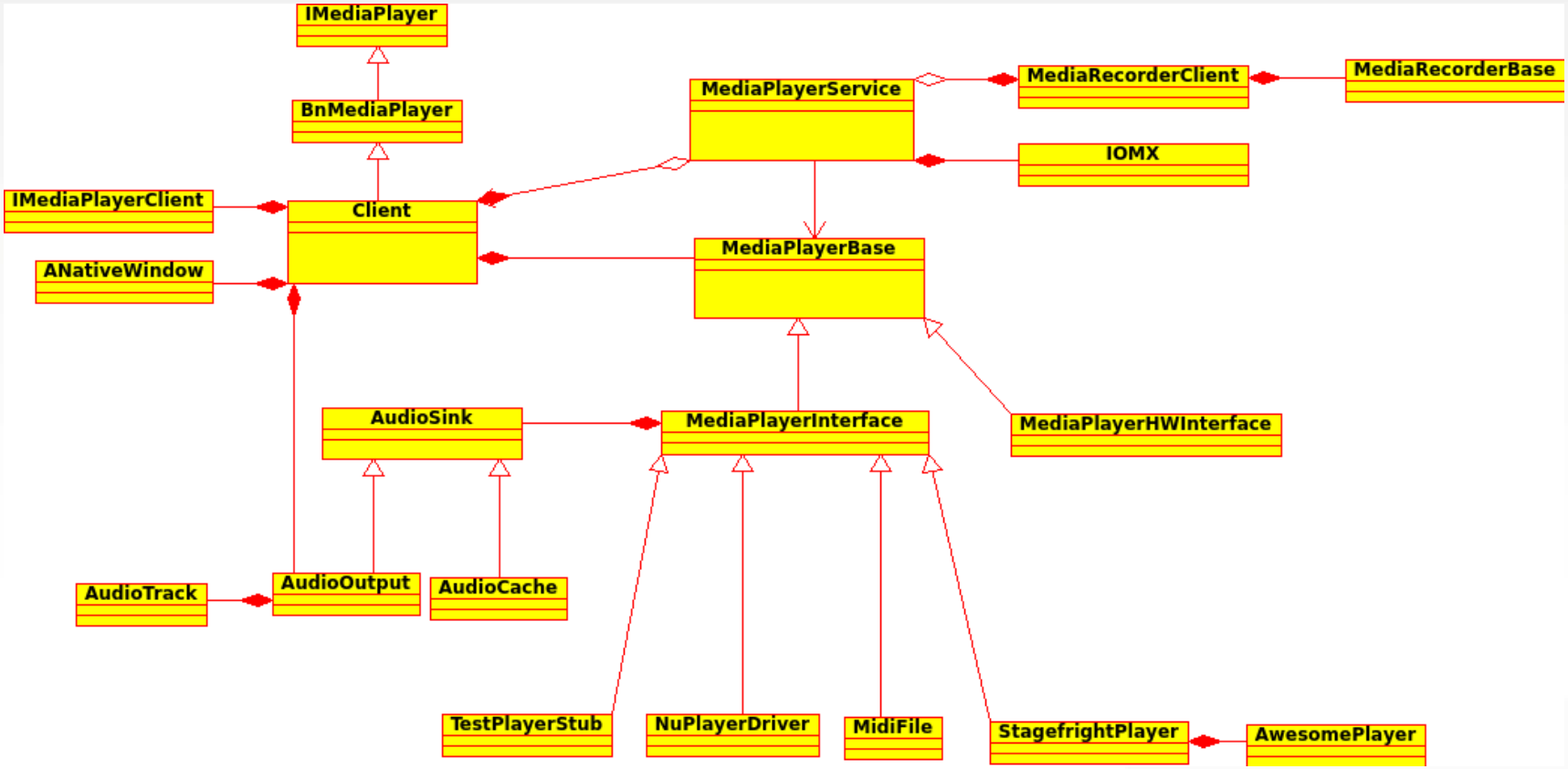


Lessons Learned VIII: Hardware Acceleration

- Two possibilities
  - Integrate mulitmedia framework supporting HW acceleration
    - ✔ Has bindings for HW accelerator
    - ✔ Might have more codecs then stagefright
    - ✗ Maintenace might be costly
  - Integrate HW acceleration support in existing Android multimedia framework
    - ✔ Should be easy to maintain
    - ✗ Need to create bindings for the HW accelerator

Lessons Learned VIII: Hardware Acceleration

libmediaplayerservice:



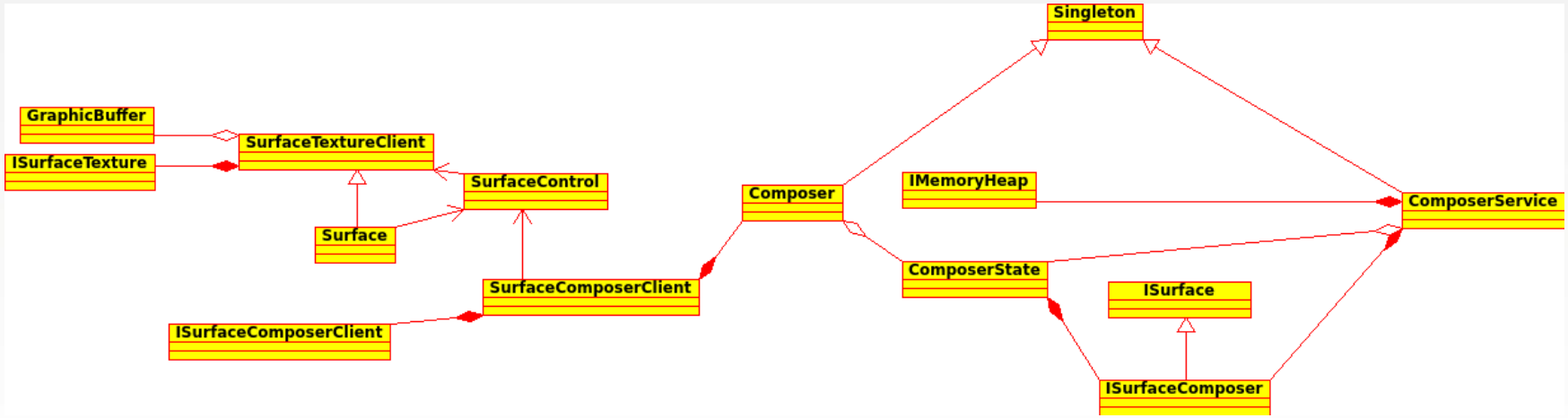
Lessons Learned VIII: Hardware Acceleration

- Add own multimedia framework
  - Register your framework as MediaPlayerInterface
  - Create player instance in MediaPlayerService
  - Implement new MetadataRetriever in MetadataRetrieverClient

- Implement wrapper
  - Audio sink using AudioTrack
  - Video sink using Surface

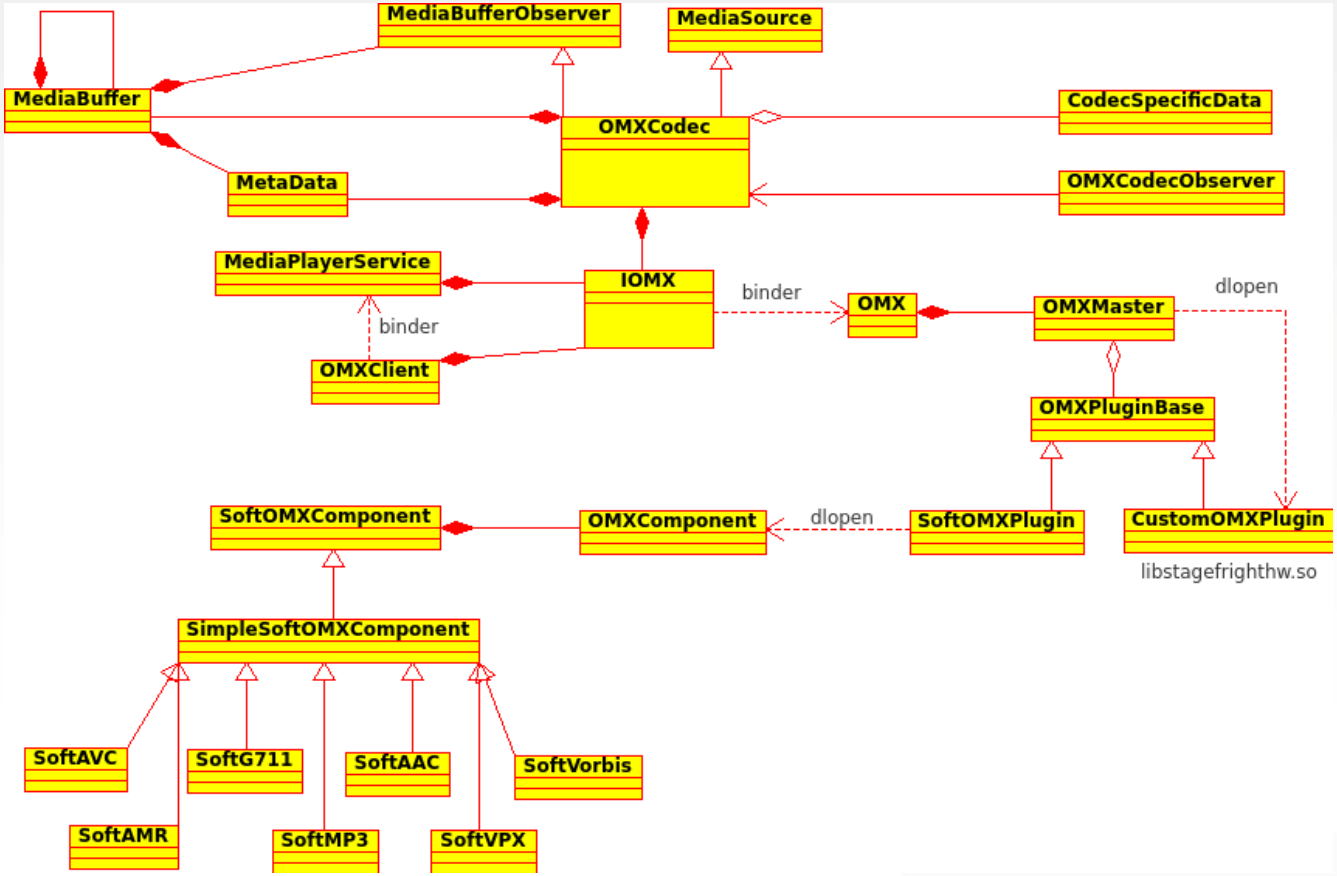
Lessons Learned VIII: Hardware Acceleration

libsurfaceflinger:



Lessons Learned VI: Hardware Acceleration

libstagefright:



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IGEP™

Danke schön

Thank you

ありがとう

謝謝

Gracias

3Q

Moito Brigado

Merci Beaucoup

Dank U wel

감사합니다