

Embedded Android Workshop

Part 4 - Using and Customizing the Android Framework

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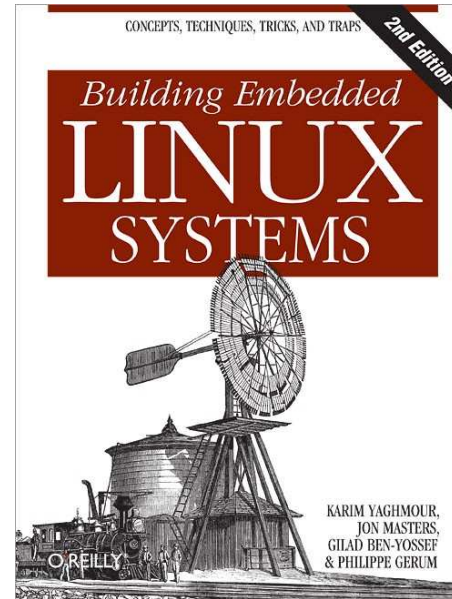
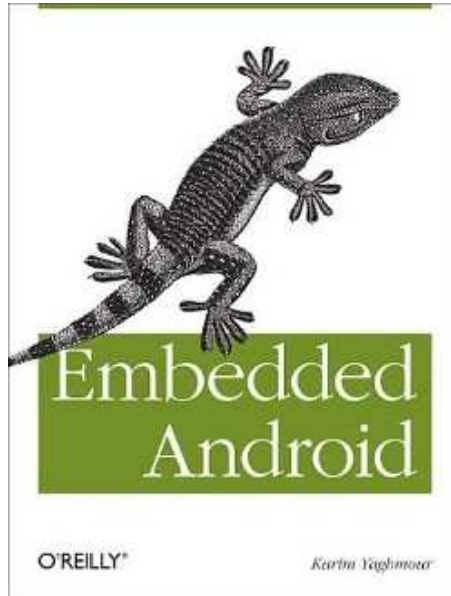
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About

- Author of:



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

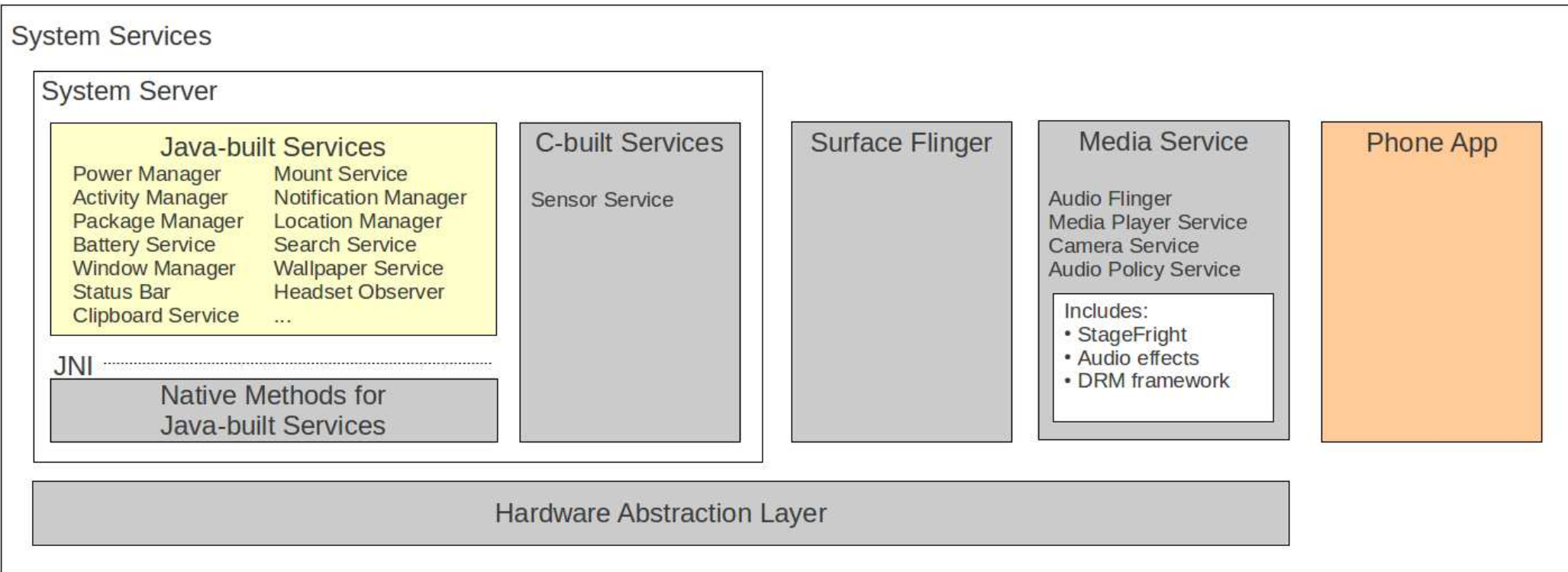
1. Kickstarting the Framework

- Core building blocks
- System services
- Boot animation
- Dex optimization
- Apps startup

1.1. Core building blocks

- Service manager
- Dalvik
- Android runtime
- Zygote

1.2. System services



1.3. Boot animation

- Default boot animation
- bootanimation.zip
- setprop debug.sf.nobootanimation 1

1.4. Dex optimization

- Files:
 - .jar
 - .apk
- Directories:
 - BOOTCLASSPATH
 - /system/etc/permission/platform.xml
 - /system/framework
 - /system/app
 - /vendor/app
 - /data/app
 - /data/app-private

1.5. Apps startup

- Input methods
- Persistent apps
- Home screen
- BOOT_COMPLETED intent
- APPWIDGET_UPDATE intent

2. Utilities and Commands

- General-purpose commands
 - services
 - dumpsys
 - dumpstate
 - rawbu
- Service-specific utilities
 - am
 - pm
 - svc

- ime
- input
- monkey
- bmgr
- stagefright
- Dalvik utilities
 - dalvikvm
 - dvz
 - dexdump

3. Native daemons

- servicemanager
- installd
- vold
- netd
- rild
- keystore

3.1. servicemanager

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

3.2. installd

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

3.3. vold

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

3.4. netd

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

3.5. rild

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

3.6. keystore

- In aosp:
 - frameworks/base/cmds/keystore/
- In filesystem:
 - /system/bin
- Provides:
 - Store key-value pairs
 - Security keys for connecting to network infrastructure

4. System Services Internals

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

4.1. 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

4.1.1. Some stats

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

4.2. Observing the System Server

- Logcat
- dumpsys

4.2.1. 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.
...
```

4.2.2. dumphys

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

...

4.3. 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);
```

4.4. 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 ...

4.4.1. 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

4.4.2. Package Manager

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

4.4.3. Window Manager

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

4.4.4. Notification Manager

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

4.4.5. Power Manager

- Wakelocks
- Sleep
- Brightness
- Lock

4.4.6. Network Management Service

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

4.4.7. Mount Service

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

4.4.8. Location Manager

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

4.4.9. Status Bar Manager

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

4.4.10. Backup Manager

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

4.5. 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 ...

4.5.1. 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);
    }
}
}
}

```


4.5.2. IOpersysService.aidl

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

4.5.3. frameworks/base/Android.mk

...

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

```

...

4.5.4. SystemServer.java

Should eventually be Context.OPERSYS_SERVICE

...

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

...

4.5.5. HelloServer.java

```
package com.opersys.helloserver;

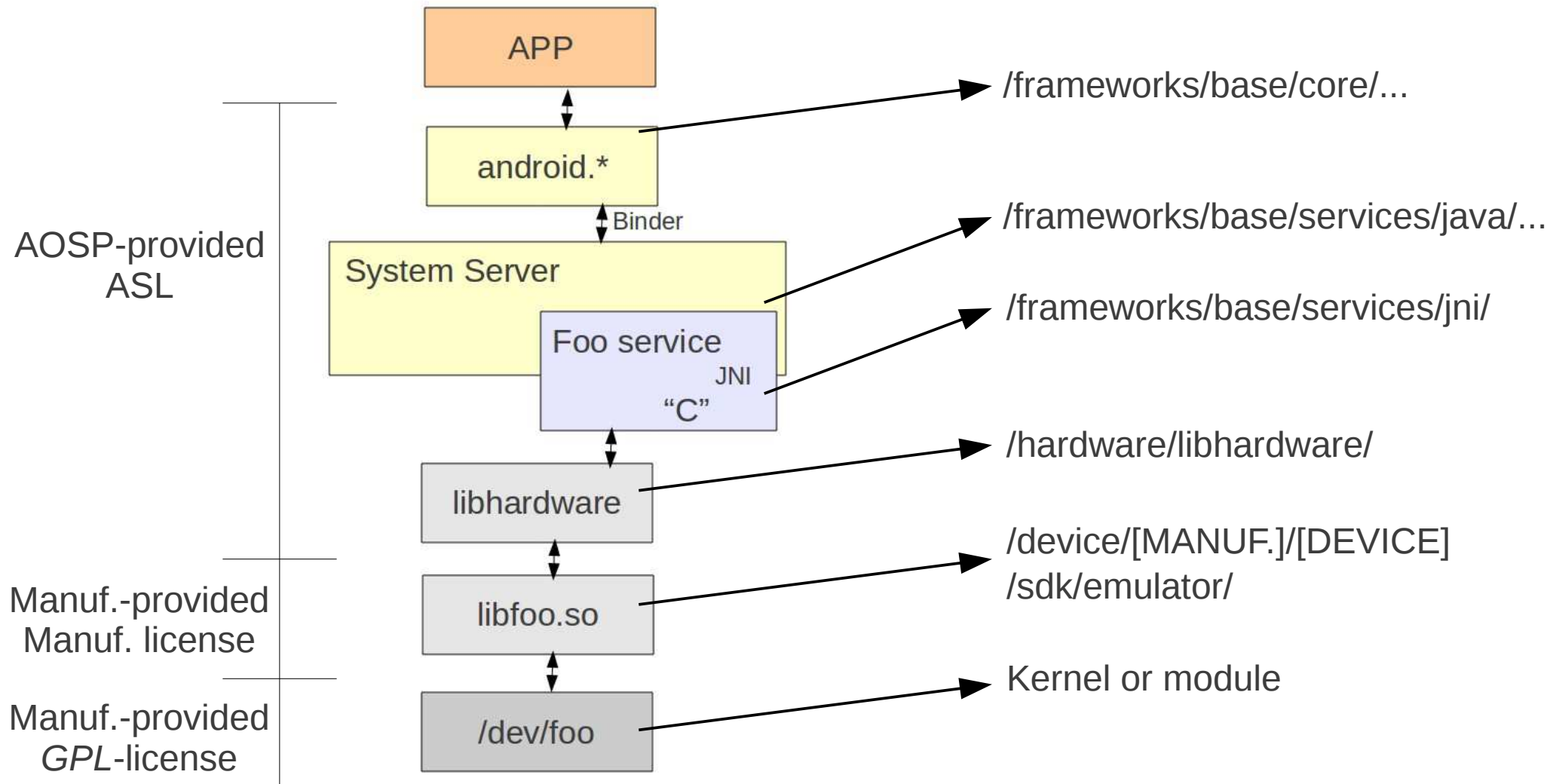
import android.app.Activity;
import android.os.Bundle;
import android.os.ServiceManager;
import android.os.IOpersysService;
import android.util.Log;

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();
        }
    }
}
```

5. 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

6. Android Framework

- Location and components
- android.*
- Customization

6.1. 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.

6.2. 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

6.3. Customization

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

6.3.1. Extending API – System service

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

6.3.1.1. app/ContextImpl.java

```
...  
import android.os.IOpsysService;  
import android.os.OpersysManager;  
...  
    private DownloadManager mDownloadManager = null;  
    private NfcManager mNfcManager = null;  
    private OpsysManager mOpsysManager = null;  
...  
        return getDownloadManager();  
    } else if (NFC_SERVICE.equals(name)) {  
        return getNfcManager();  
    } else if (OPERSYS_SERVICE.equals(name)) {  
        return getOpsysManager();  
    }  
...  
...
```

```
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;  
}
```

6.3.1.2. 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";  
...
```

6.3.1.3. 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;
}
```

6.3.2. Status bar

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

6.3.3. 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"  
>
```

6.3.4. 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>
```

```
...
```

6.3.5. 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>
```

...

6.3.6. Themes

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

Thank you ...

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