Dive Into Android Networking: Adding Ethernet Connectivity

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ABS 2013 – 19th February 2013 – San Francisco, CA

Dive Into Android Networking: Adding Ethernet Connectivity
About Me

ALCATEL LUCENT

ANDROID PLATFORM ARCHITECT

- Expert and Evangelist on Open Source Software.
- 9y experience on various multimedia/network embedded devices design.
- From low-level BSP integration to global applicative software architecture.

OPEN SOURCE

PROJECT FOUNDER, LEADER AND/OR CONTRIBUTOR FOR:

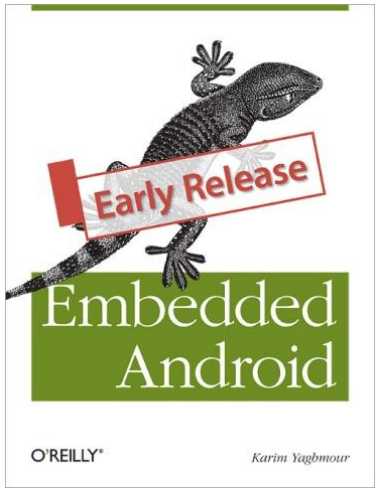
• OpenBricks	Embedded Linux cross-build framework.
• GeeXboX	Embedded multimedia HTPC distribution.
• uShare	UPnP A/V and DLNA Media Server.
• MPlayer	Linux media player application.

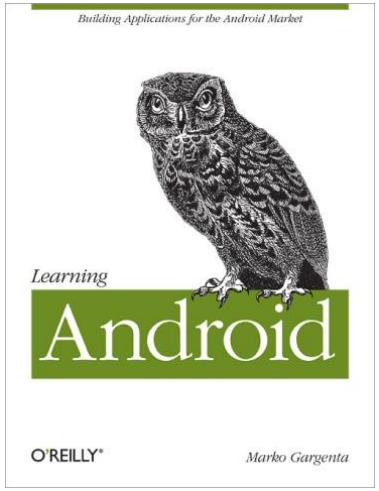
LINUX FOUNDATION CONFERENCES

FORMER LINUX FOUNDATION'S EVENTS SPEAKER

• ELC 2010	GeeXboX Enna: Embedded Media Center
• ELC-E 2010	State of Multimedia in 2010 Embedded Linux Devices
• ELC-E 2011	Linux Optimization Techniques: How Not to Be Slow ?
• ABS 2012	Android Device Porting Walkthrough
• ELC-E 2012	Dive Into Android Networking: Adding Ethernet Connectivity

Dive Into Android Networking: Adding Ethernet Connectivity
Bibliographical References





My Android bibles,
from my Android mentors:

Karim Yaghmour
Marko Gargenta

Followed by my own publications:
« Discovering Android »

Series of articles published in
GNU/Linux Magazine France

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Android Supported Connectivity Means

- **Mobile** (i.e. GSM / EDGE / HSDPA / LTE) ans its siblings:
  - **Mobile MMS** (*Multimedia Messaging Service*)
  - **Mobile SUPL** (*Secure User Plan Location*)
  - **Mobile DUN** (*Dial Up Networking [bridge]*)
  - **Mobile HIPRI** (*High Priority*)
- **Wi-Fi**
- **WiMax**
- **Bluetooth**
- **Ethernet** (*really ??*)

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Android Networking Architecture

- Kernel Drivers (Ethernet, Wi-Fi, Bluetooth, WiMax …)
- Kernel TCP/IP layer with POSIX user-space API support.
- Android **Hardware Abstraction Layer** (*HAL*)
- Android **Bionic** C library (not 100% POSIX …)
- Android **libnetutils** (*Network Utilities*)
- Android **Netd** (*Network Daemon*)
- Android **ConnectivityManager** and **ConnectivityService** (part of the Java Framework).
- Android Java Apps

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Bionic C Library

- No **/etc/network/interfaces** support.
- No **/etc/nsswitch.conf** support.
- No **/etc/resolv.conf** support.
- Everything (IP, DNS, router, proxy …) is property-based
  - Available through **getprop/setprop** commands

```
[net.hostname]: [android-eafc65fa82572120]
[dhcp.eth0.gateway]: [172.25.52.8]
[dhcp.eth0.ipaddress]: [172.25.52.225]
[dhcp.eth0.mask]: [255.255.252.0]
[dhcp.eth0.dns1]: [155.132.12.50]
[net.dns1]: [155.132.12.50] [net.eth0.dns1]: [155.132.12.50]
[net.http.proxy]: [155.132.8.49:3128]
[net.proxy]: [155.132.8.49:3128]
```

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Netd and libnetutils

- **Netd**
  - Mostly provides tethering capabilities.
  - Accepts commands through UNIX socket.
  - Can be controlled by apps or **ndc** command.
  - Features bandwidth control, IP forwarding, NAT/PAN for SoftAP …
- **Libnetutils**
  - Low-level interface control interface
  - Provides API to **ifconfig** / **netcfg** / **route** / **dhcpcd**
  - Used by HAL and system framework to control network interfaces.

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ConnectivityManager and ConnectivityService

- Orchestrate and manage global networking at Java framework level.
- Rely on underlying **libnetutils** and **netd** services to control hardware.
- Interact with interface-specific managers (**WifiManager** …).

- **Role and Duties:**
  - Track and monitor various network connectivity interfaces (*Mobile, Bluetooth, Wi-Fi* …)
  - Notify registered apps (through *Intent* broadcasting) of a system connectivity state change.
  - Switch from one network type to another when connection is lost.
  - Provide an interface for apps to retrieve all possible connections' states.

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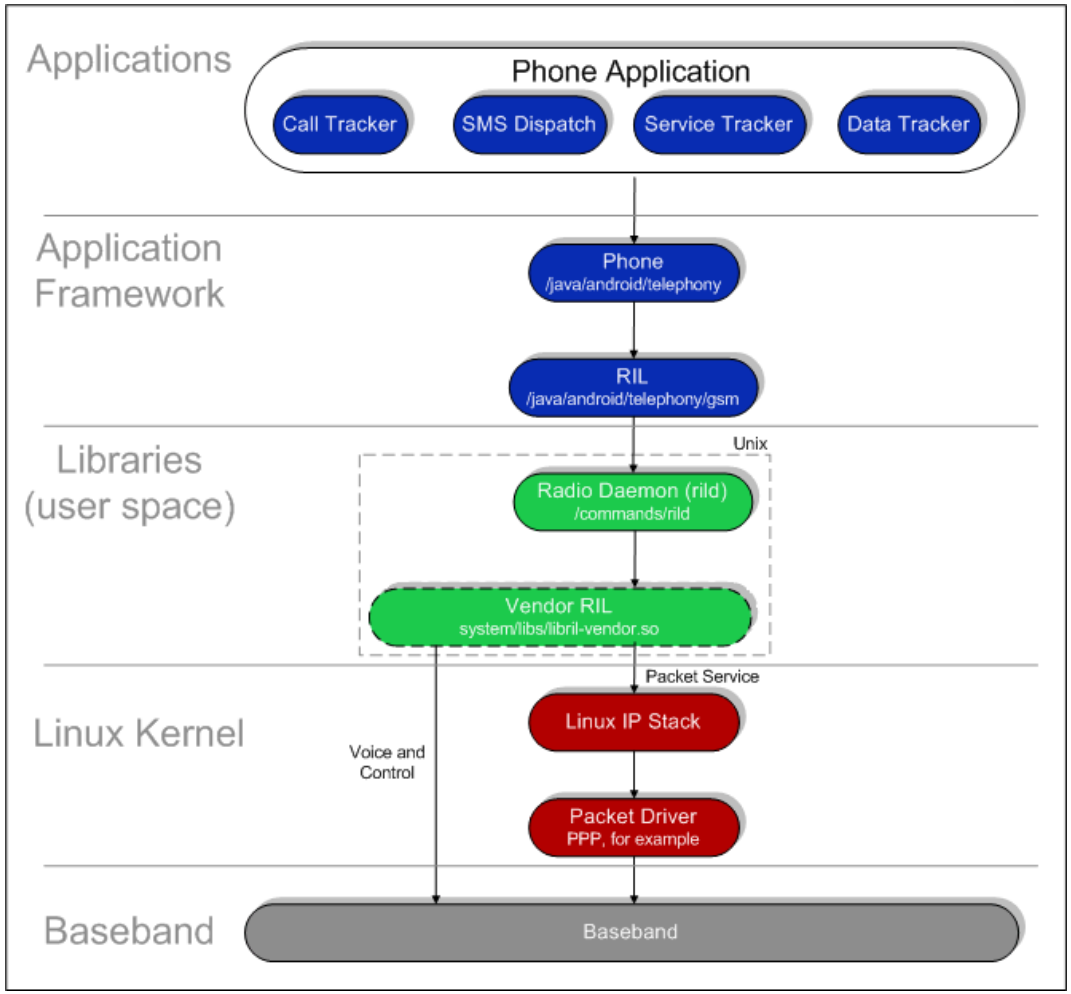
Radio Layer Interface

- Communicates with broadband processor for both voice and data.
- Uses **RIL** and proprietary **rild** to interface with system.
- Data connection is exported by **Connectivity Manager** through **TYPE_MOBILE_***



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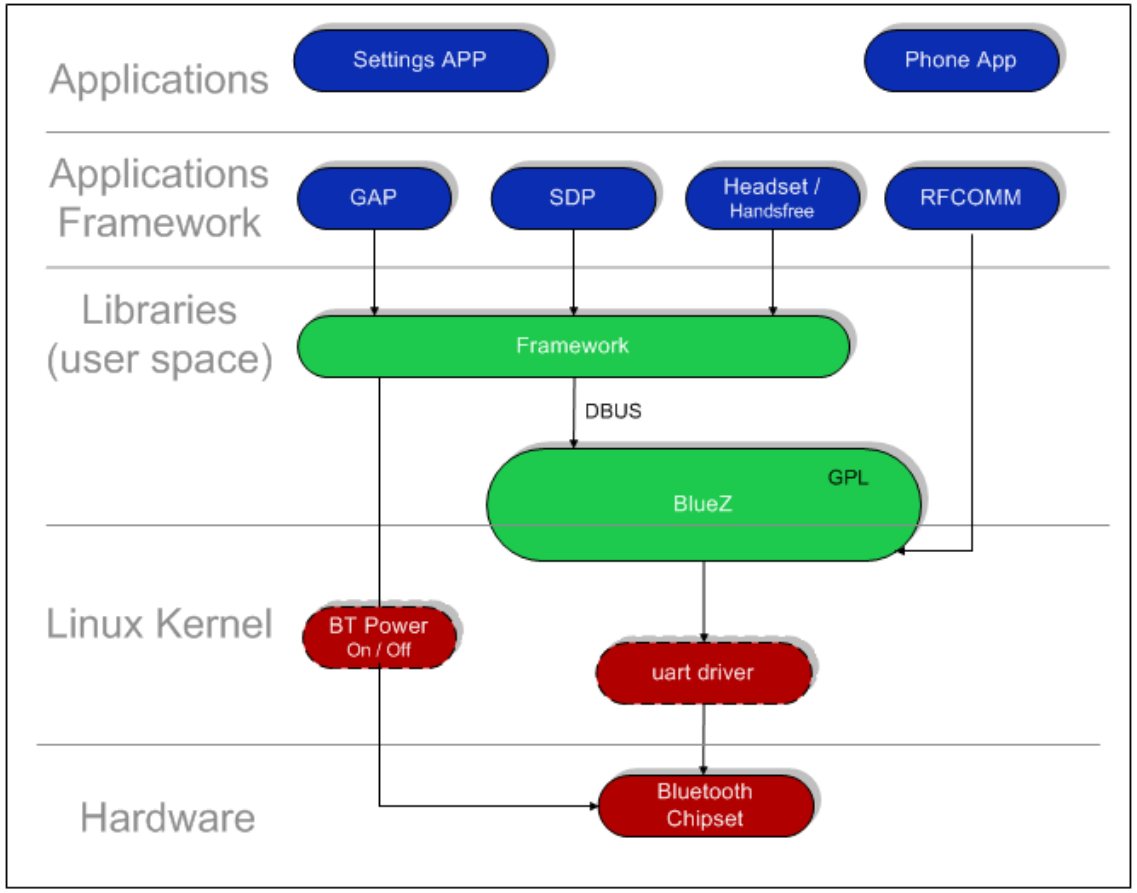
Bluetooth Interface

- Communicates with BT chipset through **BlueZ** and **libbluedroid**.
- Provides both audio and data management.
- Data connection is exported by **Connectivity Manager** through **TYPE_BLUETOOTH**.
- Interface with **netd** for tethering.



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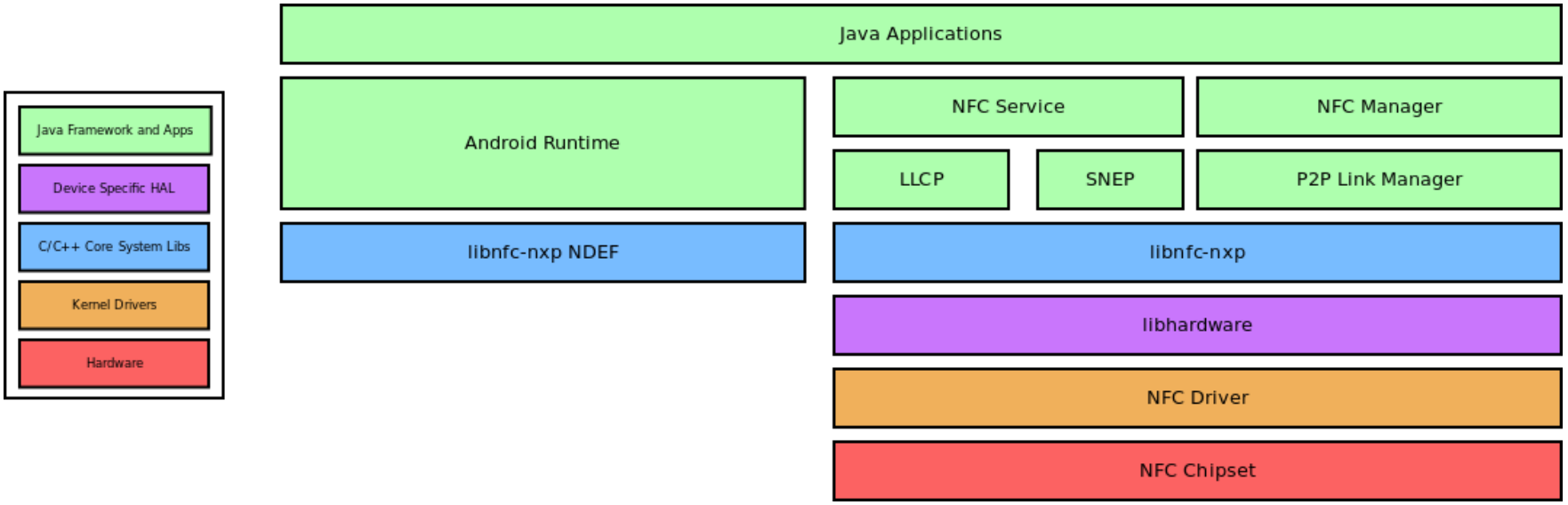
NFC Interface



- Introduced with **Ice Cream Sandwich** for **Near Field Communication**.
- Rely on **NFC HAL**.
- Currently only support chips from NXP (PN544).
- Uses **Android Beam** for P2P data exchange.
- Doesn't interface with **Connectivity Service/Manager**.

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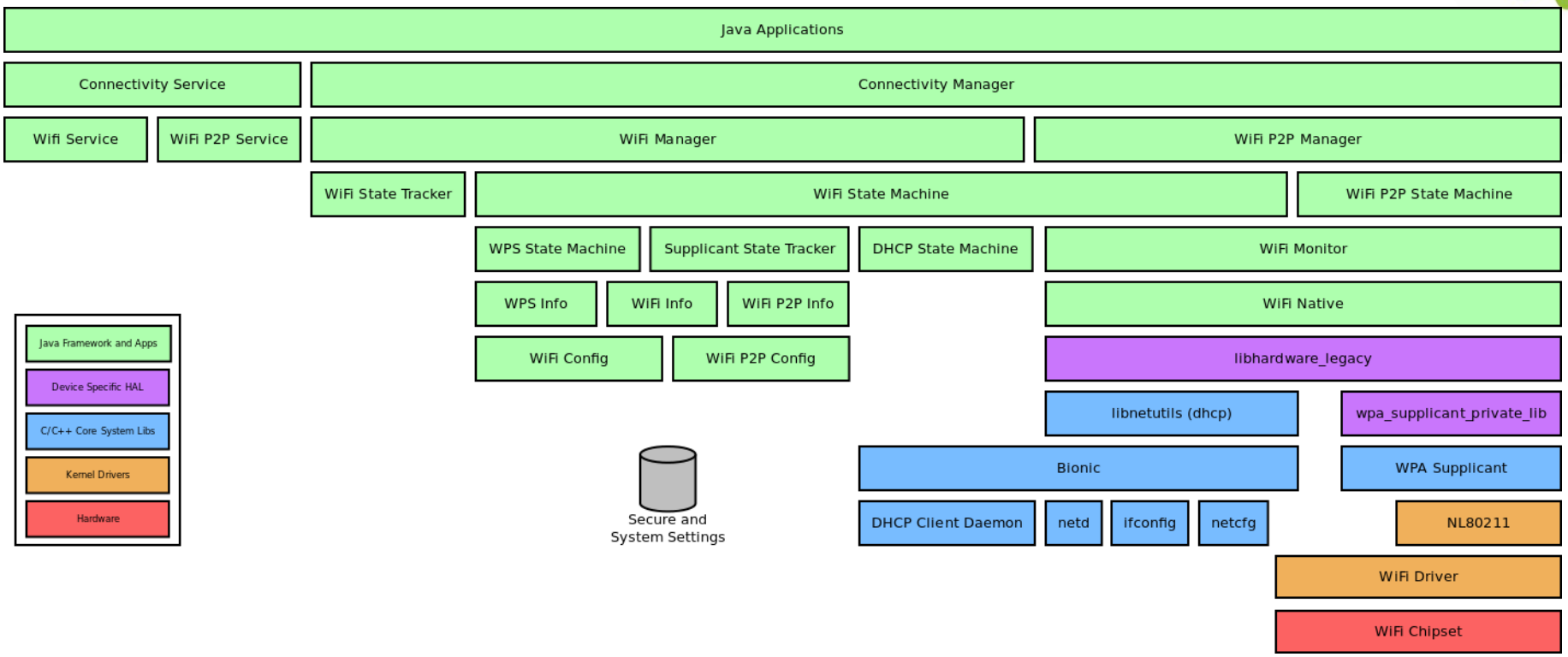
WiFi Station/AP/P2P Interface



- Rely on **HAL** for specific driver interface with **JNI binding**.
- Data connection is exported by **Connectivity Manager** through **TYPE_WIFI**.
- WiFi configuration is stored in file system and SQLite database.

So what about Ethernet ??

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Work Context

- Designing an **Enterprise Desktop IP Phone**.

- Differs heavily from usual Android devices:
  - Always connected, no battery
  - No Radio (GSM/CDMA).
  - No WiFi Station mode, AP only.
  - **LAN through Ethernet PHY/Switch.**
  - Always docked, no screen rotation.
  - No accelerometer, no GPS …
  - **=> Not a Smartphone**

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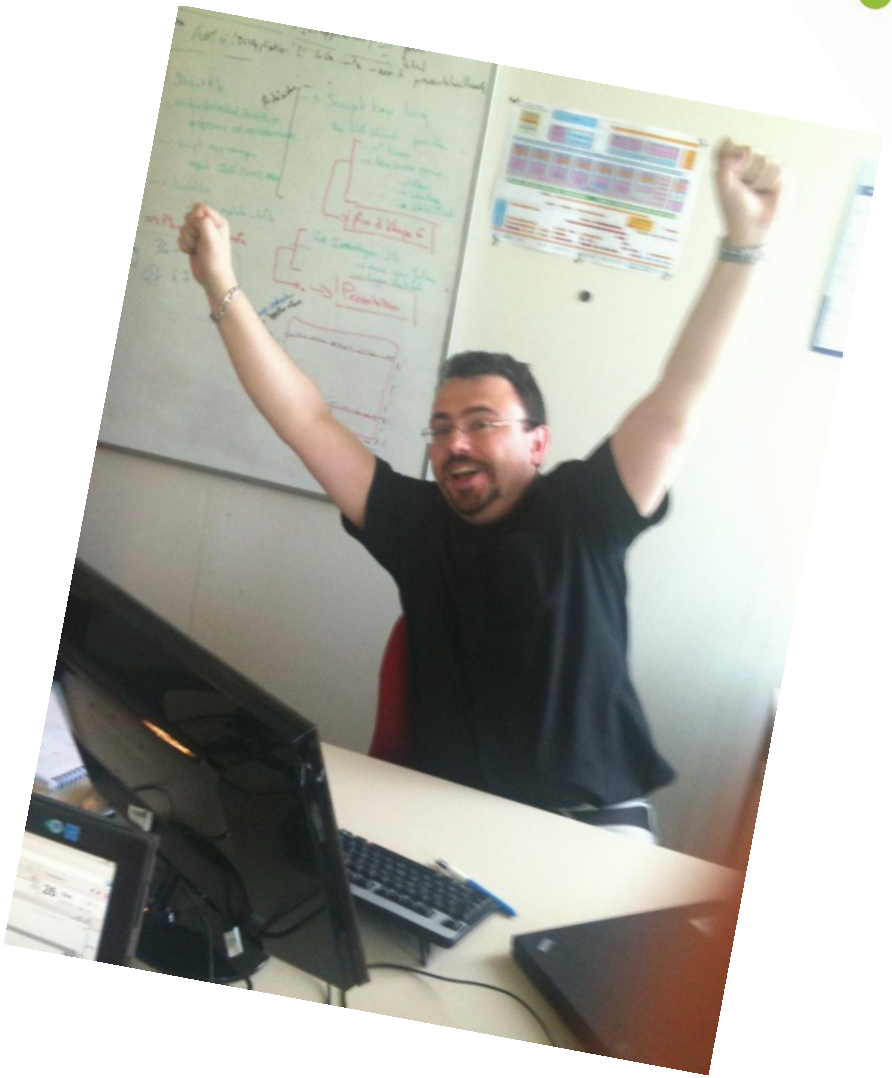
Give Unto Caesar What is Caesar's …

Most of the work presented hereafter is courtesy of

Fabien Brisset



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Android Ethernet Upstream Status

- Ethernet is supported through native Linux kernel drivers.
- **ifconfig / netcfg / ping** commands work but remain at platform level.
- Regular **/etc/resolv.conf** DNS is not supported due to **Bionic** host resolution.
- Native system daemons (C/C++) support regular Linux networking API.
- Java framework services and apps rely on **Connectivity Manager** and have no clue what Ethernet route/connection actually means.
  - Except for some apps (e.g. **Browser**, which relies on native implementation).
- Barely no Android device features Ethernet
  - Except from some obscure Chinese tablets.
- Ethernet connection type exists in ICS API.
  - But with no **Connectivity Manager** or **Connectivity Service** implementation.

Dive Into Android Networking: Adding Ethernet Connectivity
Enterprise Requirements & ECM Status

- **Enterprise Requirements:**
  - Reliability: Ensuring data connection works in 100% cases for all possible applications.
  - HTTP(S) seamless proxy support for all applications.
  - Corporate firewalls prevents some services behavior (e.g. NTP).
    - Need to ensure everything stays behind the walls.
  - Ethernet 802.1x authentication.

- **Ethernet Connectivity Manager (ECM) Status**
  - ECM patch has been done by **Android-x86** team for netbooks.
    - **Not 100% accurate or sufficient.**

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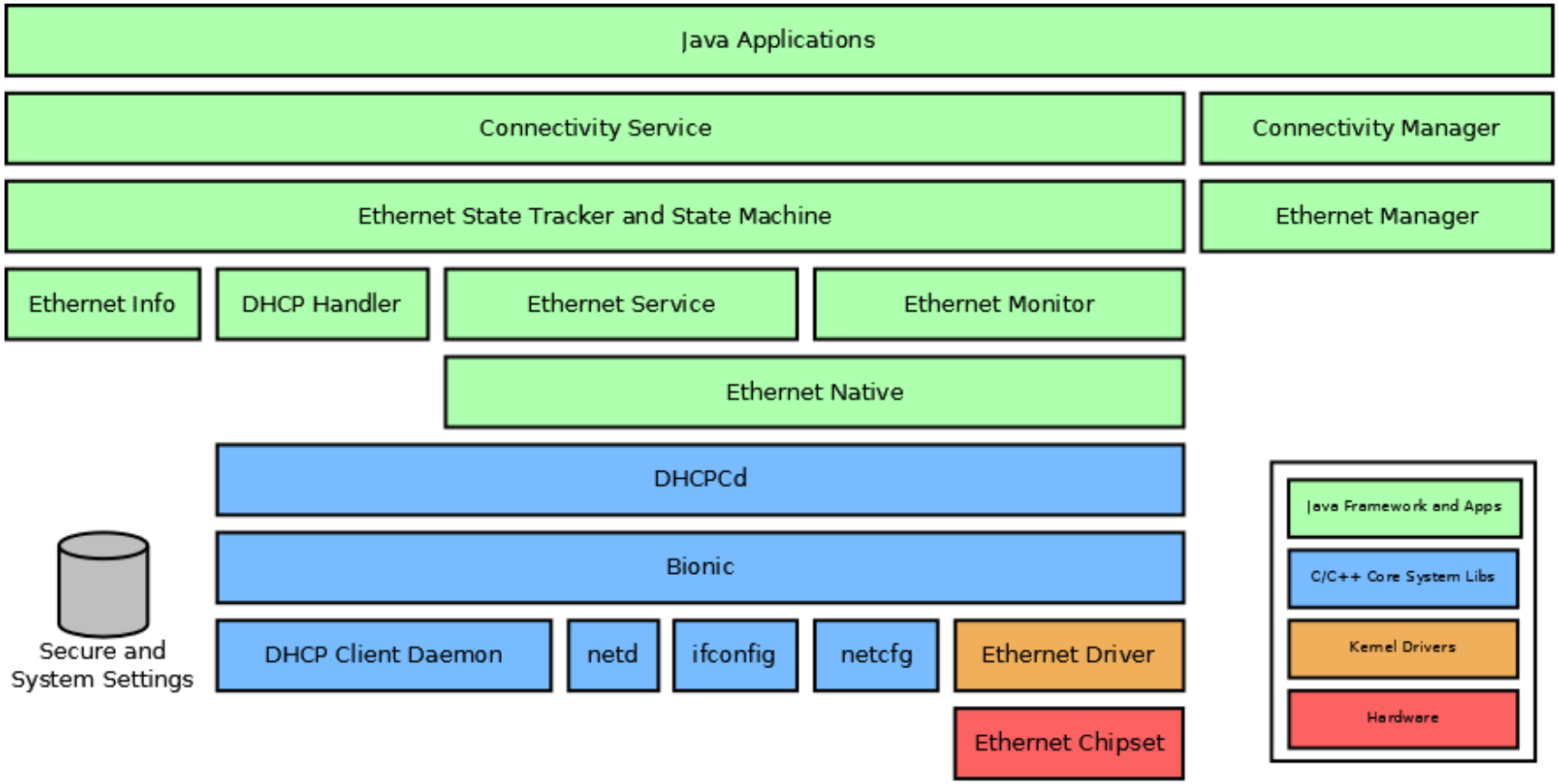
Ethernet Interface – ECM Patch Status



- Mismatch in implementation towards WiFi.
- Rely on **DHCPCd** dhcp implementation instead of **libnetutils**.
- Not completely bind on **Connectivity Manager and Service**.

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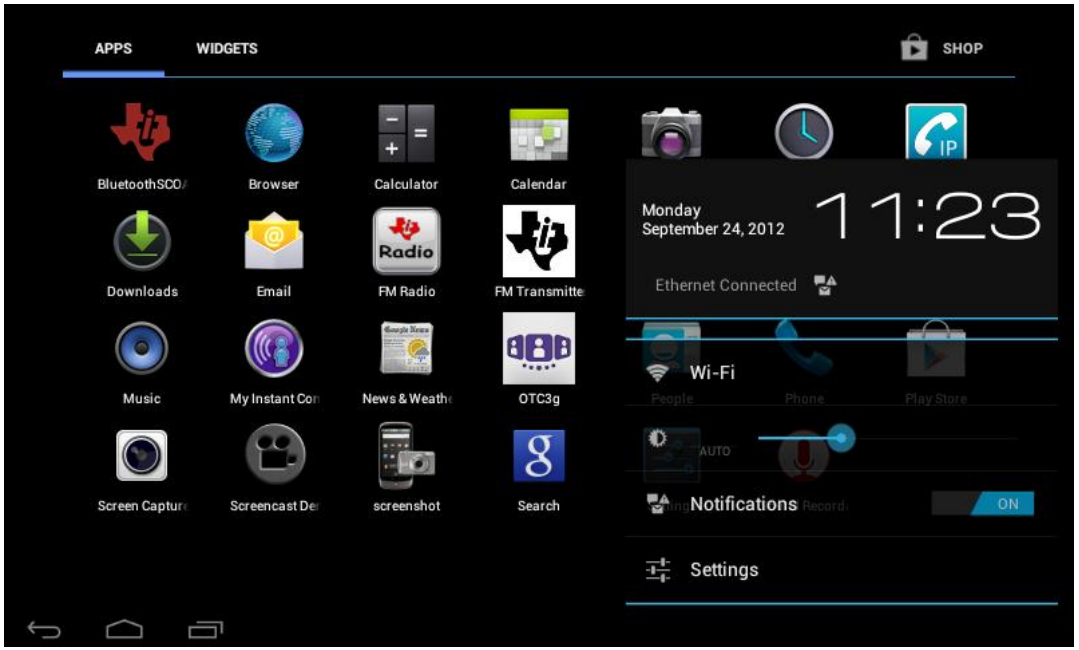
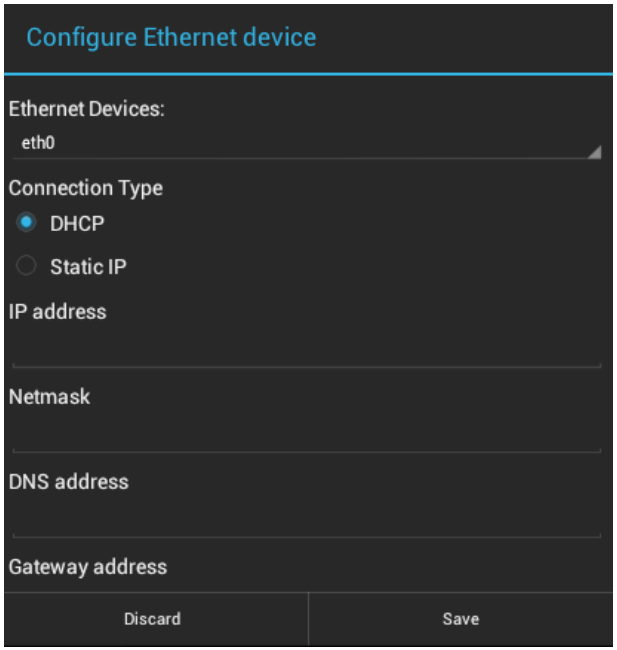
Am I Connected or What ?

- Changes in Android framework, Settings app and System UI.
- Supports DHCP (ECM patch default) and Static IP (added) addressing.
- Connection status is available in notification bar.





Dive Into Android Networking: Adding Ethernet Connectivity
ECM Patch Additions

- **Register Ethernet Service**
  - **In framework's core/java/android/app/ContextImpl.java:**

```
registerService(ETHERNET_SERVICE, new ServiceFetcher() {
  public Object createService(ContextImpl ctx) {
    IBinder b = ServiceManager.getService(ETHERNET_SERVICE);
    IEthernetManager srv = IEthernetManager.Stub.asInterface(b);
    return new EthernetManager(srv, ctx.mMainThread.getHandler());
}});
```

- **Letting Connectivity Service know about Ethernet:**
  - **In framework's services/java/com/android/server/ConnectivityService.java:**

```
[...] else if (networkType == ConnectivityManager.TYPE_ETHERNET)
            usedNetworkType = ConnectivityManager.TYPE_ETHERNET;
```

Dive Into Android Networking: Adding Ethernet Connectivity
ECM Patch Additions

- **Forcing default network preferences:**
  - **In framework's core/java/android/net/ConnectivityManager.java:**

```
-     public static final int DEFAULT_NETWORK_PREFERENCE = TYPE_WIFI;
+     public static final int DEFAULT_NETWORK_PREFERENCE = TYPE_ETHERNET;
```

Issue: Android public API is being modified and **make update-api** is required.

  - **In framework's packages/SettingsProvider/res/values/defaults.xml:**

```
-     <integer name="def_network_preference">1</integer>
+     <integer name="def_network_preference">9</integer>
```

  - **In framework's services/java/com/android/server/EthernetService.java:**

```
-     Settings.Secure.putString(cr, Settings.Secure.ETHERNET_IFNAME, DevName[0]);
+     Settings.Secure.putString(cr, Settings.Secure.ETHERNET_IFNAME, "eth0");
```

And now, bugs and workarounds for various use cases:

Making Ethernet 100% functional.

Dive Into Android Networking: Adding Ethernet Connectivity

Connection Information

Symptom:

What is my Ethernet IP configuration or MAC address info ?

Dive Into Android Networking: Adding Ethernet Connectivity

Connection Information – IP Address

- **In Settings's res/xml/device_info_status.xml:**

```
<Preference android:key="ethernet_ip_address"
    style="?android:attr/preferenceInformationStyle"
    android:title="@string/ethernet_advanced_ip_address_title"
    android:summary="@string/device_info_not_available"
    android:persistent="false" />
```

- **In src/com/android/settings/deviceinfo/Status.java:**

```
private void setEthernetIpAddressStatus() {

    EthernetManager mgr = getSystemService(ETHERNET_SERVICE);
    EthernetDevInfo info = mgr.getSavedConfig();

    Preference ip = findPreference("ethernet_ip_address");

    String addr = null;

    if (info != null) {
        if (info.getIpAddress() != null)
            addr = info.getIpAddress();
        else
            addr = SystemProperties.get("dhcp.eth0.ipaddress");
    }

    ip.setSummary(!TextUtils.isEmpty(addr) ? Addr :
        getString(R.string.status_unavailable));
}
```

Dive Into Android Networking: Adding Ethernet Connectivity
Connection Information – MAC Address

- **In framework's JNI code core/jni/android_net_ethernet.cpp:**

```
{"getInterfaceMacAddress", "()Ljava/lang/String;",
      (void *)android_net_ethernet_getInterfaceMacAddress},

[...]

static jstring android_net_ethernet_getInterfaceMacAddress(JNIEnv *env, jobject clazz) {

    struct ifreq ifr;
    strcpy (ifr.ifr_name, "eth0");
    strcpy (ifr.ifr_hwaddr.sa_data, "");

    sock = socket (AF_INET, SOCK_STREAM, 0);

    ioctl (sock, SIOCGIFHWADDR, &ifr);

    ptr = (unsigned char *) ifr.ifr_hwaddr.sa_data;

    snprintf (buf, 64, "%02x:%02x:%02x:%02x:%02x:%02x",
         (ptr[0] & 0377), (ptr[1] & 0377), (ptr[2] & 0377),
         (ptr[3] & 0377), (ptr[4] & 0377), (ptr[5] & 0377));

    return env->NewStringUTF(buf);
}
```

Dive Into Android Networking: Adding Ethernet Connectivity
Connection Information – MAC Address

- **In Settings' res/xml/device_info_status.xml:**

```
<Preference android:key="ethernet_mac_address"
    style="?android:attr/preferenceInformationStyle"
    android:title="@string/status_ethernet_mac_address"
    android:summary="@string/device_info_not_available"
    android:persistent="false" />
```

- **In Settings' src/com/android/settings/deviceinfo/Status.java:**

```
private void setEthernetMacAddress() {

    EthernetManager mgr = getSystemService(ETHERNET_SERVICE);
    EthernetDevInfo info = mgr.getSavedConfig();

    Preference mac = findPreference("ethernet_mac_address");

    String addr = info == null ? null : info.getMacAddress();

    mac.setSummary(!TextUtils.isEmpty(addr) ? addr
            : getString(R.string.status_unavailable));
}
```

Dive Into Android Networking: Adding Ethernet Connectivity
Android DNS Entry Management

Symptom:

DHCP can't seem to provide me with valid DNS entries.

- **Match Android process (AID) authorizations to update system properties in init's init/property_service.c:**

```
    { "rw.",                AID_SYSTEM,   0 },
    { "net.",               AID_DHCP,     0 },
```

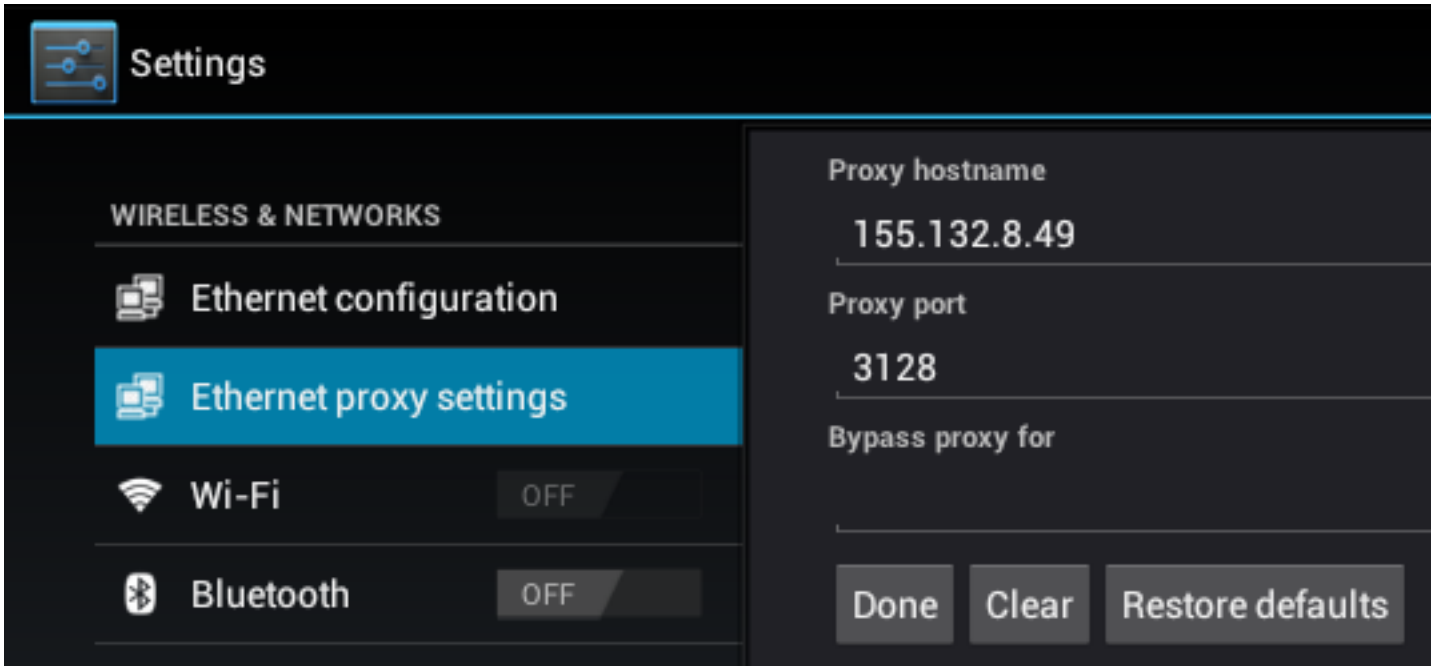
- **In DHCPCD's dhcpcd-hooks/20-dns.conf:**

```
      for dnsaddr in ${new_domain_name_servers}; do
          setprop dhcp.${interface}.dns${count} ${dnsaddr}
+         setprop net.dns${count} ${dnsaddr}
+         setprop net.${interface}.dns${count} ${dnsaddr}
          count=$(($count + 1))
      done
```

- **In framework's ethernet/java/android/net/ethernet/EthernetStateTracker.java:**

```
SystemProperties.set("net.dns1", mDhcpInfo.dns1);
SystemProperties.set("net." + mInterfaceName + ".dns1", mDhcpInfo.dns1);
```

Dive Into Android Networking: Adding Ethernet Connectivity
HTTP(S) Proxy



Symptom:

I'm behind HTTP(S) proxy.
I need my apps to seamlessly know about that !

Dive Into Android Networking: Adding Ethernet Connectivity
HTTP(S) Proxy

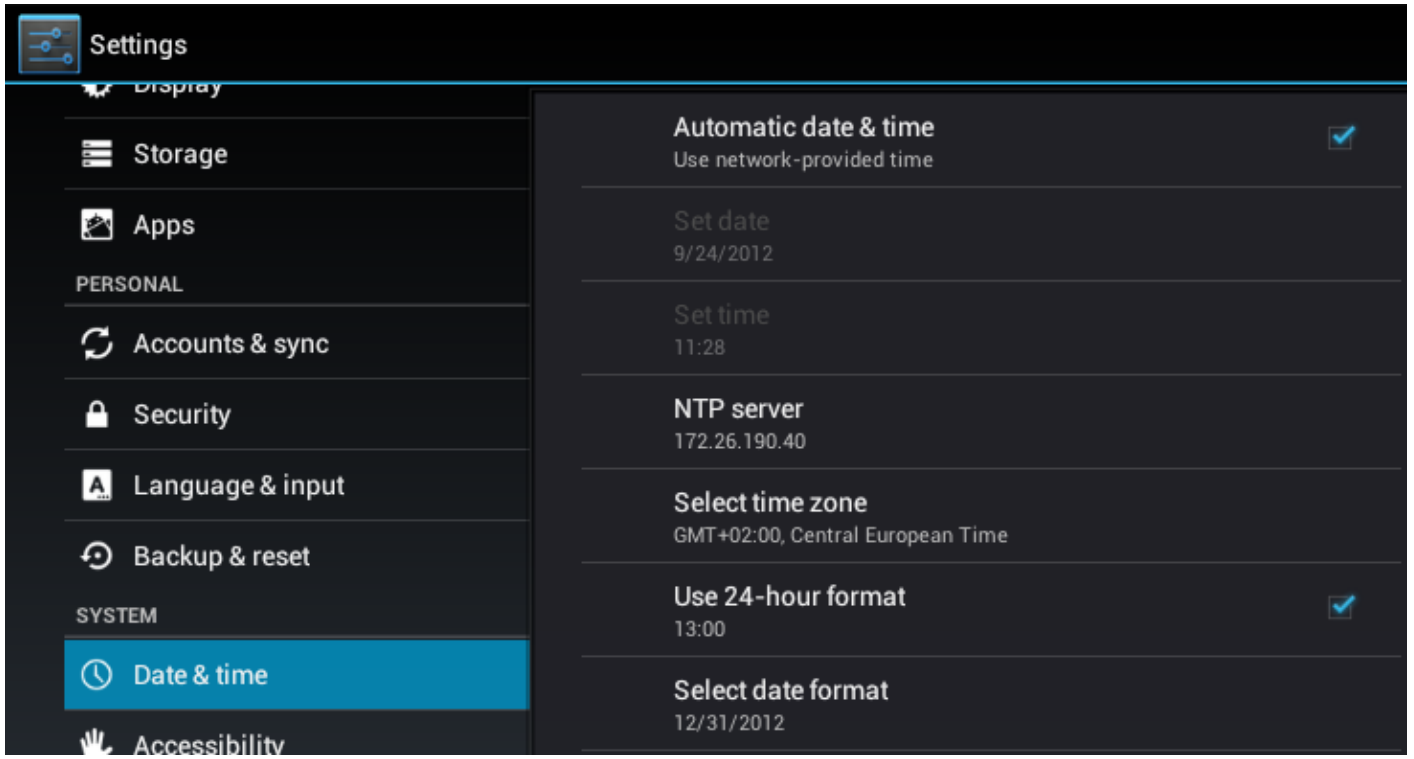
- **Overlay frameworks/base/core/res/res/values/config.xml:**

```
<string name="config_default_proxy_host" translatable="false">a.b.c.d</string>
<integer name="config_default_proxy_port" translatable="false">8080</integer>
```

- **In framework's services/java/com/android/server/ConnectivityService.java:**

```
String proxyHost = context.getResources().getString(
          com.android.internal.R.string.config_default_proxy_host);

int proxyPort = context.getResources().getInteger(
          com.android.internal.R.integer.config_default_proxy_port);

mGlobalProxy = new ProxyProperties(proxyHost, proxyPort, null);

SystemProperties.set("net.http.proxy", proxyHost + ":" + proxyPort);
```

Dive Into Android Networking: Adding Ethernet Connectivity
Custom NTP Server



Symptom:

I'm behind corporate firewall and can't do NTP request.
My company provides its internal NTP server.

Dive Into Android Networking: Adding Ethernet Connectivity
Custom NTP Server

- **Overlay frameworks/base/core/res/res/values/config.xml:**

```
<!-- Remote server that can provide NTP responses. -->
<string translatable="false" name="config_ntpServer">a.b.c.d</string>

<!-- Timeout to wait for NTP server response. -->
<integer name="config_ntpTimeout">20000</integer>
```

- **In framework's core/java/android/util/NtpTrustedTime.java:**

```
-    final String defaultServer =
          res.getString(com.android.internal.R.string.config_ntpServer);

+    String defaultServer = Settings.System.getString(resolver, Settings.System.NTP_SERVER);
```

- **In framework's services/java/com/android/server/NetworkTimeUpdateService.java:**
  - Force NTP update on Ethernet state change:

```
if (netInfo.getState() == NetworkInfo.State.CONNECTED &&
      netInfo.getType()  == ConnectivityManager.TYPE_ETHERNET)
    mHandler.obtainMessage(EVENT_ETHERNET_CONNECTED).sendToTarget();

[...]

case EVENT_WIFI_CONNECTED:
case EVENT_ETHERNET_CONNECTED:
   onPollNetworkTime(msg.what);
```

Dive Into Android Networking: Adding Ethernet Connectivity
Custom NTP Server

- **In Settings's res/xml/date_time_prefs.xml:**

```
<EditTextPreference
    android:title="@string/ntp_server_time"
    android:key="ntp_server"
    android:singleLine="true"
    android:summary="192.168.1.1"
    android:inputType="textUri"/>
```

- **In Settings' src/com/android/settings/DateTimeSettings.java:**

```
EditTextPreference pref = findPreference("ntp_server");

String server =
      Settings.System.getString(getContentResolver(), Settings.System.NTP_SERVER);

pref.setText(server);
pref.setSummary(server);
```

Dive Into Android Networking: Adding Ethernet Connectivity
Email

Symptom:

I can't download email attachments.

- In src/com/android/email/AttachmentInfo.java:

```
- if (networkType != ConnectivityManager.TYPE_WIFI) {

+ if ((networkType != ConnectivityManager.TYPE_WIFI) &&
          (networkType != ConnectivityManager.TYPE_ETHERNET)) {
```

- In src/com/android/email/service/AttachmentDownloadService.java:

```
- if (ecm.getActiveNetworkType() != ConnectivityManager.TYPE_WIFI) {

+ if ((ecm.getActiveNetworkType() != ConnectivityManager.TYPE_WIFI) &&
       (ecm.getActiveNetworkType() != ConnectivityManager.TYPE_ETHERNET)) {
```

Dive Into Android Networking: Adding Ethernet Connectivity

Connectivity Route

Symptom:

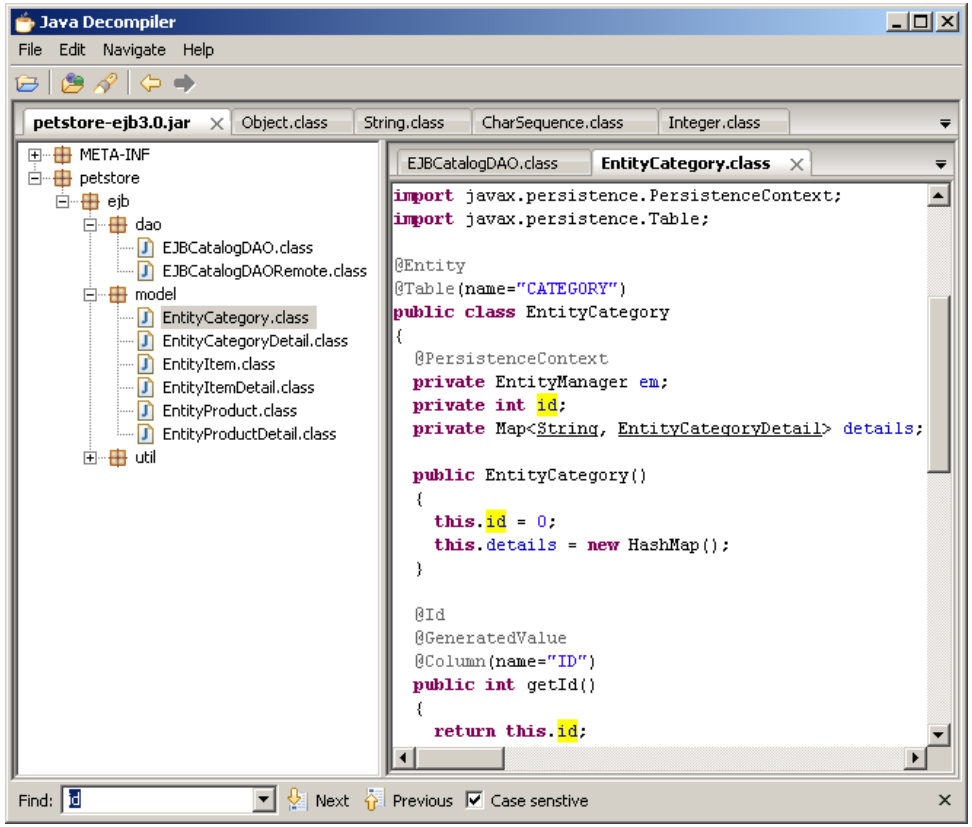
I can't access to Google Play Store.
The application just crash !

Dive Into Android Networking: Adding Ethernet Connectivity
Connectivity Route

Reverse engineering apps may help:

- **Dex2jar**
  - Extracts usable classes.jar from APK archives.
  - See http://code.google.com/p/dex2jar/

- **Java Decompiler (jd-gui)**
  - See http://java.decompiler.free.fr/?q=jdgui



Dive Into Android Networking: Adding Ethernet Connectivity
Connectivity Route

- **Many (certified?) apps assume that WiFi or mobile connection is always present.**
  - We need to trick the system for Ethernet.
  - But this is truly an ugly hack.

- **In framework's services/java/com/android/server/ConnectivityService.java:**

```
    public NetworkInfo getNetworkInfo(int networkType, int uid) {
-       return getNetworkInfo(networkType, uid);
+       switch (networkType) {
+           case ConnectivityManager.TYPE_MOBILE:
+           case ConnectivityManager.TYPE_WIFI:
+           case ConnectivityManager.TYPE_WIMAX:
+               networkType = ConnectivityManager.TYPE_ETHERNET;
+               break;
+           default:
+               break;
+       }
+       return getNetworkInfo(networkType, uid);
    }
```

- **Android shouldn't expose WiFi Manager API !**
  - Apps should always go through Connectivity Manager for all network information.

- **Limitations:**
  - Connectivity Manager API can't configure default connection type (currently hardcoded).
  - Too few information on existing devices' connectivity states.

Dive Into Android Networking: Adding Ethernet Connectivity
Download Provider

Symptom:

My browser works fine but I just can't download files.

- **In DownloadProvider's src/com/android/providers/downloads/DownloadInfo.java:**
  - Add Ethernet connectivity support

```
case ConnectivityManager.TYPE_ETHERNET:
   return DownloadManager.Request.NETWORK_ETHERNET;

[...]

if (networkType == ConnectivityManager.TYPE_ETHERNET) {
   return NETWORK_OK; // anything goes over ethernet
}
```

Dive Into Android Networking: Adding Ethernet Connectivity
Multimedia Streaming

Symptom:

My browser works fine but I can't play multimedia contents.

- **Force Chrome HTTP stack instead of Android HTTP stack.**
  - By default, **Stagefright** can't bypass proxy (see **frameworks/base/media/libstagefright/Android.mk**)
  - Overlay in your device's **device.mk** file: `HTTP := chrome`

- **In framework's media/libstagefright/chromium_http/support.cpp:**

```
char value[PROPERTY_VALUE_MAX];
property_get("net.http.proxy", value, "Unknown");

net::ProxyConfigServiceAndroid cfg = new net::ProxyConfigServiceAndroid();
if (strcmp(value_proxy,"Unknown") != 0) {
   std::string proxy = value;
   cfg->UpdateProxySettings(proxy, "");
}

set_proxy_service(net::ProxyService::CreateWithoutProxyResolver(cfg, net_log()));
```

- **In framework's services/java/com/android/server/ConnectivityService.java:**
  - Optionally force proxy detection in proprietary OMX Codecs:

```
SystemProperties.set("net.proxy", host + ":" + port);
SystemProperties.set("rw.HTTP_PROXY", "http://" + host + ":" + port);
```

Dive Into Android Networking: Adding Ethernet Connectivity
Phone / SIP VoIP

Symptom:

I can do VoIP SIP calls over WiFi but not over Ethernet.

- **Overlay frameworks/base/core/res/res/values/config.xml:**

```
<bool name="config_sip_ethernet">true</bool>
```

- **In framework's voip/java/android/net/sip/SipManager.java:**

```
public static boolean isSipEthernet(Context context) {
    return context.getResources().getBoolean(com.android.internal.R.bool.config_sip_ethernet);
}
```

- **In framework's voip/java/com/android/server/sip/SipService.java:**

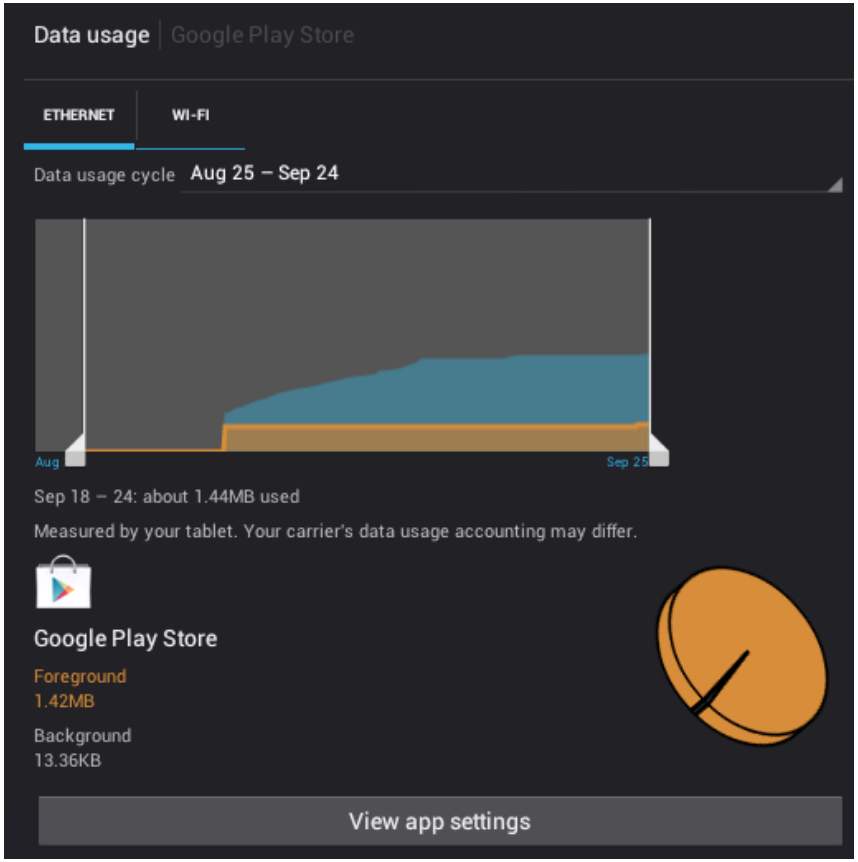
```
boolean mSipOnWifiOnly = SipManager.isSipWifiOnly(context);
boolean mSipEthernet = SipManager.isSipEthernet(context);

boolean connected = (info != null && info.isConnected() &&
         ((!mSipOnWifiOnly || info.getType() == ConnectivityManager.TYPE_WIFI) ||
           ( mSipEthernet   && info.getType() == ConnectivityManager.TYPE_ETHERNET));
```

- **In Phone's src/com/android/phone/SipCallOptionHandler.java:**

```
return ((ni.getType() == ConnectivityManager.TYPE_WIFI) || !SipManager.isSipWifiOnly(this)) ||
       ((ni.getType() == ConnectivityManager.TYPE_ETHERNET) && SipManager.isSipEthernet(this));
```

Dive Into Android Networking: Adding Ethernet Connectivity

Network Statistics



Symptom:

How much data did I use ?
Where are my network statistics ?

Dive Into Android Networking: Adding Ethernet Connectivity
Network Statistics

- **Overlay frameworks/base/core/res/res/values/config.xml:**

```
<!-- Set of NetworkInfo.getType() that reflect data usage. -->
<integer-array translatable="false" name="config_data_usage_network_types">
    <item>9</item> <!-- TYPE_MOBILE_ETHERNET -->
</integer-array>

<!-- The default iface on which to monitor data use -->
<string name="config_datause_iface">eth0</string>
```

- **Update Logtags samples in framework's services/java/com/android/server/EventLogTags.logtags:**

```
51102 netstats_ethernet_sample
(dev_rx_bytes|2|2),(dev_tx_bytes|2|2),(dev_rx_pkts|2|1),(dev_tx_pkts|2|1),(xt_rx_bytes|2|2),
(xt_tx_bytes|2|2),(xt_rx_pkts|2|1),(xt_tx_pkts|2|1),(uid_rx_bytes|2|2),(uid_tx_bytes|2|2),(u
id_rx_pkts|2|1),(uid_tx_pkts|2|1),(trusted_time|2|3),(dev_history_start|2|3)
```

- **In framework's ethernet/java/android/net/ethernet/EthernetStateTracker.java:**
  - One need to add support for **LinkProperties**

```
LinkProperties mLinkProperties = mDhcpInfo.makeLinkProperties();
mLinkProperties.setInterfaceName("eth0");
```

Dive Into Android Networking: Adding Ethernet Connectivity
Network Statistics

- **In framework's services/java/com/android/server/net/NetworkStatsService.java:**
  - Need to collect Ethernet samples.

```
import static android.net.NetworkTemplate.buildTemplateEthernet;

NetworkTemplate template = buildTemplateEthernet();

devTotal = getSummaryForNetworkDev(template, start, end).getTotal(devTotal);
devHistoryStart = getHistoryStartLocked(template, mNetworkDevStats);
xtTotal = getSummaryForNetworkXt(template, start, end).getTotal(xtTotal);
uidTotal = getSummaryForAllUid(template, start, end, false).getTotal(uidTotal);

EventLogTags.writeNetstatsEthernetSample(
      devTotal.rxBytes, devTotal.rxPackets, devTotal.txBytes, devTotal.txPackets,
      xtTotal.rxBytes, xtTotal.rxPackets, xtTotal.txBytes, xtTotal.txPackets,
      uidTotal.rxBytes, uidTotal.rxPackets, uidTotal.txBytes, uidTotal.txPackets,
      trustedTime, devHistoryStart);
```

- **Adding ConnectivityManager.TYPE_ETHERNET support to Monkey's NetworkMonitor**
  - Used to display time spent proceeding data from Ethernet interface.

Dive Into Android Networking: Adding Ethernet Connectivity
Next Steps ?

- Patchset is available on **GitHub**:
  - Current changeset with extra features is 504 kB big.
  - https://github.com/gxben/aosp-ethernet
- Properly redesign the **ECM patch** to match Wi-Fi architecture.
- Port from **Ice Cream Sandwich** to **Jelly Bean** (ongoing work)
- Design Ethernet HAL for **802.1x / WPA support**.
- Contribute / upstream to **Linaro** ?
- And then to **Google** ?

Thank You



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