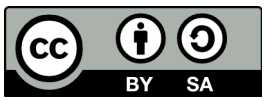
## Hands-On Exercises for

# Embedded Android

## v. 2013.06

**WARNING:**

The order of the exercises does not always follow the same order of the explanations in the slides. When carrying out the exercises, carefully follow the exercise requirements. Do **NOT** blindly type the commands or code as found in the slides. Read every exercise **in its entirety** before carrying out the instructions.



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Originals at: www.opersys.com/community/docs

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# Day 1

## Introduction to Embedded Android

1. Get the repo tool (see slide 85)
2. Download gingerbread branch of the AOSP (see slide 85)
3. Have a look at the following websites to get a good grasp of available resources:
    - source.android.com
    - developer.android.com
    - tools.android.com
    - cyanogenmod.com
    - wiki.cyanogenmod.com
    - elinux.org/Android_Portal
    - www.omappedia.org/wiki/OMAP_Android_Main

## Concepts and Internals

Note:

- The list of initial prerequisites for Android development changes over time
- The latest version is at: http://developer.android.com/sdk/installing.html

1. Get and install the JDK 6. The JDK is here: http://www.oracle.com/technetwork/java/javase/downloads/
And the instructions for installing it on Ubuntu are here:
https://help.ubuntu.com/community/Java
2. Get and install Eclipse (use 3.6.2 or above and make sure OpenJDK is installed along w/ Eclipse)
3. Get and install the SDK. If you are running a 64-bit Ubuntu, make sure you have “ia32-libs” installed using: “sudo apt-get install ia32-libs”.
4. Get and install the ADT plugin for Eclipse
5. Use the Android SDK manager to download the 2.3.3 platform. Don't download any other platform as the more platforms you download, the more time it will take. One platform is sufficient for what we will be doing.
6. Create a virtual machine using the “android” tool
7. Create a HelloWorld program and run it

## Android Open Source Project

1. Install all ubuntu packages required for the AOSP build
2. Apply any required symbolic link fixes
3. Apply any required patches and/or fixes to the AOSP
4. Build the AOSP
5. Check out the size of the images generated in [aosp]/out/target/product/generic
6. Start the emulator and go to the settings to check which version of the AOSP thinks it's running.

7. Modify the AOSP to add the HelloWorld app created in the previous section. Use an Android.mk similar to this in your [aosp]/packages/apps/HelloWorld/ directory (you can copy one from another app in [aosp]/packages and edit it):

```
LOCAL_PATH:= $(call my-dir)
include $(CLEAR_VARS)

LOCAL_MODULE_TAGS := optional

LOCAL_SRC_FILES := $(call all-java-files-under, src)

LOCAL_PACKAGE_NAME := HelloWorld

include $(BUILD_PACKAGE)
```

8. Recompile, launch emulator and HelloWorld app

## Kernel Basics

1. Check kernel version in emulator ("cat /proc/version")
2. Fetch kernel for Android from android.googlesource.com. Use "git" to fetch the "qemu" kernel. Or get it from http://opersys.com/downloads/goldfish.tar.bz2
3. Revert the checked-out kernel to 2.6.29. Use "git checkout android-goldfish-2.6.29".
4. Get the kernel configuration from emulator. Use "adb pull" to retrieve the "/proc/config.gz" file from the running emulator generated by the previous AOSP build.
5. Copy the config.gz to the kernel sources, extract it using "gunzip" and rename it to ".config".
6. Use menuconfig to add support for modules and module unloading to that kernel. These are two separate options. The former is on the top-most menu and the latter is visible when you enter the modules sub-menu from the top menu.
7. Cross-compile kernel with the ARM toolchain in [aosp]/prebuilt/linux-x86/toolchain/arm-eabi-4.4.0/bin/ in 2.3.x and [aosp]/prebuilts/gcc/linux-x86/arm/arm-eabi-4.6/bin in 4.x
8. Boot the emulator with newly-built kernel and check the kernel version run by the emulator
9. Check the new kernel's version ("cat /proc/version")

# Day 2

## Linux root filesystem

1. Get and install the Opersys BeagleBone Embedded Linux Workspace. For using it on the actual BeagleBone, get this one:

    http://www.opersys.com/downloads/bbone-workspace.tar.bz2

For using it with the emulator, get this one instead:

    http://www.opersys.com/downloads/bbone-ws-121114.tar.bz2

2. Customize the “devbb” workspace script in the extracted directory to match your own paths.

3. Create yourself a root filesystem that includes the glibc shared libraries as in slides 141 and 147, save for the “strip” command. Note that you'll need to replace BBONE_WS_DIR with the location where you installed the Workspace in exercise #1 of this section.

4. Extract the BuysBox in sysapps/, configure it, build it and install it using the toolchain in the Workspace into the root filesystem you just created. You may need to run this command before the configuration menu comes up:

```
$ sudo apt-get install libncurses5-dev
```

## Native Android user-space

Preamble:

- To the exception of exercise 5, it is implied that you should build the AOSP and run the emulator after each exercise to check that your changes have indeed been correctly reflected in your newly modified AOSP.
- Once built, the AOSP will have an [aosp]/out/target/product/generic/ directory containing a directory and a corresponding image for:
    - The root filesystem (root/ and ramdisk.img)
    - /system (system/ and system.img)
    - /data (data/ and userdata-qemu.img)
- If you modify the AOSP or the linux root filesystem created earlier, you may need to erase those directories and images from [aosp]/out/target/product/generic/ to force the AOSP's build system to regenerate them. Sometimes, those directories and images don't get updated properly, hence the need to erase them and using “make” within [aosp]/ to force their re-creation.
- Do **NOT** get rid of [aosp]/out/target/product/generic/ itself or any of the parent directories. If you do so, you will have to wait for the AOSP to rebuild itself. Only get rid of the previously-mentioned directories on a case-by-case basis as needed.

1. Modify AOSP build system to copy content of your rootfs to its default ramdisk. You will need to:

- Amend [aosp]/system/core/rootdir/Android.mk to make it look like this (a. additions are in bold, b. don't forget to use TABS, not spaces for the “my_dir” make target's command, c. PATH_TO_MY_GLIBC_ROOTFS is a placeholder you need to replace with the location of the filesystem created in the exercises of the previous section):

    ...

```
    $(TARGET_OUT_DATA)

my_dir:
    cp -af $(PATH_TO_MY_GLIBC_ROOTFS)/* $(TARGET_ROOT_OUT)

$(DIRS): my_dir
...
```

- Amend [aosp]/system/core/include/private/android_filesystem_config.h's "static struct fs_path_config android_files[]" to add an entry for "lib/*" so that the execute bit is preserved for all files in that directory.

2. Modify init so that it starts BusyBox httpd by default.

- You will need to add something similar to the following to your init.rc:

  4.x

```
service httpd /usr/sbin/httpd
        class main
        oneshot
```

  2.3.x

```
service httpd /usr/sbin/httpd
        oneshot
```

  If you add this at the bottom of the file, make sure there's a line-wrap after the last line.

- Make sure the system path includes "/usr/sbin". That path is set in the init.rc file which is placed into your rootfs. The original copy of it is in [aosp]/system/core/rootdir/. The path setting line in your init.rc should then look something like:

```
export PATH /sbin:/vendor/bin:/system/sbin:/system/bin:/system/xbin:/usr/sbin
```

3. Modify the AOSP so that ADB uses BusyBox' shell instead of the default Android shell.

- ADB is in [aosp]/system/core/adb
- You need to modify the SHELL_COMMAND macro in services.c

```
#if ADB_HOST
#define SHELL_COMMAND "/bin/sh"
#else
//#define SHELL_COMMAND "/system/bin/sh"
#define SHELL_COMMAND "/bin/sh"
#endif
```

- Also make sure the system path ($PATH) points to the BusyBox "binaries". The path setting line in your init.rc should then look something like:

```
export PATH /bin:/sbin:/vendor/bin:/system/sbin:/system/bin:/system/xbin:/usr/sbin
```

- You likely also want to change the console service declaration in init.rc to start BusyBox:

```
#service console /system/bin/sh
service console /bin/sh
```

4. Write a C program that is packaged into the "embedded Linux" root filesystem and that opens a socket to listen for a connection and prints out a message to the console accordingly. Write a C program that is built as part of the native Android utilities in frameworks/base/cmds and that connects to a sockets and prints out a message stating that the connection was successful. Examples can be found here: http://www.linuxhowtos.org/C_C++/socket.htm
To have a C component build against Bionic:

- Add it as [aosp]/frameworks/base/cmds/foo
- Make sure "foo" is added to [aosp]/build/core/user-tags.mk
- Make sure you have an appropriate Android.mk within [aosp]/frameworks/base/cmds/foo to get your app to build. Here's a sample:

```
LOCAL_PATH:= $(call my-dir)
include $(CLEAR_VARS)
```

```
LOCAL_SRC_FILES:= \
        foo.cpp

LOCAL_SHARED_LIBRARIES := \
        libcutils

LOCAL_MODULE:= foo

include $(BUILD_EXECUTABLE)
```

- To build a C file against glibc, you can use the toolchain that's part of the glibc-based rootfs we had earlier:
  `~/.../bbone-ws/tools/arm-unknown-linux-gnueabi/bin/arm-unknown-linux-gnueabi-gcc -o foobar client.c`

5. Create a setup where a second emulator instance is able to view pages served by the httpd running on a first emulator instance. See the “Using the Android Emulator” documentation for more information and how it makes use of “telnet” to connect to a special control port of the emulator. Note that there are “magic” IPs and that 10.0.2.2 in the emulator points to your host's loopback interface (127.0.0.1).

## A quick introduction to Java

1. Create and run a HelloWorld in Java
2. Create a java program that creates two threads that call a same synchronized function that increments a number shared by the two threads and prints out the number's value along with a string identifying the caller. Have a look at the separate and combined use of “static” and “synchronized”.

## System server

1. Use the following tools to observe the System Server's behavior: logcat, dumpsys, dumpstate
2. Use strace to monitor the operation of dumpsys. You should see dumpsys using ioctl() to talk to the binder driver (/dev/binder).
3. Add your own system service that prints out a message to the logs when it is called. You can use the templates from the following tarball to copy-n-paste: http://opersys.com/downloads/systemserver-samples-130625.tar.bz2. If you copy and paste from the slides, make sure the pasting doesn't introduce “magic characters” that will cause the compiler to complain about your code.
4. Build the AOSP and use “logcat” to check that your service is started upon system startup.
5. Modify the HelloWorld program merged earlier into the AOSP to invoke your new system service's callback. Make sure your Android.mk **doesn't** include a “LOCAL_SDK_VERSION” tag.
6. Implement the dump() function in your system service to allow dumpsys to poke it for status. The prototype is:

```
@Override
public void dump(FileDescriptor fd, PrintWriter pw, String[] args) {
...
}
```

# Day 3

## Linux device driver

1. We will use the following driver for the exercises:

http://www.opersys.com/downloads/circular-driver-111207.tar.bz2

This drivers implements a circular buffer over the read/write file-ops. Refer to LDD3 slide-set for both code examples and a Makefile. The driver doesn't implement blocking/waking semantics. When there's no content available, it returns 0 bytes. Have a look at the driver at the following address as another driver exxample: http://tldp.org/LDP/lkmpg/2.6/html/x569.html

LDD3 is here: http://lwn.net/Kernel/LDD3/

- If you're building for the beaglebone, put the driver in [aosp]/device/ti/beaglebone/
- If you're building for the emulator, put it outside the AOSP.
- This driver uses misc_register() instead of register_chrdev() as it will register your char dev and fire off a hotplug event. See: http://www.linuxjournal.com/article/2920
- Building the module with 2.3.x:

```
$ make ARCH=arm CROSS_COMPILE=~/aosp-2.3.4/prebuilt/linux-x86/toolchain/arm-eabi-4.4.3/bin/arm-eabi-
```

- Building the module with 4.x:

```
$ export TARGET="~/.../TI-Android-JB-4.1.2_AM335x_4.0.1/prebuilts/gcc/linux-x86/arm/arm-eabi-4.6/bin/arm-eabi-"
$ make ARCH=arm CROSS_COMPILE=${TARGET}
```

- To have the circular-driver.ko included in the final image when using the BeagleBone, edit the device/ti/beaglebone/beaglebone.mk to add the following:

```
PRODUCT_COPY_FILES += \
        device/ti/beaglebone/circular-driver/circular-char.ko:system/modules/circular-char.ko
```

- To have the module loaded at startup, modified an init.rc file to get it loaded. The board-specific file in the case of the BeagleBone is device/ti/beaglebone/init.am335xevm.rc:

```
on early-init
...
    insmod /system/modules/circular-char.ko
```

- To have ueventd create the proper entry in /dev at runtime, you'll need to modify a ueventd.rc to have a proper entry for the module. For the BeagleBone, you can modify the device/ti/beaglebone/ueventd.am335xevm.rc file to add:

```
/dev/circchar          0666  system     system
```

2. If you haven't already modified the build system and the startup configuration files to load the driver automatically as above, load your driver into your custom-built kernel on your emulator or device using adb to push the ".ko" to "/data/local" temporarily. "/data" is mounted from an image which is persisted to disk at runtime. That image, however, will get destroyed when the AOSP is used to generate an SDK.

3. Use "cat" and "echo" to "read" and "write" to your "device". For example, "cat /dev/foo" will read from the device and "echo *string* > /dev/foo" will write to it.

## HAL

1. We will use the code from the following tarballs for this hands-on session:
For the BeagleBone:

http://opersys.com/downloads/libhw-opersys-beaglebone-130502.tar.bz2

For the emulator:

http://opersys.com/downloads/libhw-opersys-goldfish-130502.tar.bz2

Otherwise:

1. Create a libopersyshw.so that exposes your driver's read/write functionality through basic read/write functions.
   - Place libopersyshw as “opersyshw/” in [aosp]/sdk/emulator/; the latter contains some HAL implementations for the virtual devices in the emulator. Refer to [aosp]/sdk/emulator/gps for an example.
   - You will need to ensure that the driver is loaded prior to libopersyshw.so being loaded by the System Server. To do that, modify the init.goldfish.sh script in [aosp]/system/core/rootdir/etc to run insmod on the .ko file.
   - If you had used the “misc_register()” call in your driver to register it as a miscellaneous character driver, you will need to modify the ueventd.rc file in [aosp]/system/core/rootdir/ in order to ensure the the /dev entry created for your device has the proper access rights set to it. By the default, an entry will be created but it will only be accessible to “root” and they System Server doesn't run as root. Sample ueventd entry:
     ```
     /dev/mychar              0660    system      system
     ```
2. Write the JNI code that allows the functions of your libopersyshw.so to be exposed to Java.

2. Extend the previously-implemented system server to allow it to invoke the read/write functions provided by libopersyshw.
   - To test the behavior of the entire opersys stack, hard-code calls to write() and read() in the Opersys Service's constructor in OpersysService.java.
   - Remember that you will need to modify the AIDL file matching the Opersys Service in order to expose the new read() and write() calls through Binder.

3. Implement a dump() within your system server in order to allow the dumpsys utility to retrieve the number of calls read() and write() having been made since system startup.

# Day 4

## HAL use

1. Change the HelloWorld app added to the AOSP to use the system server's calls to do read/write operations to libopersyshw

## Android Framework

1. Amend the framework to make the Opersys system service available to apps through binder
2. Modify the status bar in order to remove the phone signal icon

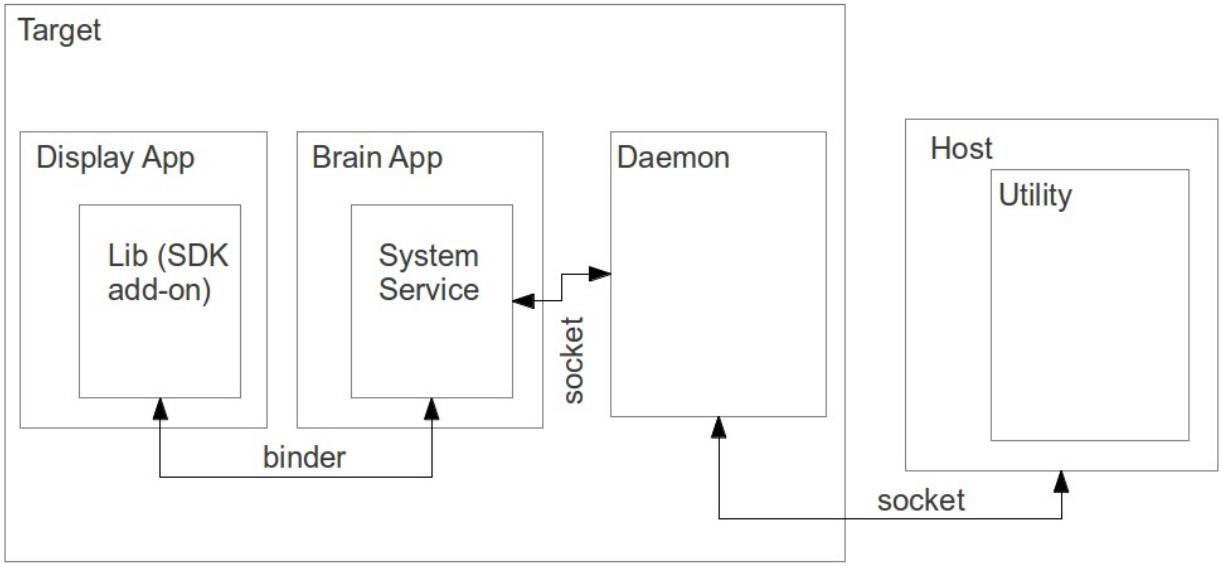
## Custom SDK

1. Create your own SDK allowing developers to call Opersys as any other system service
2. Configure Eclipse to use your newly-built SDK
3. Create a new app in eclipse that uses the newly-built SDK to call on the Opersys system service

# Stack Extension Exercises

1. Modify the driver to use “misc_register()” instead of “register_chrdev()” to register the device. “misc_register()” will cause a hotplug event to be sent to user-space which will be caught by ueventd. Change ueventd's ueventd.rc to create the /dev entry with the proper rights. You should then not need to manually create a node in /dev entry for your device any more.
2. Implement the ioctl() call of the driver to:
    a. Zero out the content of the circular buffer
    b. Poll the driver to see if there's new data in the buffer
    c. Get last write time-stamp
    d. Get the number of calls to read()
    e. Get the number of calls to write()
    f. Set the entire content of the buffer to a given character value
3. Modify the OpersysManager's API and the stack underneath it all the way to the driver to provide access to the following methods:
    void clearBuffer(), which empties the circular buffer
    boolean isThereContent(), which tells the caller whether there's content to read
    long getLastWriteTime(), which returns the time at which the last write happens
    int getReadStat(), which returns the number of read() calls made to the driver
    int getWriteStat(), which returns the number of write() calls made to the driver
    void setBufferToChar(char), which sets the buffer's content to a char value
4. Update the SDK and make sure you can use these calls from within an app created within Eclipse.
5. Add a “void enableIntentOnContent()” and “void disableIntentOnContent()” to the OpersysService that makes it so that the service periodically polls the driver to see if it's got new content and broadcasts a new Intent when new content is found. Use the driver's ability to give you the time of the last write to avoid sending an Intent twice for the same addition to the buffer.
6. Modify your app to call on “enableIntentOnContent()” and catch the Intent with a BroadcastReceiver.

# Platform Internals Exercises





1. Have the Brain App be a standalone app in packages/apps (in the case of the emulator) or device/ti/beaglebone/ (in the case of the Beaglebone.) To make sure the app is part of PRODUCT_PACKAGES, you'll need to modify build/target/product/generic_no_telephony.mk (in the case of the emulator) and

device/ti/beaglebone/beaglebone.mk (in the case of the emulator). Follow the Phone app example on how to make your app a standalone app that has a system service. You can use your existing system service as a basis for your new system service in the Brain App.

2. The system service in the brain app should maintain an internal buffer which is fed from the buffer your circular driver has; more on this below. The API of the system service in the brain app should be:

String read(), which returns what's in its buffer
int write(), which writes a string to the system service's internal buffer
void clearBuffer(), which empties the circular buffer
boolean isThereContent(), which tells the caller whether there's content to read
long getLastWriteTime(), which returns the time at which the last write happens
int getReadStat(), which returns the number of read() calls made to the system service
int getWriteStat(), which returns the number of write() calls made to the system service
void setBufferToChar(char), which sets the buffer's content to a char value
void enableIntentOnContent(), makes it so that system service sends an intent when there's new data
void disableIntentOnContent(), disables the intent on data
void registerCallbackInterface(), to allow an app to register a callback remote binder interface
void unregisterCallbackInterface(), to deregister the remote callback interface

3. Create a thread in your system service that periodically reads the driver's buffer to fill the buffer maintained by the system service. Instead of using the HAL to read from the driver, put the code that was in opersyshw_qemu.c (in the case of the emulator) or opersyshw_beaglebone.c (in the case of the BeagleBone) inside a C library that is called through JNI by your system service. You'll have to get that library loaded by your app. Have a look at the Hello JNI sample in the NDK.

4. Extend the Status Bar app to have a new overlay window such as the one displayed by LoadAverageService.java; copy the latter and start from there. Have your new addition connect to the system service in the Brain App and register a callback interface to allow the system service to call the service back with new data added to the buffer. When new data comes in, have your Status Bar extension display the new data as an overlay as the example in the previous page shows. Have a look at the registerStatusBar() call part of the IStatusBarService.aidl in frameworks/base/core/java/com/android/internal/statusbar/ for an example of how a system service can allow a caller to register a callback interface.

5. Create a library that exposes the system service's API through a Java library that is exposed to regular applications using an SDK add-on. Import the SDK add-on to your SDK and create a sample application with Eclipse that can read() and write() to your system service through the add-on.

6. Create a native daemon that listens to socket connections from the system service and also receives remote connections from a host utility. The commands received from the system service should be (assuming a text based interface like the one between installd and the Package Manager):

“get_host_message”, to retrieve any messages buffered in the daemon from the host utility
“new_data_in_buffer”, for sending new messages added to the system service' buffer

The system service should connect to the daemon through a Unix domain socket like the ones in /dev/socket/ while the host utility will connect to the daemon through a classic IP port; pick a port number of your choice. You'll want to extend the thread created earlier in the system service to periodically poll the daemon for host messages.

7. Create a utility for using on the host to:

a. read new messages available from the daemon on the target
b. push new messages to the daemon on the target

At the end of this, you should be able to push a new message from the utility on the host and have it display to the screen through the extension to the status bar.

# Extra Exercises

1. Mark Zygote as “disabled” in init.rc and start it by hand after boot using the “start” command.
2. Modify the bootloader parameters to have the system boot remotely from the network.
    a. Create a “uEnv.txt” file on the “boot” partition of the micro-SD card to provide appropriate values for the “net_boot” command to operate properly. You'll likely need to set “serverip” to your host's IP address. You'll likely also want to set “rootpath” to the location of your rootfs. To load environment variables from “uEnv.txt”, type:
    U-Boot# mmc rescan
    U-Boot# run loadbootenv
    U-Boot# run importbootenv
    b. Create a U-Boot image of the kernel built earlier
    c. Configure your host for serving TFTP requests
    d. Use TFTP to download image to target
    e. Boot with image
    f. Configure your host and your target so that the target's configuration is obtained at boot time via DHCP and the rootfs is mounted on NFS.
3. Extend the “svc” command in frameworks/base/svc to make it capable of talking to the Opersys system service, thereby allowing you to communicate with that system service straight from the command-line. “svc” already implements commands for a couple of system services (PowerManager, ConnectivityManager, TelephonyManager, and WifiManager).
4. Create app w/ EditText and Button that sends text entered in the text box all the way down to the driver.
5. Create an app that acts as the home screen. You'll to have an activity with the following set of filters:

```
<intent-filter>
     <action android:name="android.intent.action.MAIN" />
     <category android:name="android.intent.category.HOME"/>
     <category android:name="android.intent.category.DEFAULT" />
 </intent-filter>
```

Have a look at development/samples/Home for an example basic home app. You're not expected to have a full app allowing the starting of other apps. Just make sure you can get a “HelloWorld” to kick in right after boot up.

6. Implement a C-built system service and a corresponding C command-line utility that use Binder to communicate. Have a look at:

frameworks/base/libs/surfaceflinger_client/ISurfaceComposer.cpp
frameworks/base/services/surfaceflinger/SurfaceFlinger.cpp frameworks/base/core/jni/android_view_Surface.cpp

# Android on the BeagleBone

MicroSD Programming:

1. Extract BeagleBone.tar.gz
2. Plug the MicroSD card into the MicroSD-USB connector and into your host
3. Program the MicroSD card (you need to use the “dmesg” command to check the exact name under which the device appears - **WARNING: if you get this wrong you could destroy your host's Ubuntu installation**)

```
$ sudo ./mkmmc-android.sh /dev/sd???
```

BeagleBone Recognition

1. Modify or add an /etc/udev/rules.d/51-android.rules with this content:

```
SUBSYSTEM=="usb", SYSFS{idVendor}=="18d1", MODE="0666"
```

Some more recent versions of Ubuntu (12.04) may require the use of this instead:

```
SUBSYSTEM=="usb", ATTR{idVendor}=="18d1", MODE="0666"
```

2. Add a /etc/udev/rules.d/73-beaglebone.rules (also here: http://www.opersys.com/downloads/73-beaglebone.rules):

```
ACTION=="add", SUBSYSTEM=="usb", ENV{DEVTYPE}=="usb_interface", \
    ATTRS{idVendor}=="0403", ATTRS{idProduct}=="6010", \
    DRIVER=="", RUN+="/sbin/modprobe -b ftdi_sio"

ACTION=="add", SUBSYSTEM=="drivers", \
    ENV{DEVPATH}=="/bus/usb-serial/drivers/ftdi_sio", \
    ATTR{new_id}="0403 6010"

ACTION=="add", KERNEL=="ttyUSB*", \
        ATTRS{interface}=="BeagleBone/XDS100V2", \
    ATTRS{bInterfaceNumber}=="00", \
        SYMLINK+="beaglebone-jtag"

ACTION=="add", KERNEL=="ttyUSB*", \
        ATTRS{interface}=="BeagleBone/XDS100V2", \
    ATTRS{bInterfaceNumber}=="01", \
        SYMLINK+="beaglebone-serial"
```

3. Force udev to reread its rules:

```
$ sudo udevadm control --reload-rules
```

4. Get minicom

```
$ sudo apt-get install minicom
```

5. Configure minicom

```
$ sudo minicom -s
```

"Serial port setup"
/dev/beaglebone-serial
115200 8N1 no hardware flow control
ESC
"Save setup as dfl"
"Exit from minicom"

BeagleBone Bootup

1. Plug Bone through barrel connector to your host
2. Plug Bone mini USB to you host
3. Start minicom
   $ minicom
   You should now see the kernel start up and Android's boot sequence

Android Visualization

1. Connect to target using ADB (if it's not in your path already, go to the AOSP's root directory and type ". build/envsetup.sh" and then "lunch"):
   $ adb shell
2. Start the VNC server
   # androidvncserver &
3. Tunnel VNC traffic over ADB
   $ adb forward tcp:5901 tcp:5901
4. Connect to target over VNC
   $ vinagre &
   Connect->
   Protocol: VNC
   Host: localhost:5901
   Use JPEG encoding
   You should now be able to see Android UI
   If you encounter too many issues with the VNC over USB
   See explanation on how to set up VNC over Ethernet: http://www.opersys.com/blog/beaglebone-android-start

Android @Work:

1. Explore the Android UI through VNC
2. Note that all events have to have a "left-click" appended for them to propagate to the target
3. Check the version of Android you're running
   apps->Settings->About Phone->Android version

Use "logcat" to observe the target's Android
   $ adb logcat

4. Create a "Hello World" application in the VM and run it on the target

5. Have fun

Building AOSP for BeagleBone

1. Install U-Boot mkimage
   $ sudo apt-get install uboot-mkimage
2. Make sure you're using the right “jar”
   $ sudo update-alternatives --config jar
   Select the jar tool from Sun's SDK
3. Extract the TI BeagleBone Sources
   $ tar xvzf TI_Android_GingerBread_2_3_4_AM335x_Sources.tar.gz
4. Retrieve source
   $ cd TI_Android_GingerBread_2_3_4_AM335x_Sources/
   $ ./.repo/repo/repo sync --local-only
5. Build source
   $ make TARGET_PRODUCT=beaglebone OMAPES=4.x -j4

Run your own build

1. Assuming your operating directory is “~/Desktop/android”
2. Preserve old copy of default Bone images
   $ cp -a BeagleBone BeagleBone-orig
3. Create new rootfs images
   $ cd TI_Android_GingerBread_2_3_4_AM335x_Sources/out/target/product/beagleboard
   $ mkdir android_rootfs
   $ cp -a root/* android_rootfs/
   $ cp -r system android_rootfs/
   $ sudo ../../../../build/tools/mktarball.sh ../../../host/linux-x86/bin/fs_get_stats android_rootfs . rootfs
   rootfs_beaglebone.tar.bz2
4. Copy new rootfs to BeagleBone directory
   $ sudo cp rootfs_beaglebone.tar.bz2 ~/Desktop/android/BeagleBone/Filesystem
5. Plug the MicroSD card into the MicroSD-USB connector and into your host
6. Program the MicroSD card
   $ sudo ./mkmmc-android.sh /dev/sdb
7. Put the SD card back into the Bone, reboot it and connect through VNC as we did earlier
8. Check the version of Android you're running, it should be time-stamped with the date of your build
   apps->Settings->About Phone->Android version
   or
   $ adb shell
   # cat /system/build.prop
   and check the ro.build.fingerprint and ro.build.description to see if it contains your build's time-stamp