Bringing up Android on your favorite X86 Workstation or VM

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Android Builders Summit 2013

Agenda

- What is a "ROM"?
- Examples of Android ROMs
- ROMs in the Android developer world
- Building your first ROM out of the AOSP
- ***Android and X86***

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Introduction to ROM Cooking

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"ROM" - Definition

From Wiktionary, the free Dictionary:

“ROM”:

- (electronics, computing) read-only memory
- (video games) A software image of read-only memory (as of a game cartridge) used in emulation
- (medicine) Range of Motion
- (finance) Return on Margin
- (estimating and purchasing) Rough order of magnitude. An informal cost or price estimate provided for planning and budgeting purposes only, typically expected to be only 75% accurate

“ROM” - Definition (cont.)

From Wikipedia, the free Encyclopedia:

ROM, ***Rom***, or ***rom*** is an abbreviation and name that may refer to:

In computers and mathematics (that's us!):

- **Read-only memory**, a type of storage media that is used in computers and other electronic devices
- **ROM image**, a computer file which contains a copy of the data from a read-only memory chip
- ROM (MUD), a popular MUD codebase
- Random oracle model, a mathematical abstraction used in cryptographic proofs
- ROM cartridge, a portable form of read-only memory
- RoM, Request of Maintainer (see Software maintainer)
- Rough order of magnitude estimate

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Terminology check

As CyanogenMod educates us in their overview of Modding:

"You can flash a ROM onto the ROM, which isn't really ROM"

http://wiki.cyanogenmod.com/wiki/Overview_of_Modding

Android ROM components

Traditional terminology – whatever lies on the read-only partitions of the device's internal flash memory:

- Recovery Mode:
  - Recovery Image (kernel + initrd)
- Operational Mode:
  - Boot Image (kernel + initrd)
  - System Image
- The magical link between the two:
  - Misc

What is ***not*** a part of the ROM?

- User data: /data, /cache, /mnt/sdcard/...

Android ROM Storage Layout

Since Android is Linux at its core, we can examine its storage layout via common Linux tools:

```
shell@android:/ $ df
Filesystem             Size   Used   Free   Blksize
/dev                   487M    32K   487M   4096
/mnt/secure            487M     0K   487M   4096
/mnt/asec              487M     0K   487M   4096
/mnt/obb               487M     0K   487M   4096
/system                639M   464M   174M   4096
/cache                 436M     7M   428M   4096
/data                    5G     2G     3G   4096
/mnt/shell/emulated      5G     2G     3G   4096
```

Android ROM Storage layout: "Standard Linux"

```
shell@android:/ $ mount
rootfs / rootfs ro,relatime 0 0
tmpfs /dev tmpfs rw,nosuid,relatime,mode=755 0 0
devpts /dev/pts devpts rw,relatime,mode=600 0 0
proc /proc proc rw,relatime 0 0
sysfs /sys sysfs rw,relatime 0 0
debugfs /sys/kernel/debug debugfs rw,relatime 0 0

### Output of mount continues in next slide
```

Android ROM Storage layout: "Standard Android"

```
none /acct cgroup rw,relatime,cpuacct 0 0
tmpfs /mnt/secure tmpfs rw,relatime,mode=700 0 0
tmpfs /mnt/asec tmpfs rw,relatime,mode=755,gid=1000 0 0
tmpfs /mnt/obb tmpfs rw,relatime,mode=755,gid=1000 0 0
none /dev/cpuctl cgroup rw,relatime,cpu 0 0
/dev/block/platform/sdhci-tegra.3/by-name/APP  /system ext4 ro,relatime,
user_xattr,acl,barrier=1,data=ordered 0 0
/dev/block/platform/sdhci-tegra.3/by-name/CAC /cache ext4 rw,nosuid,nodev,
noatime,errors=panic,user_xattr,acl,barrier=1,nomblk_io_submit,
data=ordered,discard 0 0
/dev/block/platform/sdhci-tegra.3/by-name/UDA /data ext4 rw,nosuid,nodev,
noatime,errors=panic,user_xattr,acl,barrier=1,nomblk_io_submit,
data=ordered,discard 0 0
/dev/fuse /mnt/shell/emulated fuse rw, nosuid, nodev, relatime,
user_id=1023,group_id=1023,default_permissions,allow_other 0 0
```

Android ROM Storage Layout

```
shell@android:/ $ cat /proc/partitions
major minor  #blocks  name
 179        0    7467008 mmcblk0
 179        1      12288 mmcblk0p1
 179        2       8192 mmcblk0p2
 179        3     665600  mmcblk0p3
 179        4     453632 mmcblk0p4
 179        5        512 mmcblk0p5
 179        6      10240 mmcblk0p6
 179        7       5120 mmcblk0p7
 179        8        512 mmcblk0p8
 179        9    6302720 mmcblk0p9
```

So, where is my stuff?!

```
shell@android:/ $ ls -l /dev/block/platform/sdhci-tegra.3/by-name/
lrwxrwxrwx root     root   2013-02-06 03:54  APP -> /dev/block/mmcblk0p3
lrwxrwxrwx root     root   2013-02-06 03:54 CAC -> /dev/block/mmcblk0p4
lrwxrwxrwx root     root   2013-02-06 03:54 LNX -> /dev/block/mmcblk0p2
lrwxrwxrwx root     root   2013-02-06 03:54 MDA -> /dev/block/mmcblk0p8
lrwxrwxrwx root     root   2013-02-06 03:54 MSC -> /dev/block/mmcblk0p5
lrwxrwxrwx root     root   2013-02-06 03:54 PER -> /dev/block/mmcblk0p7
lrwxrwxrwx root     root   2013-02-06 03:54 SOS -> /dev/block/mmcblk0p1
lrwxrwxrwx root     root   2013-02-06 03:54 UDA -> /dev/block/mmcblk0p9
lrwxrwxrwx root     root   2013-02-06 03:54 USP -> /dev/block/mmcblk0p6
```

Legend: APP is system, SOS is recovery, UDA is for data…

Why should we care about it?

For a couple of reasons:

- Backup
- Recovery
- Software updates
- Error checking
- Board design
- Curiosity
- ...

Android Open Source Project

- “Semi-Open source”
- Maintained by Google
- Contributions accepted using “gerrit”
- Mostly Apache licensed
- Provides templates for building an Android system, including bootloaders etc.
- Vendors derive their products for their hardware layout (BSP, binaries, etc.)
- Provides the complete source code (but usually missing proprietary binaries) for a bunch of supported devices (e.g. Galaxy Nexus, Motorola Xoom, Nexus 4/7/10, Android Emulator)

AOSP ROM building

- In a single line:
  - just do whatever they say in http://source.android.com

- In a bit more:
  - Set up a 64bit Linux development machine. Officially Supported:
    - Ubuntu 10.04 LTS (Lucid) for versions < JB 4.2.1
    - Ubuntu 12.04 LTS (Precise Pangolin) for versions >= JB 4.2.1
  - mkdir / cd / repo init / repo sync
  - . build/envsetup.sh
  - lunch <Your Config>
  - make # This will take a while... Make some coffee || Get` a good nap.
  - flash/boot/run/pray/debug/show off at xda-developers et al.

A bit more about flashing

- When flashing to devices – make sure the bootloader is unlocked. For “Google phones”:
  - adb reboot-bootloader
  - fastboot oem unlock
  - Confirm on device

  Then you can flash all images using “fastboot -w flashall”,
  or particular images using “fastboot flash -w <partition> <image>”
- Some tips on flashing custom builds:
  - Having trouble using “fastboot flash” due to mismatched broadband versions?
  - Try modifying device/<vendor>/<product>/board-info.txt
  - Before building, make sure you have the “binary-blobs”, under the ***vendor/*** subtree (note the difference from ***device/***)
    - Hint: proprietary-blobs.txt

Building kernels

- Get a kernel to start from – or make one
  - 3.4+ kernel are pretty much “Android-Ready”
- Checkout/config/make
  - Don't get too freaky – avoid breaking “Userspace” (a. k.a “Android”)
- Replace prebuilt kernel with your generated bzImage
- Rebuild Android
- Pray/play/laugh/cry/show off on XDA-dev/Q&A on android-kernel / android-porting / android-*

Getting Kernel Sources

```
$ git clone https://android.googlesource.com/kernel/<target>.git
```

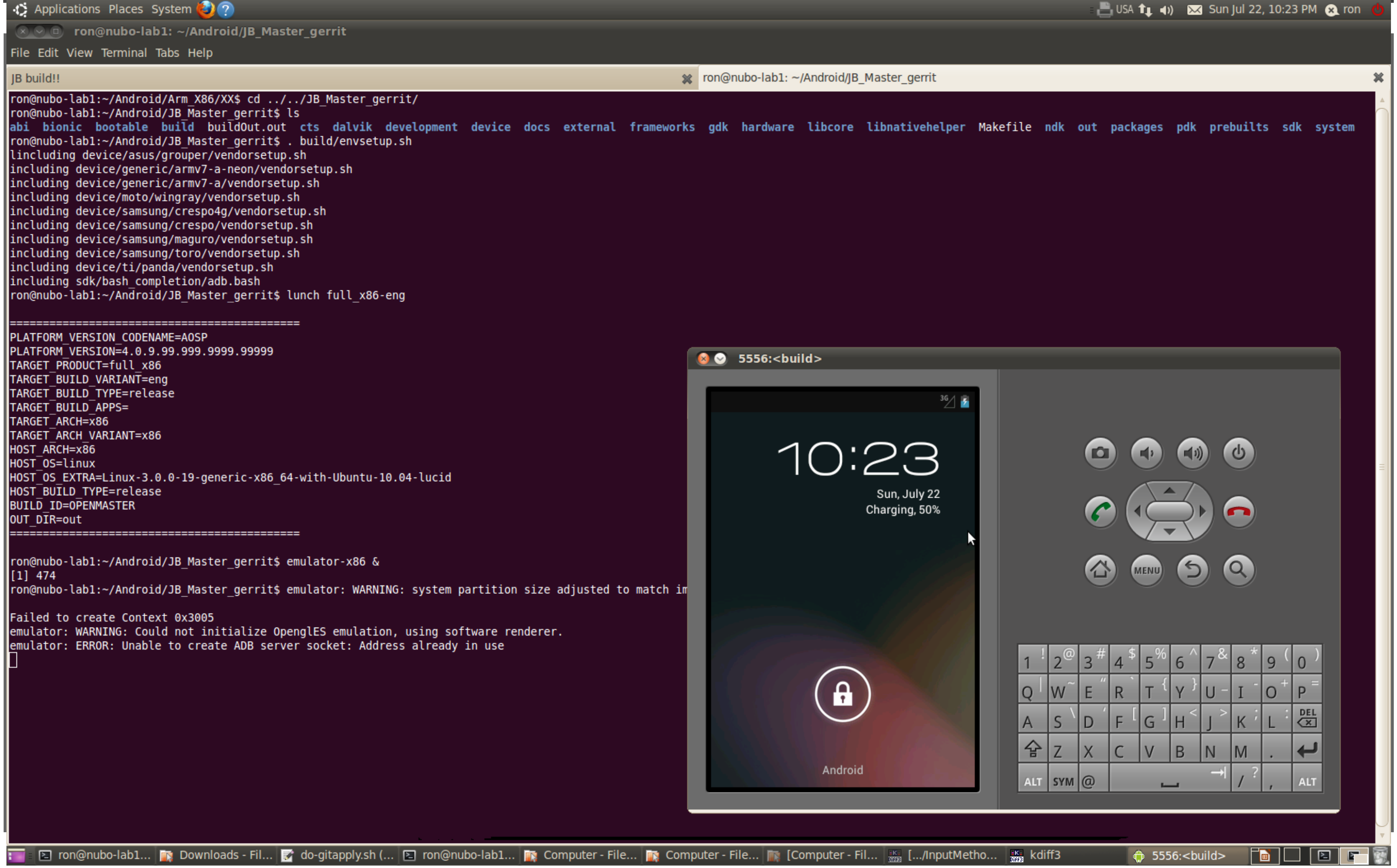
Some kernel targets hosted by the AOSP:

- Common - common kernel tree. Based on Linux 3.4+
- msm – Qualcomm msm (HTC Nexus One)
- Omap – TI's OMAP (Samsung Galaxy Nexus)
- Tegra – Nvidia's Tegra (Motorola Xoom)
- ***Goldfish - Android emulator (2.6.29)***

2.6.29?!?!?!

- Well... Yes!
- A nice thing about Android – system and kernel are reasonably decoupled
- “It's just an emulator” - and most of its consumers are only interested in testing applications, so “don't fix it if it ain't broken”
- The source for a stable X86 3.4 goldfish port can be found in http://github.com/ronubo/goldfish-3.4
  - Use at your own risk
- Talk to me if you need a 3.5+/3.6+/3.7+ goldfish porting.
- **TIP**: ${ANDROID_BUILD_TOP}/external/qemu/distrib/build-kernel.sh

AOSP case study: Building a Jelly Bean emulator


Applications Places System
USA Sun Jul 22, 10:23 PM ron
ron@nubo-lab1: ~/Android/JB_Master_gerrit
File Edit View Terminal Tabs Help
JB build!!
ron@nubo-lab1: ~/Android/JB_Master_gerrit
5556:<build>
10:23
Sun, July 22
Charging, 50%
Android
MENU
ALT SYM DEL
ron@nubo-lab1... Downloads - Fil... do-gitapply.sh (... ron@nubo-lab1... Computer - File... Computer - File... [Computer - Fil... [.../InputMetho... kdiff3 5556:<build>

```
ron@nubo-lab1:~/Android/Arm_X86/XX$ cd ../../JB_Master_gerrit/
ron@nubo-lab1:~/Android/JB_Master_gerrit$ ls
abi  bionic  bootable  build  buildOut.out  cts  dalvik  development  device  docs  external  frameworks  gdk  hardware  libcore  libnativehelper  Makefile  ndk  out  packages  pdk  prebuilts  sdk  system
ron@nubo-lab1:~/Android/JB_Master_gerrit$ . build/envsetup.sh
lincluding device/asus/grouper/vendorsetup.sh
including device/generic/armv7-a-neon/vendorsetup.sh
including device/generic/armv7-a/vendorsetup.sh
including device/moto/wingray/vendorsetup.sh
including device/samsung/crespo4g/vendorsetup.sh
including device/samsung/crespo/vendorsetup.sh
including device/samsung/maguro/vendorsetup.sh
including device/samsung/toro/vendorsetup.sh
including device/ti/panda/vendorsetup.sh
including sdk/bash_completion/adb.bash
ron@nubo-lab1:~/Android/JB_Master_gerrit$ lunch full_x86-eng

============================================
PLATFORM_VERSION_CODENAME=AOSP
PLATFORM_VERSION=4.0.9.99.999.9999.99999
TARGET_PRODUCT=full_x86
TARGET_BUILD_VARIANT=eng
TARGET_BUILD_TYPE=release
TARGET_BUILD_APPS=
TARGET_ARCH=x86
TARGET_ARCH_VARIANT=x86
HOST_ARCH=x86
HOST_OS=linux
HOST_OS_EXTRA=Linux-3.0.0-19-generic-x86_64-with-Ubuntu-10.04-lucid
HOST_BUILD_TYPE=release
BUILD_ID=OPENMASTER
OUT_DIR=out
============================================

ron@nubo-lab1:~/Android/JB_Master_gerrit$ emulator-x86 &
[1] 474
ron@nubo-lab1:~/Android/JB_Master_gerrit$ emulator: WARNING: system partition size adjusted to match im

Failed to create Context 0x3005
emulator: WARNING: Could not initialize OpenglES emulation, using software renderer.
emulator: ERROR: Unable to create ADB server socket: Address already in use
```

Android emulator storage (Goldfish kernel)

Mount points on standard Goldfish 2.6.29 kernel:

```
# mount
rootfs / rootfs ro 0 0
tmpfs /dev tmpfs rw,nosuid,mode=755 0 0
devpts /dev/pts devpts rw,mode=600 0 0
proc /proc proc rw 0 0
sysfs /sys sysfs rw 0 0
tmpfs /mnt/asec tmpfs rw,mode=755,gid=1000 0 0
tmpfs /mnt/obb tmpfs rw,mode=755,gid=1000 0 0
/dev/block/mtdblock0 /system yaffs2 ro 0 0
/dev/block/mtdblock1 /data yaffs2 rw,nosuid,nodev 0 0
/dev/block/mtdblock2 /cache yaffs2 rw,nosuid,nodev 0 0
# cat /proc/mtd
dev:    size   erasesize  name
mtd0: 0b460000 00020000 "system"
mtd1: 04000000 00020000 "userdata"
mtd2: 04000000 00020000 "cache"
#Note: Yaffs2 is obsolete. On ICS and JB devices /system is mounted as ext4.
```

Using the Android Emulator

- First and foremost: Build for X86 and use KVM!
  - Check capability with “kvm-ok”
  - Feature must be enabled in your computer's bios
  - cat /proc/cpuinfo and search for vmx/avm(intel VT/AMD-V)
- Use hardware keyboard
  - Much more comfortable then “touching” the soft keyboard
  - Although there are uses for that
  - Enable keyboard in external/qemu/android/avd/hardware-properties.ini – and rebuild external/qemu
- Windows users: Use HAXM (Intel's HW Acceleration Manager)

Additional X86 AOSP configurations

- There are more emulation configurations which are supposed to be supported by AOSP, but **tend to be broken**
  - Building for non Linux devices from Linux
    - lunch sdk-eng && make sdk_win
  - Building for virtual box and other virtual machines:
    - lunch vbox_x86-eng
    - make android_disk_vdi
    - Translate VDI image to your VM hard-drive format (e.g. qcow...)
- **Motivation for using such configurations**:
  Development teams working with different Operating Systems, but willing to use the same emulated platform

Adjusting AOSP build for KVM / QEMU (a teaser)

- Motivation - fast linux bringup procedure
  - First, bring-up the target OS on a virtual machine
  - Verify basic functionality
  - Then adjust for a designated hardware
- How to do it?
  - Short answer - use emulator images with some adjustments, mount ext4, set sdcard etc...
  - Pragmatic answer: **In the next session**

When to use the emulator

The short answer would be – whenever you can.

- Great for application development
  - when used with KVM
- Has no dependency on a particular hardware
- Very easy to build
- Integrates well with the AOSP tools
- Relatively well documented

Overall – it is a good ROM.
☺ Most used ROM for a reason.

Android Projects

Various forks to the Android Open Source Project:

- **AOSP** (4.2.2+ upstream) – The root of all (good?)
- Android-X86 (4.0.4 stable, 4.2.1+ upstream)
- Android-IA (4.2.1+ upstream)
- Many other forks
  - CyanogenMod
  - Buildroid/AndroVM
  - And many others...
  - Not all are known or Open-Sourced

CyanogenMod (special guest star)

A custom, open source distribution spawned off the AOSP

- Provides optimizations and support for over 40 different devices, along with binaries
- Builds routine similar to AOSP (note: “brunch”)
- http://wiki.cyanogenmod.com/wiki/Main_Page

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Android, X86, Google, Intel and Android-X86

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Android and X86

X86 ROMs (by chronological order):

- Android-X86 (Debut date: 2009)
  - http://android-x86.org
- Emulator-x86 (Debut date: 2011)
  - http://source.android.com
- Android-IA (Debut date: 2012)
  - https://01.org/android-ia

AOSP

The common reference, having the most recent version of the Android platform (Userspace) versions.

Provides the QEMU based ***Android Emulator***:

+ Works on any hosted OS
+ Supports multiple architectures
    - But slow on non X86 ones
- Performs terribly if virtualized
- Has no installer for X86 devices
- Very old kernel

+/- An **emulator**. For better and for worse.

Android-X86

+ Developed by the open source community
+ Developer/Linux user friendly
+ Multi-Boot friendly
+ Generally supports many Intel and AMD devices

+/- But of course requires specific work on specific HW

+ VM friendly
+ Mature, Recognized and stable

- Delays in new releases (You can help!)
    - Current version (4.2.1) still needs some work on important features such as Bluetooth, Camera etc.
    + The ICS 4.0.4 release is amazing - including running ARM apps

Android-IA

+ Installer to device
+ Relatively new versions of android and kernel
+ Works great on ivy-bridge devices
+ Integrated Ethernet Configuration Management
- Development for devices based on intel solutions only
- Very unfriendly to other OS's
- Not developer friendly – unless they make it such
- Community work can be better. But it is seems to be getting better
- Intel phones are not based on it (at the moment)
+ Made impressive progress in the last couple of months!

Android **is** Linux

- Android is Linux
  - Therefore the required minimum to run it would be:
    - A Kernel
    - A filesystem
    - A ramdisk/initrd... Whatever makes you happy with your kernel's init/main.c's run_init_process() calls.
      See http://lxr.linux.no/linux+v3.6.9/init/main.c
  - This means that we can achieve full functionality with
    - A kernel (+ramdisk)
    - A rootfs where Android system/ will be mounted (ROM)
    - Some place to read/write data

Android-IA is Android

Android-IA is, of course, Linux as well.
However, it was designed to conform to Android OEM's partition layout, and has no less than 9 partitions:

- boot - flashed boot.img (kernel+ramdisk.img)
- recovery - Recovery image
- misc - shared storage between boot and recovery
- system - flashed system.img - contents of the System partition
- cache - cache partition
- data - data partition
- install - Installation definition
- bootloader - A vfat partition containing android syslinux bootloader
- fastboot - fastboot protocol (flashed droidboot.img)

Note: On android-ia-4.2.1.-r1, the bootable liveimg works with a single partition. It still has its issues - but it is getting there.

Android-X86 **is** Linux

- One partition with two directories
  - First directory – grub (bootloader)
  - Second directory – files of android (SRC)
    - kernel
    - initrd.img
    - ramdisk.img
  - system
  - data
- This simple structure makes it very easy to work and debug

Note: Also comes with a live CD/installer. Very convenient.

Android-IA boot process

- Start bootloader
- The bootloader starts the combined kernel + ramdisk image (boot.img flashed to /boot)
- At the end of kernel initialization Android's /init runs from ramdisk
- File systems are mounted the Android way – using fstab.common that calls from init.<target>.rc

Android-X86 boot process

- Start bootloader (GRUB)
- bootloader starts kernel + initrd (minimal linux) + kernel command line
- At the end of kernel initialization
  - run the ***/init*** script from initrd.img
  - load some modules, etc.
  - At the end ***change root*** to the *Android* file system
- Run the **/init** binary from ramdisk.img
  - Which parses init.rc, and starts talking “Android-ish”

Which one is better?

It depends what you need:

- Developer options?
- Debugging the init process?
- Support for Hardware?
- Support for OTA?
- Licensing?
- Participating in project direction?
- Upstream features?
- ...

There is no Black and White.

An hybrid approach

- Use Android-X86 installer system
- And put your desired android files (***matching*** kernel/ramdisk/system) in the same partition.
- Use the Android-X86 **chroot** mechanism
  - Critics: Does redundant stuff
  - But that's just a hack anyway – devise specific solutions for specific problems
- This way, we can multiple boot various projects:
  - Android-IA
  - AOSP
  - Any other OS...

Multi-boot recipe with legacy GRUB (simplified)

- Repartition existing Linux partition (Don't do that...)
- Install Android-X86
- Add entries to GRUB
- Reboot to Android-X86 debug mode
- Copy Android-IA files from a pendrive or over SCP
  - For the former: cp /mnt/USB/A-IA/ /mnt && sync
  - /mnt is the root of Android-X86 installed partition (e.g. (hd0,1)/...
- Update GRUB entries and update GRUB
- Voila :-)
- Less simplified procedure: Debug GRUB... :-(

** **Note**: Replace *Android-IA* with *AOSP* to boot AOSP built files (system.img / kernel / ramdisk.img) on your target device.

Multi-boot recipe using GRUB2

- Repartition existing Linux partition (Don't do that...)
- Create a mount point for your multi-booting android
  - Can make a partition per distribution, it doesn't really matter.
  - For this example let's assume all Android distributions will co exist on the same partition, and that it is mounted to /media/Android-x86
- Build your images
  - AOSP: Discussed before
  - Android-x86: . build/envsetup.sh && lunch x86 && make iso_img
  - Android-IA:
    - . build/envsetup.sh && lunch ivb && make allimages   # liveimg for a live CD
    - . build/envsetup.sh && lunch bigcore && make allimages # liveimg for a live CD
- Create directories for your projects (e.g. jb-x86, A-IA, AOSP) under your mount point (e.g. /media/Android-x86)
- From Android-X86's out/product/target: Copy ***initrd.img*** to all projects.
  - Can of course only copy ramdisk to one location.
- From all projects – copy ***kernel***, ***ramdisk.img***, ***system/*** and ***data/*** to to the corresponding directory under your mount point.
- Add entries to GRUB and update grub.
      - # e.g. sudo vi /etc/grub.d/40_custom && update-grub

Multi-boot recipe with GRUB2 - A numerical example

```
$ df
Filesystem  1K-blocks      Used Available Use% Mounted on
/dev/sda5  451656948 394848292  34199920  93% /
udev         1954628         4   1954624   1% /dev
tmpfs         785388      1072    784316   1% /run
none            5120         0      5120   0% /run/lock
none         1963460      2628   1960832   1% /run/shm
/dev/sda1   15481360   5165416   9529464  36% /media/Android-
x86
```

A numerical example (cont.)- /etc/grub.d/40_custom

```
#### JB-X86
menuentry 'jb-x86' --class ubuntu --class gnu-linux --class gnu --class os {
recordfail
insmod gzio
insmod part_msdos
insmod ext2
set root='(hd0,msdos1)'
echo    'Loading Android-X86'
linux /jb-x86/kernel quiet androidboot.hardware=android_x86 video=-16 SRC=/jb-x86
initrd /jb-x86/initrd.img
}
```

A numerical example (cont.) - /etc/grub.d/40_custom

```
### android-IA
menuentry 'Android-IA' --class ubuntu --class gnu-linux --class gnu --
class os {
recordfail
insmod gzio
insmod part_msdos
insmod ext2
set root='(hd0,msdos1)'
echo    'Loading Android-IA'
linux /A-IA/kernel console=ttyS0 pci=noearly console=tty0 loglevel=8
androidboot.hardware=ivb  SRC=/A-IA
initrd /A-IA/initrd.img
}
```

Coming up next...

- In this session:
    - We have listed various ways to build ROMs for
        - AOSP devices
        - AOSP emulator(-X86)
        - Android-X86
        - Android-IA
    - We have also discussed multi booting several configurations using the Android-X86 build system
- In the next session (right after the break!), we will see how to create and modify those projects for easy customizable X86 developer friendly targets!

References

- The AOSP is hosted at http://source.android.com
- The Android-x86.org project is hosted at http://Android-X86.org
- The Android-IA project is hosted at https://01.org/android-ia
- The presentation is available at http://events.linuxfoundation.org/images/stories/slides/abs2013_munitz.pdf
- Device trees shown in the next session will be updated at https://github.com/ronubo/abs2013_aosp_kvm
- There is some more relevant material in https://github.com/ronubo/
- Updates and relevant information will be posted at https://plus.google.com/100590449141172132889
- You are welcome to contact me at:
  - ron@nubosoftware.com
  - ron@android-x86.org (preferable for topics related to the lecture)
  - Google+ / LinkedIn / Owl (;-))

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Thank You

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