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X86 ROM Cooking 101

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The slides will be available online at:
thepscg.com/talks/2014

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Agenda

- Introduction
  - You, Me, Android
- Introduction to Embedded Systems
  - Embedded Systems
  - Android Partition Layout
- Android X86 projects
  - Virtual Machine discussion
  - The Init sequence
  - Multi Booting
- The Android Build System
  - Building an AOSP ROM from scratch

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You, Me, Android

?

About://Ron Munitz

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- **Distributed Fault Tolerant Avionic Systems**
  - Linux, VxWorks, very esoteric libraries, 0's and 1's
- **Highly distributed video routers**
  - Linux
- **Real Time, Embedded, Server bringups**
  - Linux, Android , VxWorks, Windows, devices, BSPs, DSPs,...
- **Distributed Android**
  - Rdroid? Cloudroid? Too busy working to get over the legal naming, so no name is officially claimed for my open source.
- **What currently keeps me busy:**
  - Running the PSCG, a Embedded/Android consulting and Training
  - Managing R&D at *Nubo Software* and advising on Remote Display Protocols
  - Promoting open source with *The New Circle* expert network
  - Teaching, Researching and Project Advising at *Afeka's college of Engineering*
  - Amazing present, endless opportunities. (Wish flying took less time)

Android History (2002-2007)

- **2002** - SideKick by Danger Inc. - The first “Internet Phone”.
  - Technical session at Stanford by Andy Rubin, CEO of Danger Inc.
  - Google’s Brin & Page attend, and soon become Sidekick users.
  - Sidekick fails to achieve commercial success

- **2003** - Andy Rubin forms “Android”, targeted at operating mobile phones and cameras

- **2005** - Google Acquires “Android”.

- **2007** - The Open Handset Alliance is formed
  - November 5th - The OHA Announces ***Android***, an open source mobile phone platform based on the linux kernel
  - November 12th - Google Announces the Android SDK, along with a $10 million Android developer challenge

Android History (2008-2009)

- **2008** - T-mobile and Google announce the first Android phone - the G1
  - AKA. The ***HTC "Dream"***
  - Approved by the FCC on August 18th 2008
  - First available - October 22nd

- **2009** - Motorola Droid is announced, running Android 2.0
  - Considered by many as the opening note for the smartphone wars.
  - Added at least two exclusive features:
    - Hardware keyboard
    - Replaceable battery

Android History (2010)

- **2010** was an exciting year for Android:
  - Google Announces its first flagship device - the Nexus One
    - Which is one of the best phones I have ever had.
  - Samsung sets a giant's foot on the battlefield
    - Galaxy S and its variants hit the market
  - HTC's EVO4G hits the market
    - Was widely considered as the best iPhone alternative at that time
  - **Android's market share first passes the iPhone's market share**
  - Google announces the ***Gingerbread*** (2.3) Android version, debuting on the Nexus S.
    - Introducing the most popular Android version until the end of 2013
    - Introducing NFC and SIP

Android History (2011 - 2013)

- **2011** - Honeycomb (3.0), google's first aim at the tablet market is out
  - Android's market share first passes the Blackberry's market share
  - November 2011 - **Ice Scream Sandwich** is out, debutting on the ***Galaxy Nexus***

- **2012** - JellyBean is released
  - Introducing significant enhancement in user experience (Project butter)
  - Introducing multi user for tablets
  - Samsung confidently ranks as the top Android phone maker on earth

- **2013** - More devices, more market share,
  - Android 4.3 is out: Enhanced WiFi-Display, Open GL ES 3.0,...
  - Android 4.4 (**KitKat)** is out: First time a commercial brand hits Android, better memory utilization, enhanced security, in-platform PDF rendering, enhanced printer support and more...

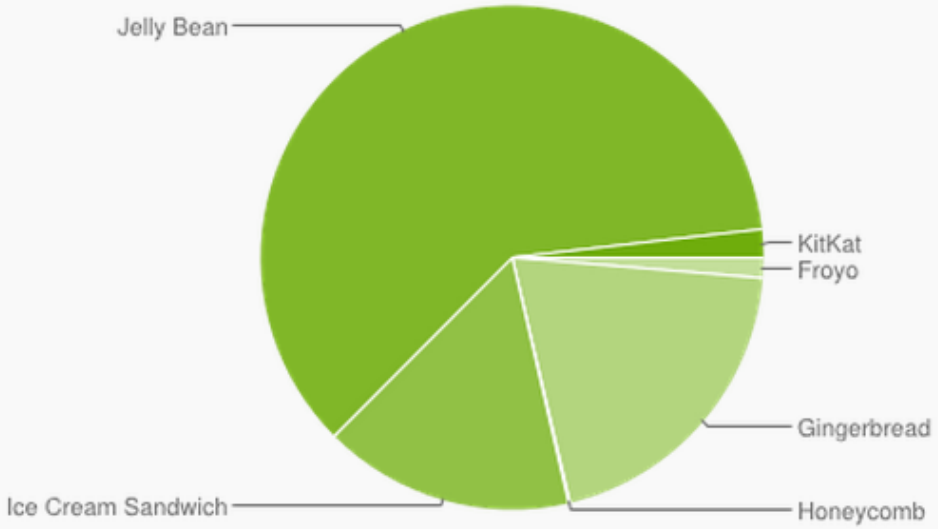
Android History (2014 - The Future)

- Foreseeable future:
  - More devices
  - More power
  - More features
  - More apps
  - More developers
  - More competition
  - **More embedded Android engineers needed.**

- Will Android be crowned as the new Embedded Linux?

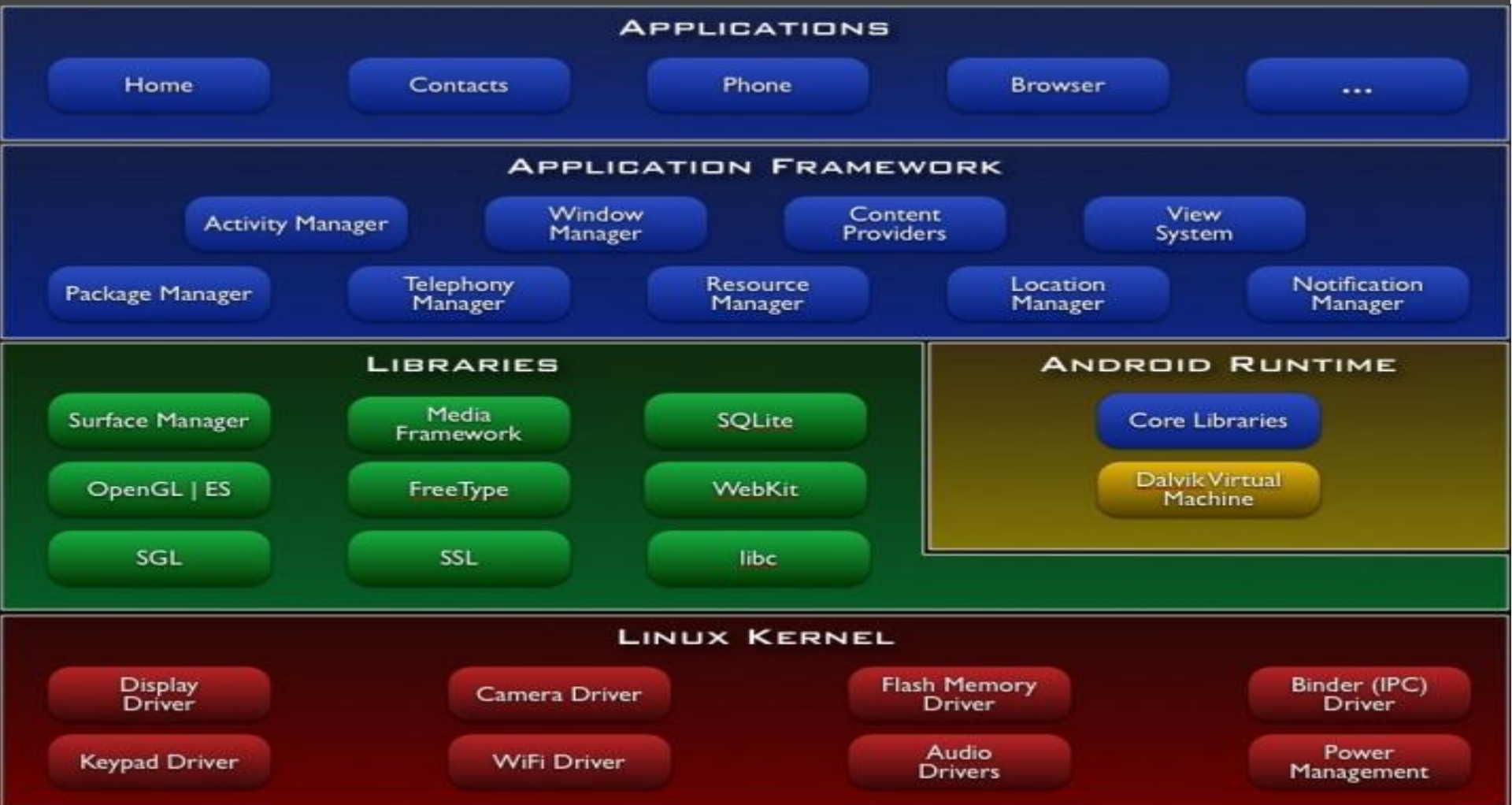
Platform Versions - Present day distributions

Version	Codename	API	Distribution
2.2	Froyo	8	1.3%
2.3.3 - 2.3.7	Gingerbread	10	20.0%
3.2	Honeycomb	13	0.1%
4.0.3 - 4.0.4	Ice Cream Sandwich	15	16.1%
4.1.x	Jelly Bean	16	35.5%
4.2.x		17	16.3%
4.3		18	8.9%
4.4	KitKat	19	1.8%



Data collected during a 7-day period ending on February 4, 2014.
Any versions with less than 0.1% distribution are not shown.

Historical Exhibit: Android Platform Overview



Introduction to ROM Cooking

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Agenda

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

"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

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

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Embedded Build Systems Primer - A quick detour for the novice

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Embedded Build Systems

- In the introduction module we saw a recipe for ***building*** Android using the AOSP ***Build System.***
- The build procedure was done on a designated machine, which has all the required tools to turn the
  - That machine is referred as ***The Host***
- The host is used to build the system for a designated device, may it be a handset, an emulator, a streamer etc.
  - That device is referred to as ***The Target***

Embedded Build Systems

- In ***Embedded Software Development***, the common case is that *host* != *target*
- They ***may*** have the same attributes:
  - architecture (i.e x86, arm, mips…),
  - library versions (libc, libstdc++, …)
  - ***toolchains*** (gcc, ar, …)
- But they **do not have to**, and will usually have **little to nothing in common.**
- Hence, the build system uses a ***cross Toolchain,*** to ***cross compile*** build artifacts for the **target** on the **host**.

Native and Cross Compiling

Native Compiling

$ cat hello.c

```
#include <stdio.h>
int main()
{
        printf("Ciao Mondo\n");
        return 0;
}
```

$ which gcc

/usr/bin/gcc

$ gcc --static -o hello_native hello.c
$ ./hello_native
Ciao Mondo
$ file hello_native
hello_native: **ELF 64-bit** LSB executable, **x86-64**, version 1 (GNU/Linux), statically linked, for GNU/Linux 2.6.24, BuildID [sha1] =0x60117523776dbf4ff7d4378cce2f184d5

Cross Compiling

$ cat hello.c

```
#include <stdio.h>
int main()
{
        printf("Ciao Mondo\n");
        return 0;
}
```

$CC=~/tc/bin/arm-linux-androideabi-gcc

$ ${CC} --static -o hello_cross hello.c

$ ./hello_cross

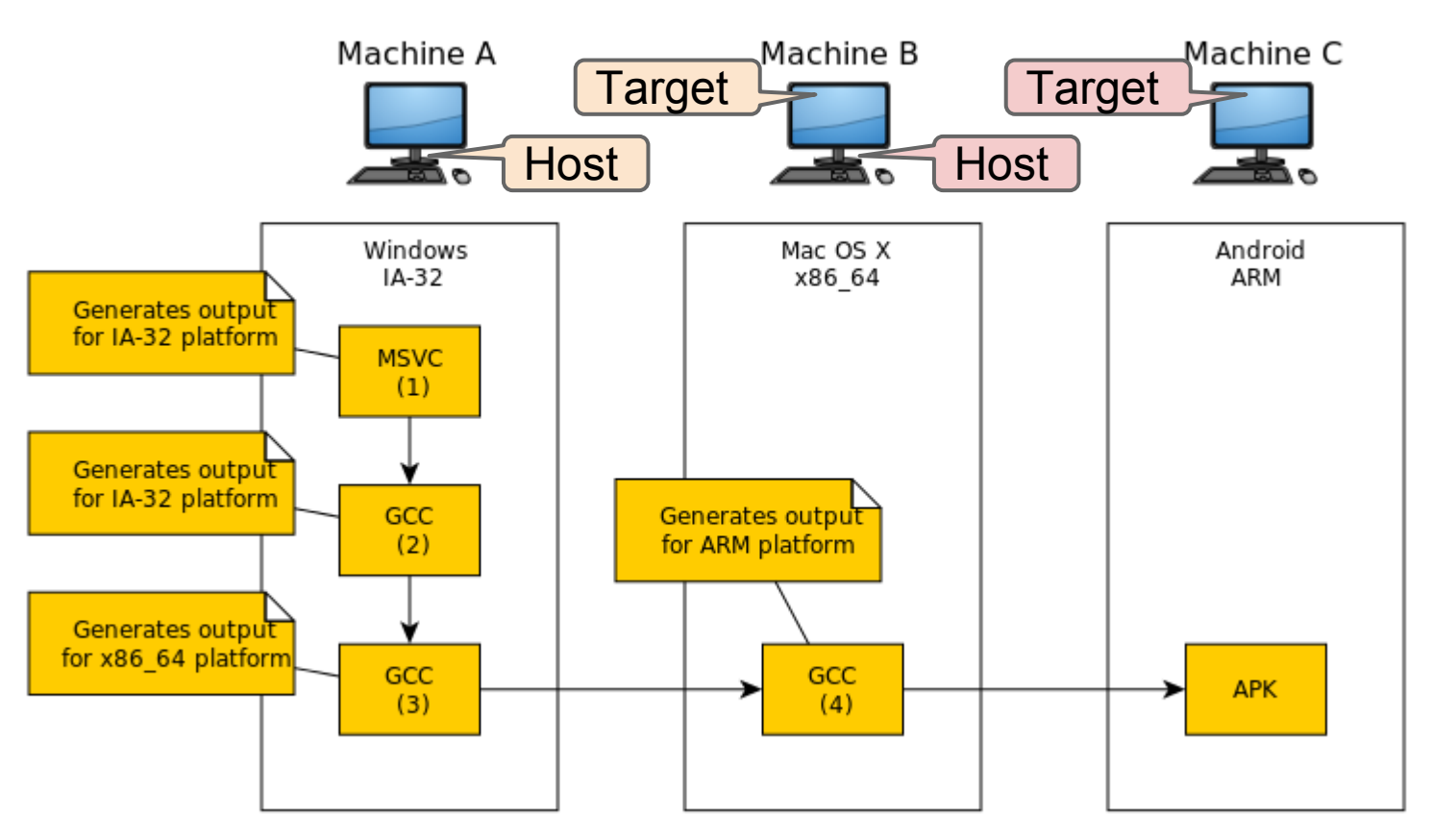
bash: ./hello_cross: cannot execute binary file

$ file hello_cross

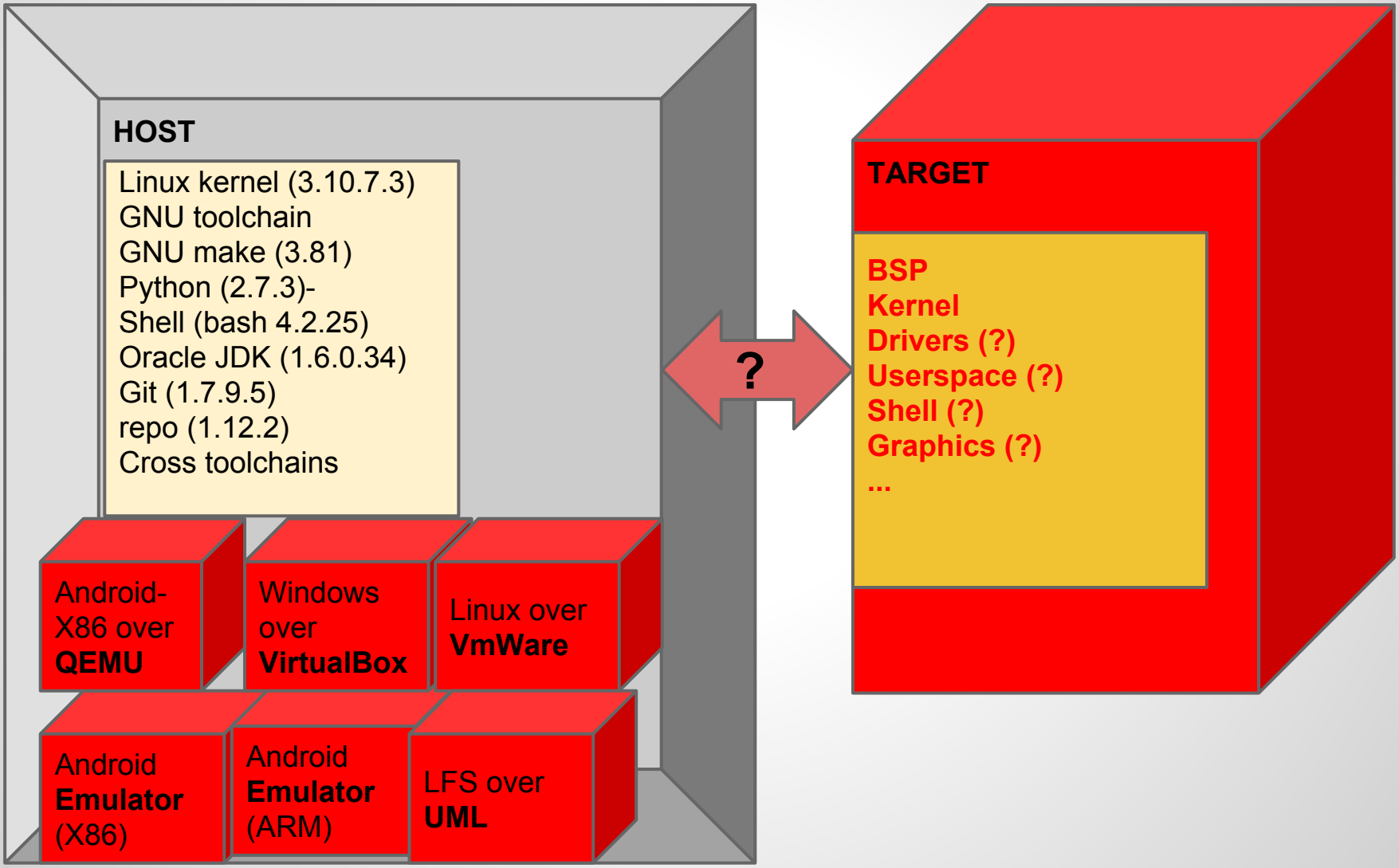
hello_cross: **ELF 32-bit** LSB executable, **ARM**, version 1 (SYSV), statically linked, not stripped

Canadian Cross

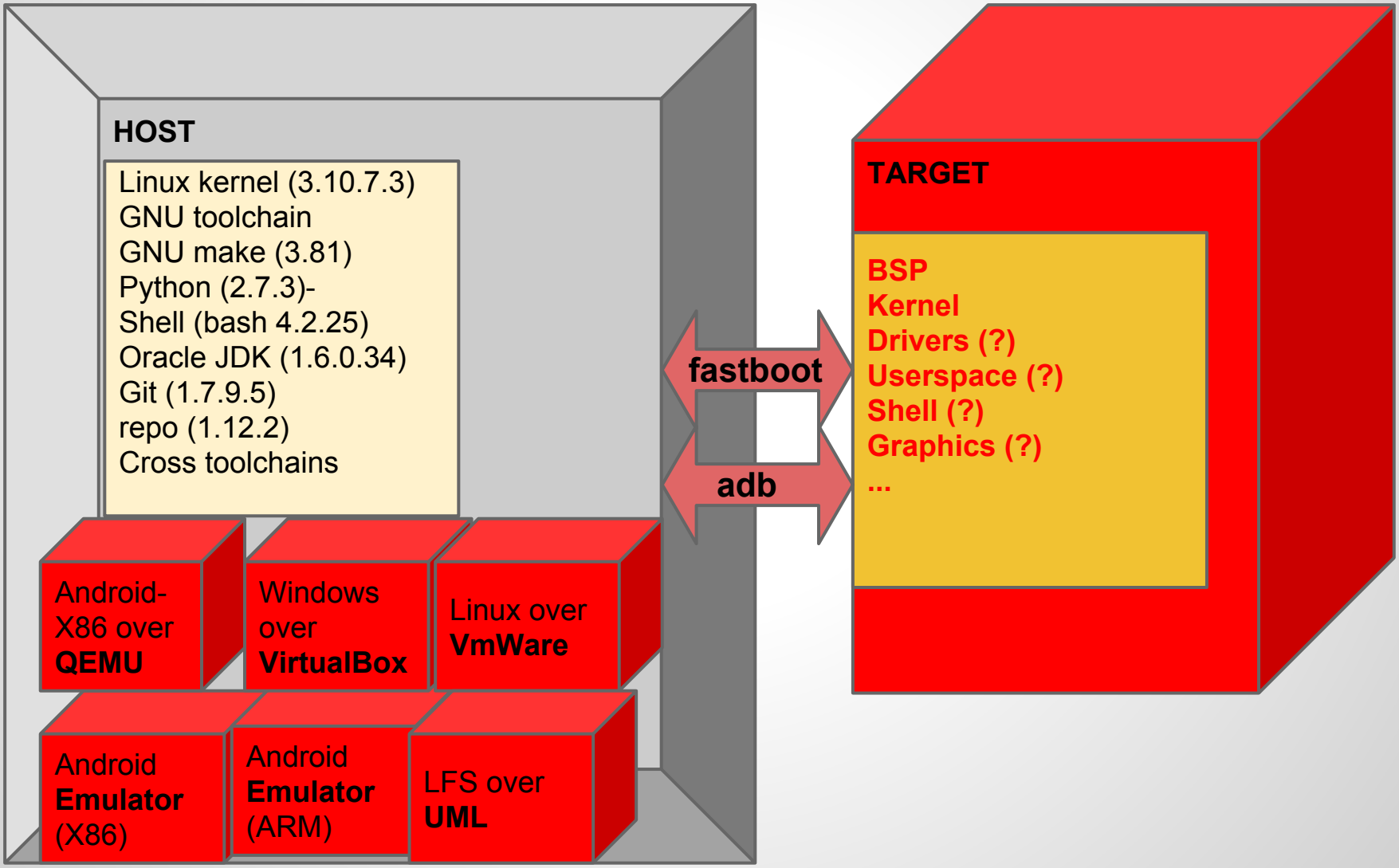
This simplified (and very inaccurate) image depicts a technique for building *Cross Compilers,* known as the ***Canadian Cross***
**source:* http://en.wikipedia.org/wiki/Cross_compiler_



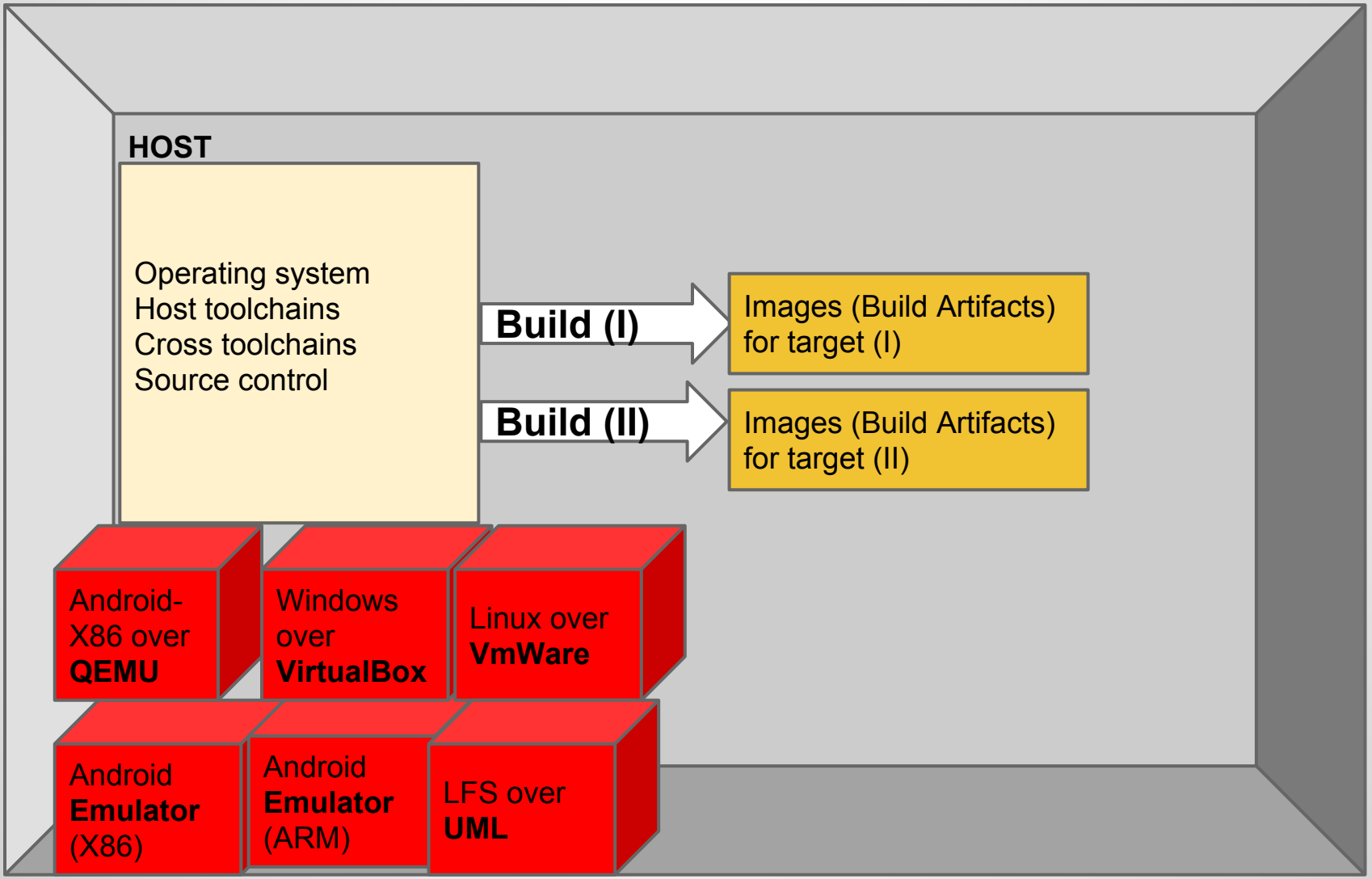
Embedded Development Overview



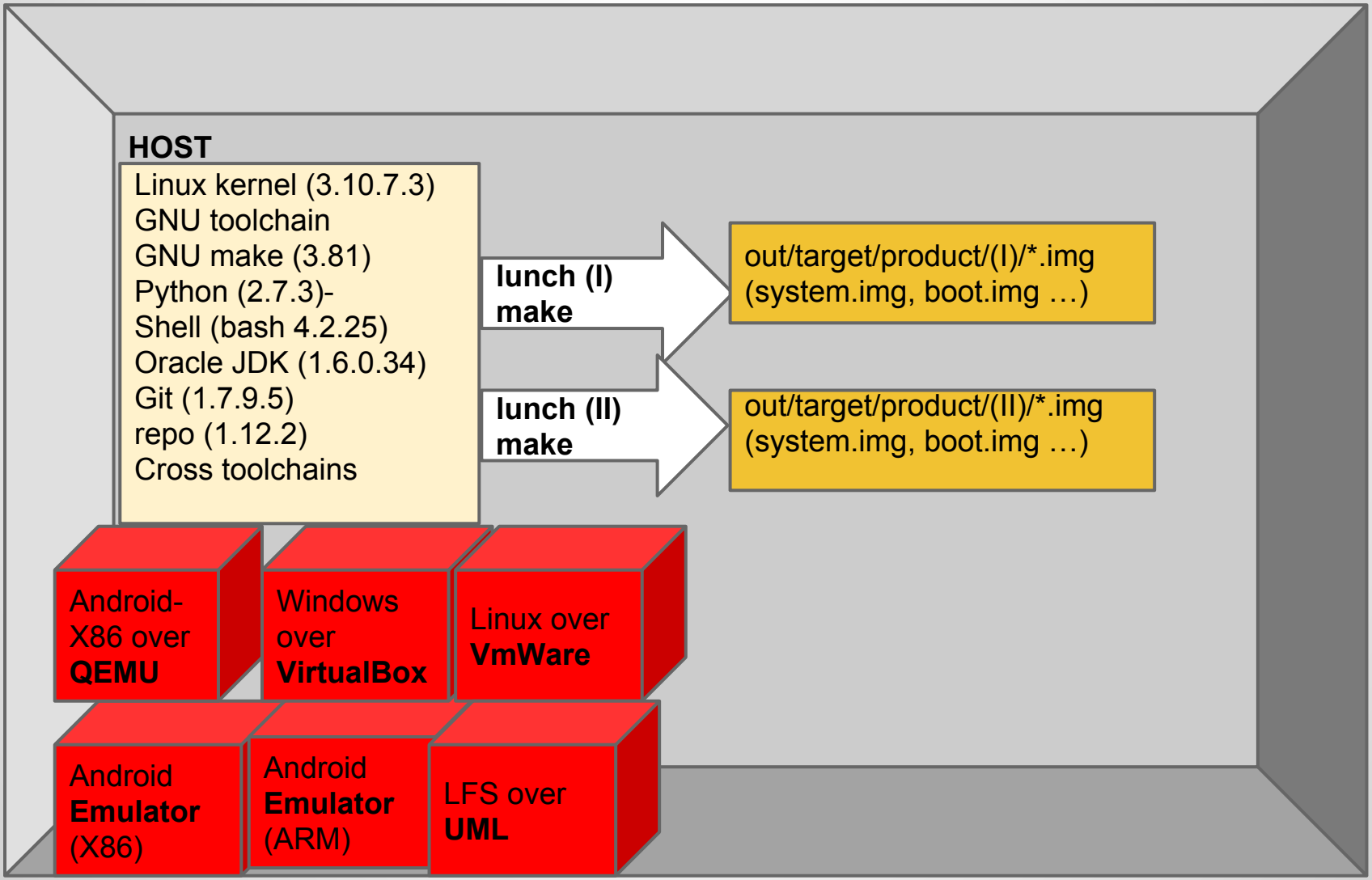
Connecting the host with the target - The Android way



Embedded Build System - Overview



Embedded Build System - The Android way



Flashing build artifacts - The Android way

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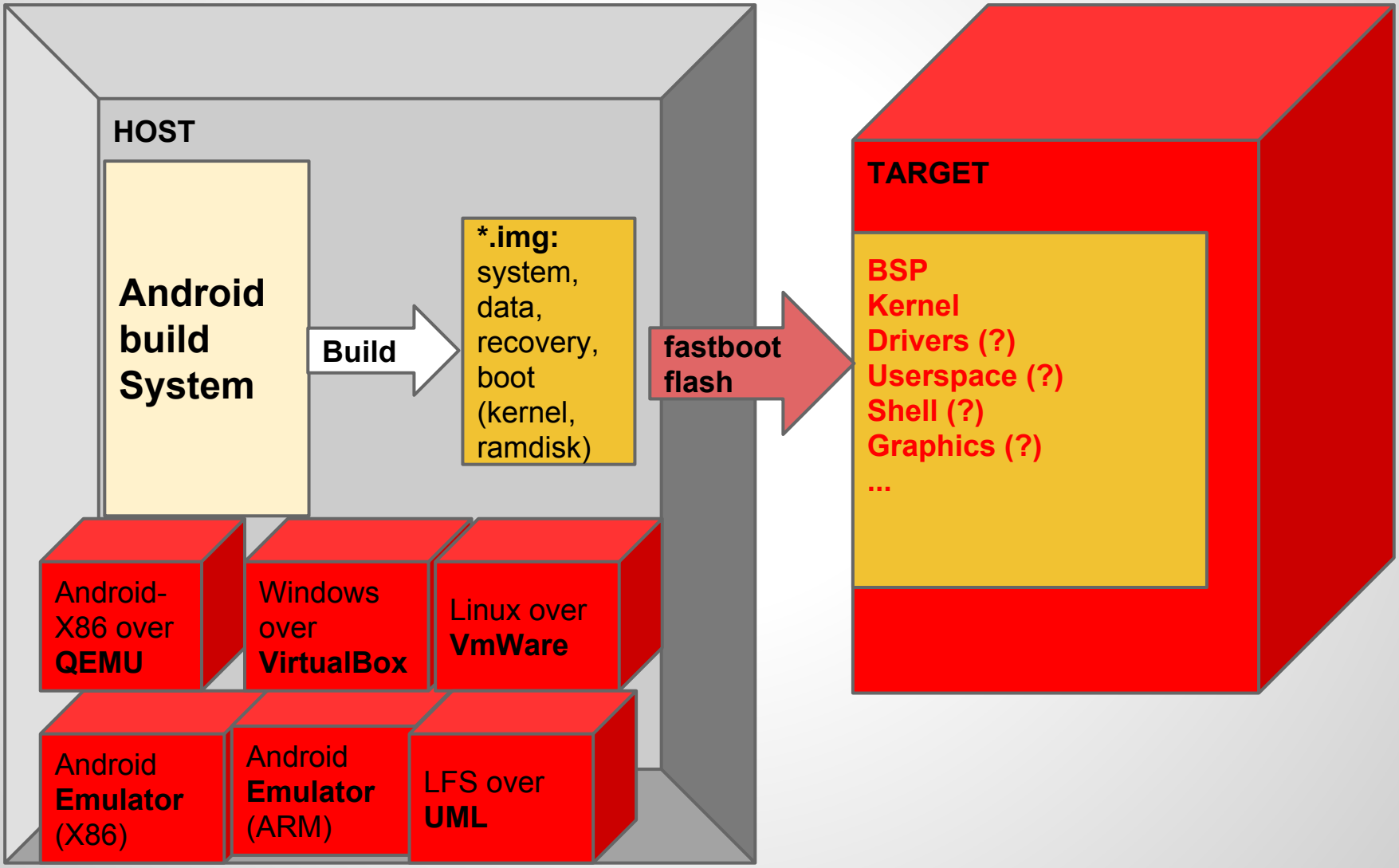

ROM flashing

- ROM Flashing (simplified) - is the action of transferring the build system output (a.k.a “Build Artifacts”) onto the ***target*** memory (i.e. flash, EEPROM, Hard drive, RAM, etc).
- Once the ROM is flashed, and assuming it is functional, it will be loaded and run when your target is power cycled / reset.
- It is the responsibility of the ***Bootloader*** to have the target’s CPU fetch, load and execute the ROM contents.

Embedded Development Example - The Android way - Flashing Maguro

- Assuming I would like to build the AOSP for my *maguro* device.
  - **The Host** is My laptop, running Ubuntu 12.04 as its Operating System.
  - **The Target** is an *Samsung Galaxy Nexus* GSM.
    - Before flashing - it is running a stock ROM
    - After flashing - it will be running what I built using the AOSP!
  - The "**Flashing"** occurs when we:
    - Reboot to fastboot mode
    - Flash the boot.img, system.img etc.
      of the build output directory (out/target/product/maguro)

Embedded Development Example - The Android way - Android Emulator

- In the previous module we built an aosp_x86-eng build variant of the AOSP.
  - **The Host** is My laptop, running Ubuntu 12.04 as its Operating System.
  - **The Target** is an *Android Emulator* - running what I built using the AOSP!
  - The "**Flashing"** pseudo-occurs when we run the emulator, and it loads the system.img, userdata-qemu.img, kernel and cache.img of the build output directory (out/target/product/generic-x86)

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And Back to the Android World!

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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, 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, LG Nexus 4)
- Omap – TI's OMAP (Samsung Galaxy Nexus)
- Tegra – Nvidia's Tegra (Motorola Xoom, Asus Nexus 7)
- Exynos - Samsung Exynos (Samsung Nexus 10)
- ***Goldfish*** **- Android emulator**

A blast from the (not so far) past

- Before we get our hands “dirty”, there is something I want you to know.
- That something is how things were done for most of the Android project lifetime.
- More precisely up until Android 4.2.
- Feel free to stick to your chairs and “enjoy” some historic moments in the *Museo di Android Internals*

Goldfish Kernels

- The Goldfish Kernel Version has traditionally been 2.6.29.
  - Even 4 years after the kernel.org release.
  - Until Android 4.2, where it was upgraded by default to 3.4
- 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”
- And trying to fix something that is not broken in the Goldfish case is extremely time consuming.
  - Ask the kernel maintainers who added extremely broken code to the staging area at late 2013 (too bad I stopped following LKML…)

Vanilla (kernel.org) kernels

- This is a serious topic.
  - So serious I won't get into it. Seriously.
- So to make a (very) long story short:
  - It can be argued that Android kernels were not well accepted. To say the least.
  - This caused an unpleasant fragementation.
  - Yet Android prevailed ⇒ **Staging Area**.
- You can basically build Android from the vanilla kernel.org. You can do it without a single patch actually for a virtual machine!
- Goldfish is a different (harder) topic.
  - Talk to me if you need a .../3.11+/3.12+/3.13+ goldfish porting.

TIP: ${ANDROID_BUILD_TOP}/external/qemu/distrib/build-kernel.sh

Vanilla (kernel.org) kernels

- This is a serious topic.
  - So serious I won't get into it. Seriously.
- Fortunately I don't have to
  - In order to get you running on your favorite ***VESA*** configuration
  - *Graphic acceleration is not only serious, but also a painful point, which we will not discuss.
- Grasping the concept is a bit easier on Virtual Machines for a starter, so let's have a quick look at such.

* Graphic Acceleration is always a mess with virtual machines, so no surprise in here.

make ARCH=x86 qemu_vanilla_config

Guidelines to follow:

- Select your architecture (32/64bits, X86/arm/…, etc.)
- Enable staging area (CONFIG_STAGING=y)
- Search for ANDROID - and enable all configs
  - Some are unnecessary, but it’s a good start
- Enable VIRTIO drivers
  - CONFIG_VIRTIO, CONFIG_VIRTIO_BLK, CONFIG_VIRTIO_PCI, CONFIG_VIRTIO_NET,...
- Enable FB configurations
  - CONFIG_FB, CONFIG_FB_VESA, ...
- Use the right command line when running qemu
- And don’t forget qemu=1 on the cmdline!

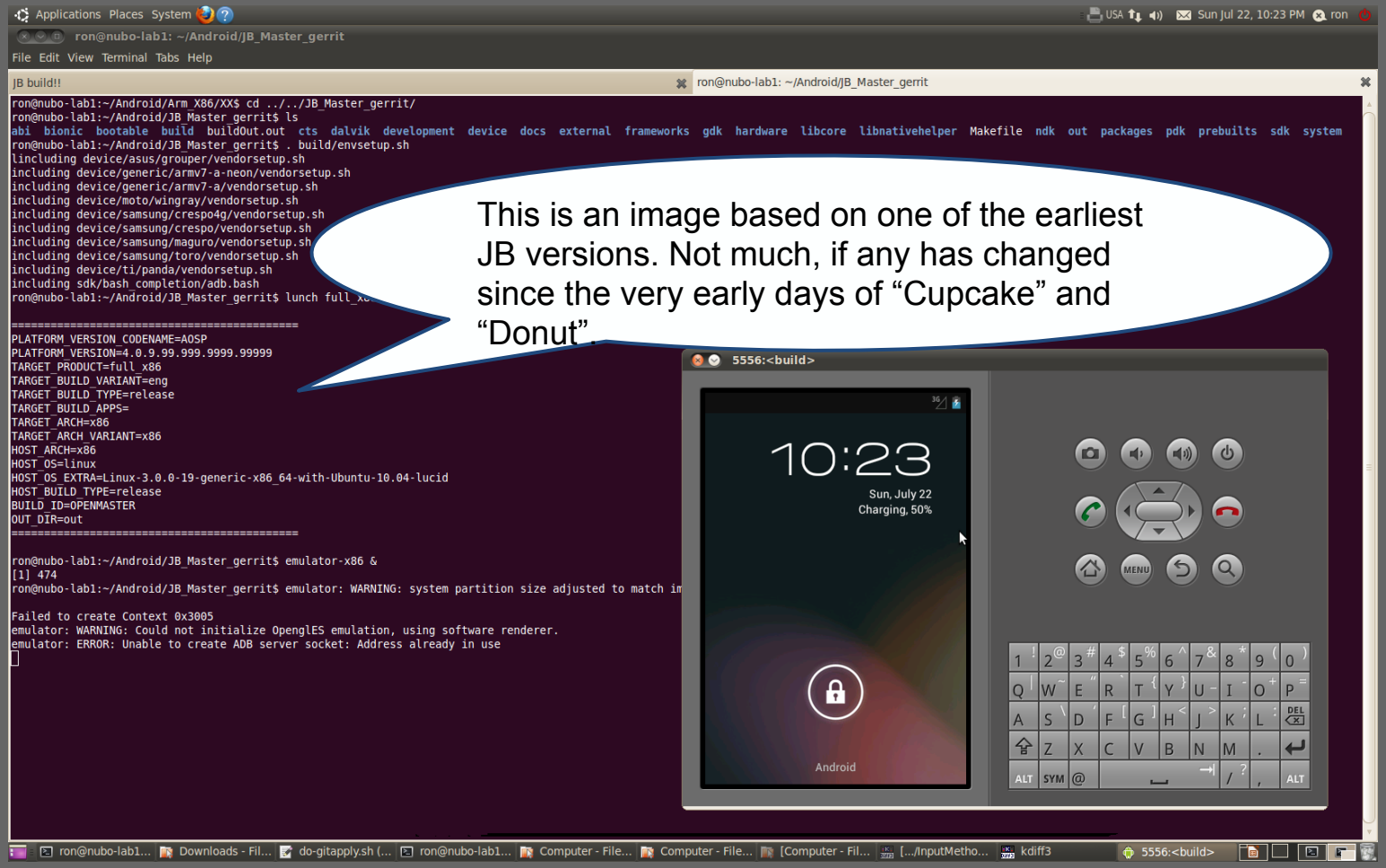
Android emulator storage (Goldfish kernel, “old” JB)

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.

Android emulator storage (Goldfish kernel, Kit-Kat)

Android emulator storage (Custom vanilla kernel)

AOSP case study: Building a Jelly Bean emulator



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 win_sdk
  - Building for VirtualBox 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/HAXM
- 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.

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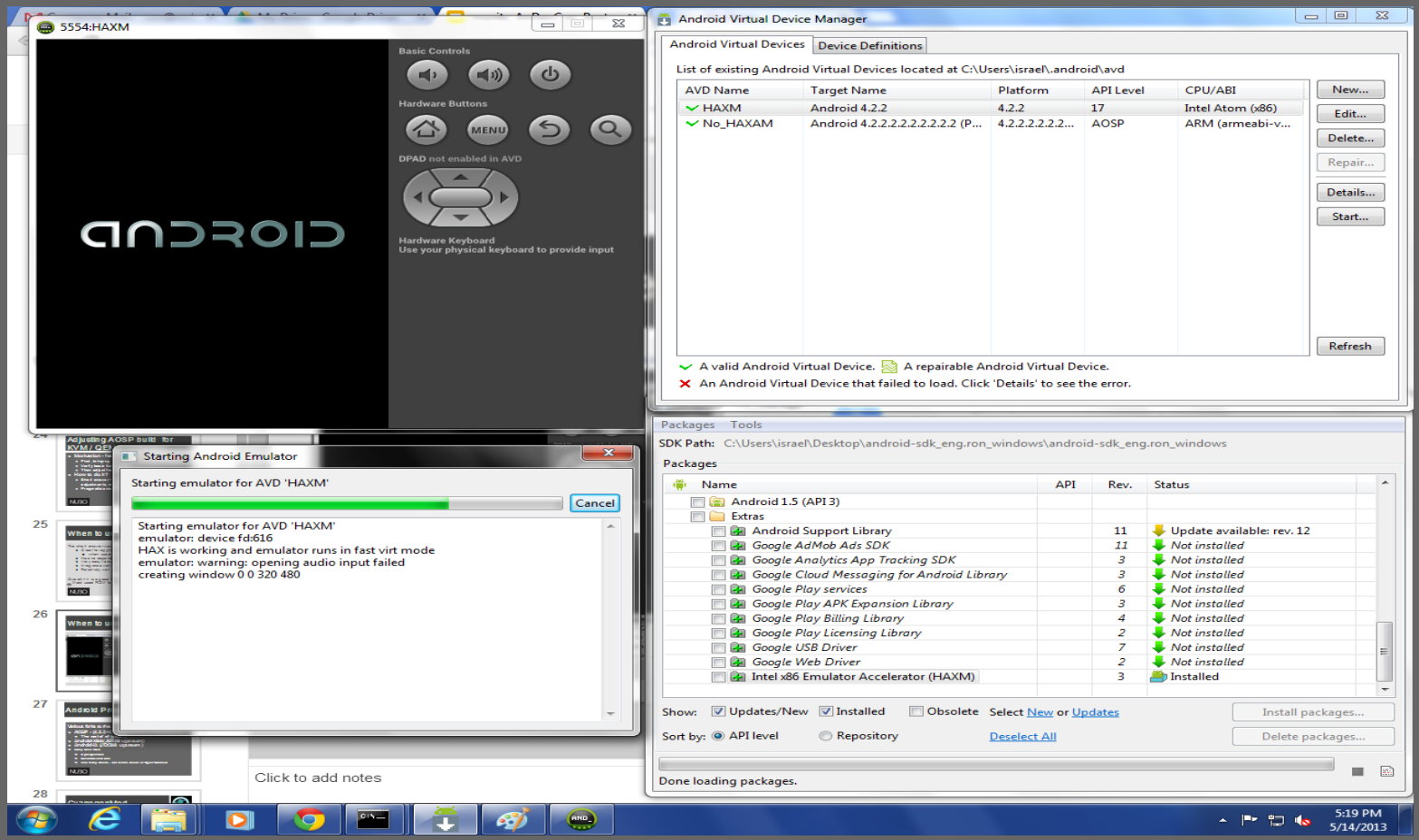
Running the Android Emulator on Windows



Android Projects

Various forks to the Android Open Source Project:

- **AOSP -** (4.4+ OPENMASTER/KVT49L upstream)
  - The root of all (good?)
- Android-X86 (KOT49H upstream, JLS36I last stable release)
- Android-IA (JDQ39 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

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!)
  - Latest version (4.4) is still very buggy, but it's been out only for a week
  +/- Latest stable version (4.3) still needs some work for some devices
  + 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 early 2013
- But suspended development at Android 4.2.2
+ Project resumption at Kit-Kat?, a bit late, but so far looks good (April 2014)

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 **(<4.2.2)**
  - A GPT partition containing gummiboot **(Only option in 4.2.2)**
- fastboot - fastboot protocol (flashed droidboot.img)

Note: On android-ia-4.2.2-r1, the bootable live.img works with a single partition, enforcing EFI. 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 is processed (*mount_all* command*)* from in ***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 multiboot various projects:
  - Android-IA
  - AOSP
  - Any other OS...

Note: You can also use chroot mechanism on any Linux Distribution, from userspace! But this is *significantly* harder...

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 android_x86-<variant> \
      && make iso_img
  - Android-IA:
    - . build/envsetup.sh && lunch core_mesa-<variant> \
      && make allimages
    - . build/envsetup.sh && lunch bigcore-<variant> && make allimages

** ***<variant>*** is either one of the following: *user, userdebug, eng*

Multi-boot recipe using GRUB2 (cont.)

- 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 module, we will:
  - Explore the Android build system
  - See how to create and modify those projects for easy customizable X86 developer friendly targets!

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Building Our First Customized Device

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April 2014

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https://github.com/ronubo/

Outline

- The build/ folder
- The device/ folder
- Adding a new device
- QEMU challenges
  - kernel
  - network
  - graphics
  - sdcard
- No slides! (pay attention!)

Challenges

- Android build system sometimes varies between versions
- Different Android build systems may have their nuances
- Android runtime varies between versions
- Binary blobs may, or may not be available
- Building takes time. Being “smart” may take more time due to Dexopt.
- OS/QEMU optimal combination varies.
- Initial bringup may be challenging

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
- Device trees shown in the next session are available at https://github.com/ronubo/AnDevCon
- *Introduction to Embedded Android course* - Ron Munitz. Taught at Afeka College of Engineering, Tel-Aviv, Israel
- You are welcome to contact me in the social networks (@ronubo)

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Thank You!

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