How to run Ubuntu, ChromiumOS, Android at the Same Time on an Embedded Device

Grégoire Gentil
Founder Always Innovating

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Why should I stay and attend this talk?

- Very cool demos that you have never seen before!
- Win some USB dongles and USB-to-HDMI adapters (Display Link inside, $59 value)!!!
- Come in front rows, you will better see the Pandaboard demo on multiple screens
Objective of the talk

• Learn how to run multiple operating systems...
  • AIOS (Angstrom fork), Ubuntu Maverick, Android Gingerbread, ChromiumOS
• …on a single ARM device (Beagleboard-xM, Pandaboard)...
• …at the same time, natively, with zero performance loss...
• …connected to one or multiple monitors simultaneously!!!!
Where does it come from? (1/2)

- Hardware is becoming so versatile
Where does it come from? (2/2)

- Open source is so fragmented
  - => “Single” (between quote) Linux but with different userspace stacks
How do we do it?

● Obviously: chroot

● Key lesson of this talk: simple theoretically, difficult to implement it right
  ● Kind of Rubik's cube puzzle
    – When assembling a face, you destroy the others

● Key issues along the way
  – Making work the core OS
  – Problem of managing output (video)
  – Problem of managing all inputs (HID, network)

  => End-up patching everything in kernel and OS
Multiple OS running side-by-side

- One kernel, multiple ARM native root file systems
- Hot-switchable at runtime
- Much faster than a usual virtual machine architecture
How to cleanly run the multiple chroots: squashfs + AUFS

- Download and replace a new factory image to update the OS without losing user data.

- Delete all files on the user overlay partition to reset the OS without losing system integrity.

OS (user view)  
read-write

AUFS

OS squashfs  
read-only

OS overlay  
read-write
chroot strategy

- Start from AIOS and prepare a chroot
  - mount the squashfs + overlay in a /tmp/dir with AUFS
  - bind /dev /proc /sys to your chroot when relevant
  - propagate useful stuff like /etc/resolv.conf
- Manage tty if needed
  - Patch chvt
  - splashcreen something!
- Init what you have to
  - chroot /tmp/dir /specific_init_script
  - … with unavoidable tweaks (3D drivers, X display, …)
Party time #1: Win a $59 USB-to-HDMI adapter

- Rule: A question will be asked on the next slide: the first person to answer correctly wins a USB-to-HDMI adapter.

The answer is a year. If you don't know, before shooting any date, give 10 or 20 seconds to the ones who might know to answer...
Party time #1: Win a $59 USB-to-HDMI adapter

In which year was chroot introduced?
Party time #1: Win a $59 USB-to-HDMI adapter

1979!
SD card partitioning

/dev/mmcblk0p1
  mlo
  u-boot.bin
  uImage

/dev/mmcblk0p2
  .images/
    ai-os.squashfs
    android.squashfs
    ubuntu.squashfs
    chromium.squashfs
  .overlay-ai-os/
  .overlay-android/
  .overlay-ubuntu/
  .overlay-chromium/

/dev/mmcblk0p3 (swap)
The puzzle of the kernel

- Each OS has its kernel specificities
  - Ubuntu: based on tons of modules => reintegrate
  - Android: bunch of specific patches to gather
    - Inter-process communication system
    - Memory management: pmem, ashmem
    - Power management (wakelocks)
    - Logger
      - Paranoia/networking security
  - Chromium: crypto stuff required
  - Compatibility issues: OS-dependent GPU drivers!
The puzzle of managing video output

- **Hardware dependent**
  - How many outputs on your board? What type?
  - Additional graphic cards (USB-to-VGA or USB-to-HDMI)

- **Single screen vs. multiple screens**
  - Only one screen => use `chvt`
  - Multiple screens => use `fb + synergy`

- => Transforming the weaknesses of the OS into advantages
The puzzle of managing Human Input Device

- Android
  - disable input events when out of android tty
- Other X-window based OS
  - single screen: different tty => OK
  - multiple screens:
    - Patch X
    - Play around X and udev/hal
    - use synergy to avoid duplications of inputs on each screen
Halftime break: Advertisement!!!

- A tribute to Texas Instruments for the superiority of their chips especially the OMAP
  - *Always Innovating has no affiliation With TI*
  - Freescale and Nvidia are so behind!
  - Updated OMAP4 will equal or beat iPad2 even for 3D

- The key AMAZING priceless differentiator: the open source community
  - Website, mailing list, chat, forums
  - Thanks to Jason, Gerald, and others...
More problems to solve

• Upstart bug #430224
  start: Unable to connect to Upstart: Failed to connect to socket /com/ubuntu/upstart: Connection refused

• no support for initctl in a chroot
  - start dbus + xinitrc instead in Ubuntu
  - Do It Yourself in ChromiumOS
    • fortunately not used in Android
    => losing good init process management

• Rotation problem
  • patch every X to get the rotation on our tablet

• Udev problem
  • Master OS' udev screws up slave OSes
The puzzle of networking

• Don’t start **multiple wpa_supplicant**!
  • `cp /etc/resolv.conf` where needed
  • patch Chromium and Android browser to avoid the network availability check at startup
• **Remove on-the-fly networking UI options** in slave OS
  • so that the user can't start another `wpa_supplicant`
• Paranoia / security problem in kernel
Sharing user data between the OS

/dev/mmcblk0p2

```
.images/os1.squashfs  read-only
.overlay-os1/         read-write
.shared/              read-write
.images/os2.squashfs  read-only
.overlay-os2/         read-write
```

AUFS

OS 1 user view
read-write

mount --bind

OS 2 user view
read-write

mount --bind

AUFS
More ideas worth mentioning

- You have to choose which OS is the master
  - Select the one you master the most
  - Emergence of the idea of an OS becoming a super-bios
- Collateral win: a useful feature to debug the port of an OS
  - Using chroot is definitely helpful to debug the port of an OS to a new platform
  - Monitoring from “outside” is easy and meaningful
Other strategy not selected

- **Hypervisor and virtualization** are possible on ARM too!
  - Acquisition of Trango by VMWare
  - Trango has developed an hypervisor of type I

- **Pros and cons** of hypervisor vs. chrooting
  - **Pros**: More waterproof, “security”
  - **Cons**: Performance, big mess up at driver level (SGX, DSP...)

- Availability of **Windows 8** for ARM might give a boost to ARM virtualization
## Statistics on Beagleboard-XM

<table>
<thead>
<tr>
<th></th>
<th>AIOS</th>
<th>Android</th>
<th>Ubuntu</th>
<th>ChromiumOS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Boot time</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>standalone</td>
<td>68 sec</td>
<td>55 sec</td>
<td>60 sec</td>
<td>46 sec</td>
</tr>
<tr>
<td>as a 2(^{nd}) OS</td>
<td>n/a</td>
<td>72 sec</td>
<td>36 sec</td>
<td>41 sec</td>
</tr>
<tr>
<td>as a 3(^{rd}) OS</td>
<td>n/a</td>
<td>118 sec</td>
<td>62 sec</td>
<td>48 sec</td>
</tr>
<tr>
<td>as a 4(^{th}) OS</td>
<td>n/a</td>
<td>237 sec</td>
<td>225 sec</td>
<td>211 sec</td>
</tr>
</tbody>
</table>

| **Memory print**     |       |         |        |            |
| standalone           | 168MB | 187MB   | 138MB | 172MB      |
| as a 2\(^{nd}\) OS  | n/a   | 153MB   | 90MB  | 140MB      |
| as a 3\(^{rd}\) OS  | n/a   | 237MB (sw) | 92MB | 140MB      |
| as a 4\(^{th}\) OS  | n/a   | 253MB (sw) | 178MB (sw) | 221MB (sw) |
Summary

- Very easy on paper (just one line command), but a real nightmare, so:
  - Think twice if you really want to do it
  - Think twice what exactly you want to do

- Everything is open source at http://git.alwaysinnovating.com

- Wishful thinking: raising awareness to think about other OS
Party time #2: Win a $59 USB-to-HDMI adapter

- Rule: A question will be asked on the next slide, the first one to answer correctly wins a USB-to-HDMI adapter?

Many answers are possible. Easy answers will win USB dongle. Complex answers will win an adapter.
Party time #2: Win a $59 USB-to-HDMI adapter

How can I add a fifth OS on a fifth screen on the Pandaboard?
Party time #2: Win a $59 USB-to-HDMI adapter

- USB dongle winners:
  - VNC

  Another USB-to-VGA or USB-to-HDMI DSI (next Pandaboard revision)

- USB-to-HDMI adapter winner:
  Expansion RGB slot with special driver to have two OS on same fb with different timing
Questions and Answers
Questions and Answers

Good questions win a USB dongle!
Outstanding questions win an HDMI adapter!!!
How could you thank us?

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