



Always **Innovating**

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

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Why should I stay and attend this talk?

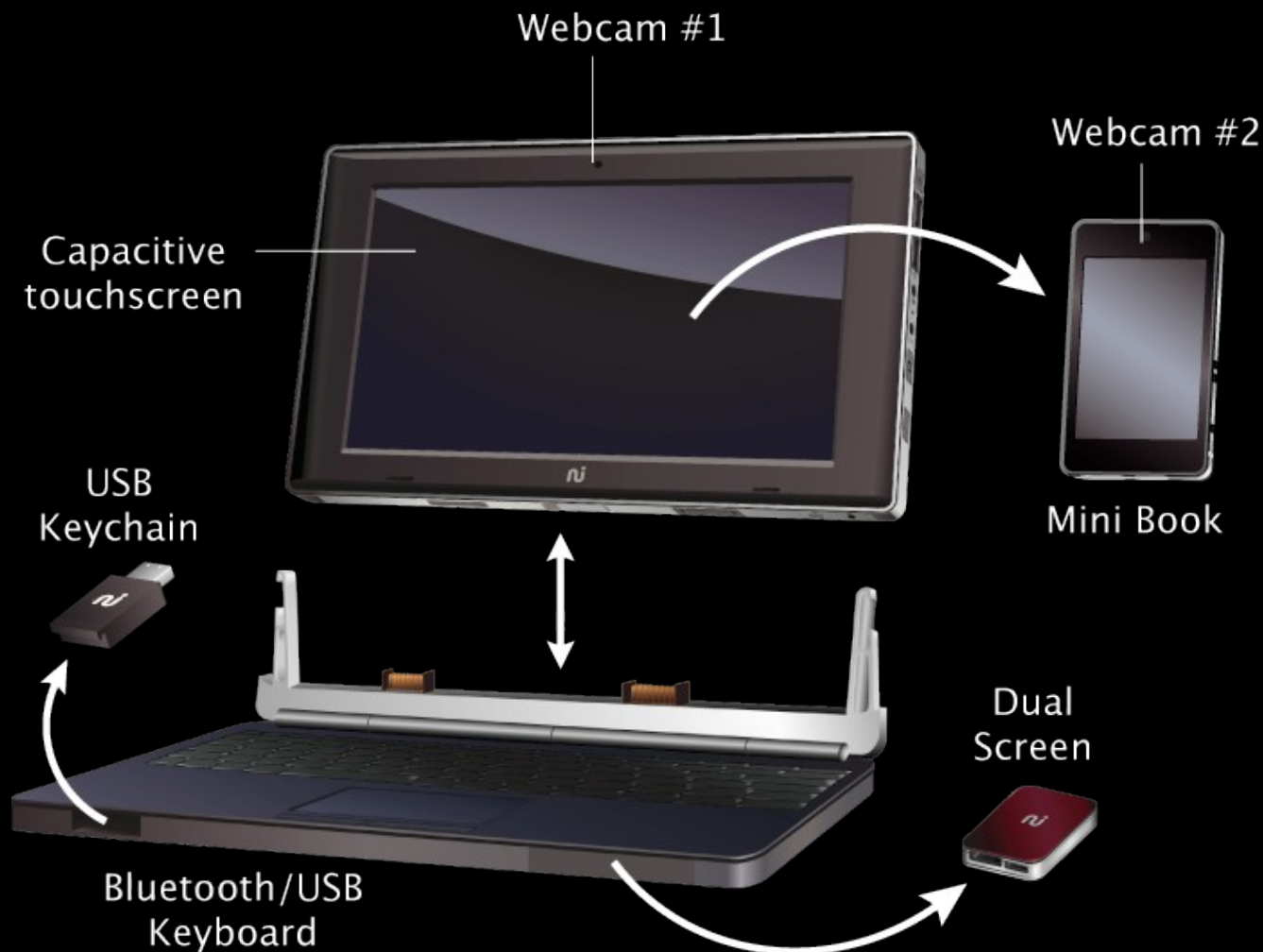
- Very cool demos that you have never seen before!
- Win some USB dongles and USB-to-HDMI adapters (Display Link inside, \$59 value)!!!
- Come in front rows, you will better see the Pandaboard demo on multiple screens

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)

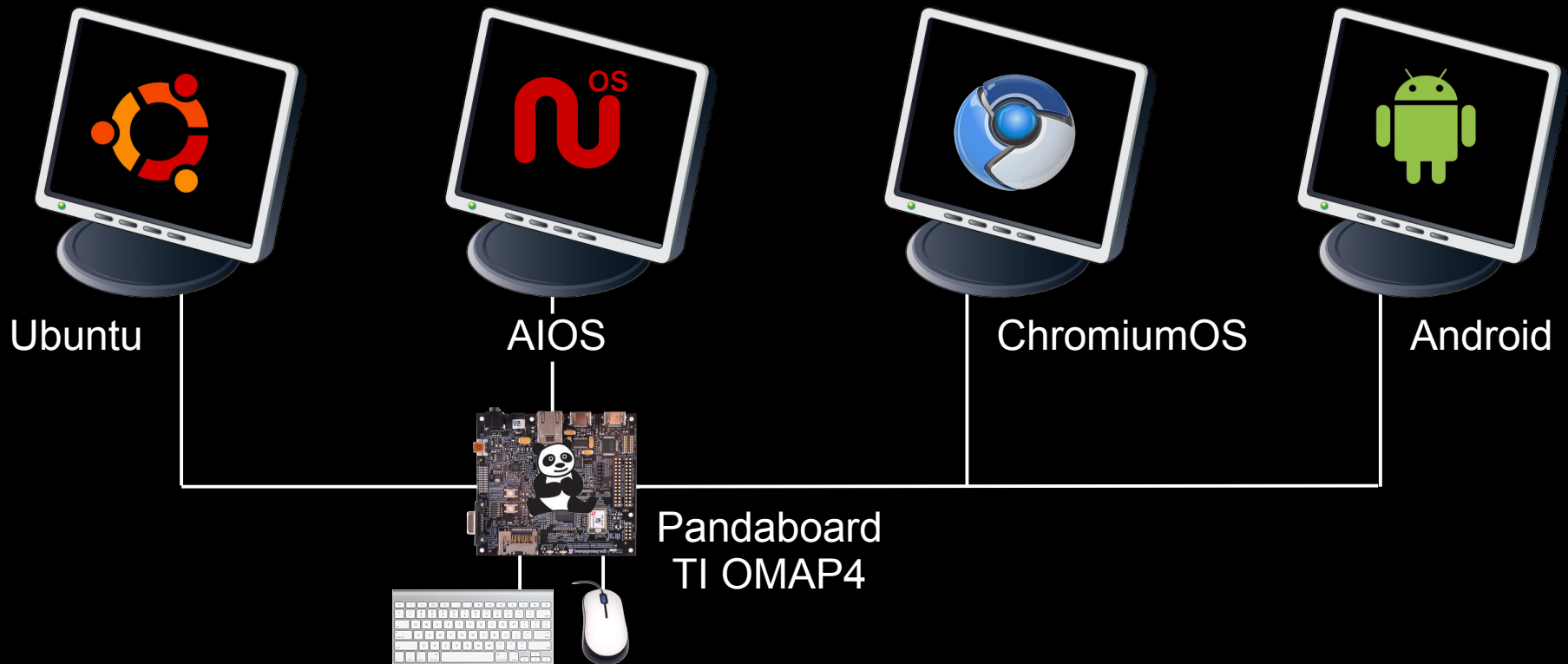
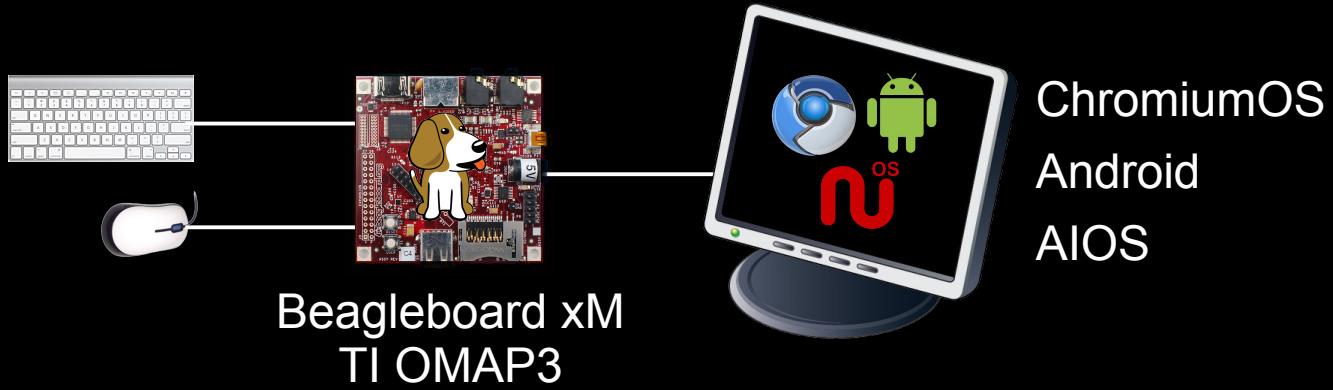
- Open source is so **fragmented**
 - => “Single” (between quote) Linux but with different userspace stacks



How do we do it?

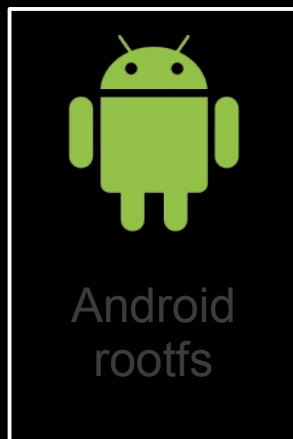
- Obviously: **chroot**
 - Key lesson of this talk: simple theoretically, difficult to implement it right
 - **Kind of Rubik's cube puzzle**
 - When assembling a face, you destroy the others
 - Key issues along the way
 - Making work the core OS
 - Problem of managing output (video)
 - Problem of managing all inputs (HID, network)
- => **End-up patching everything in kernel and OS**

Live Demo



Multiple OS running side-by-side

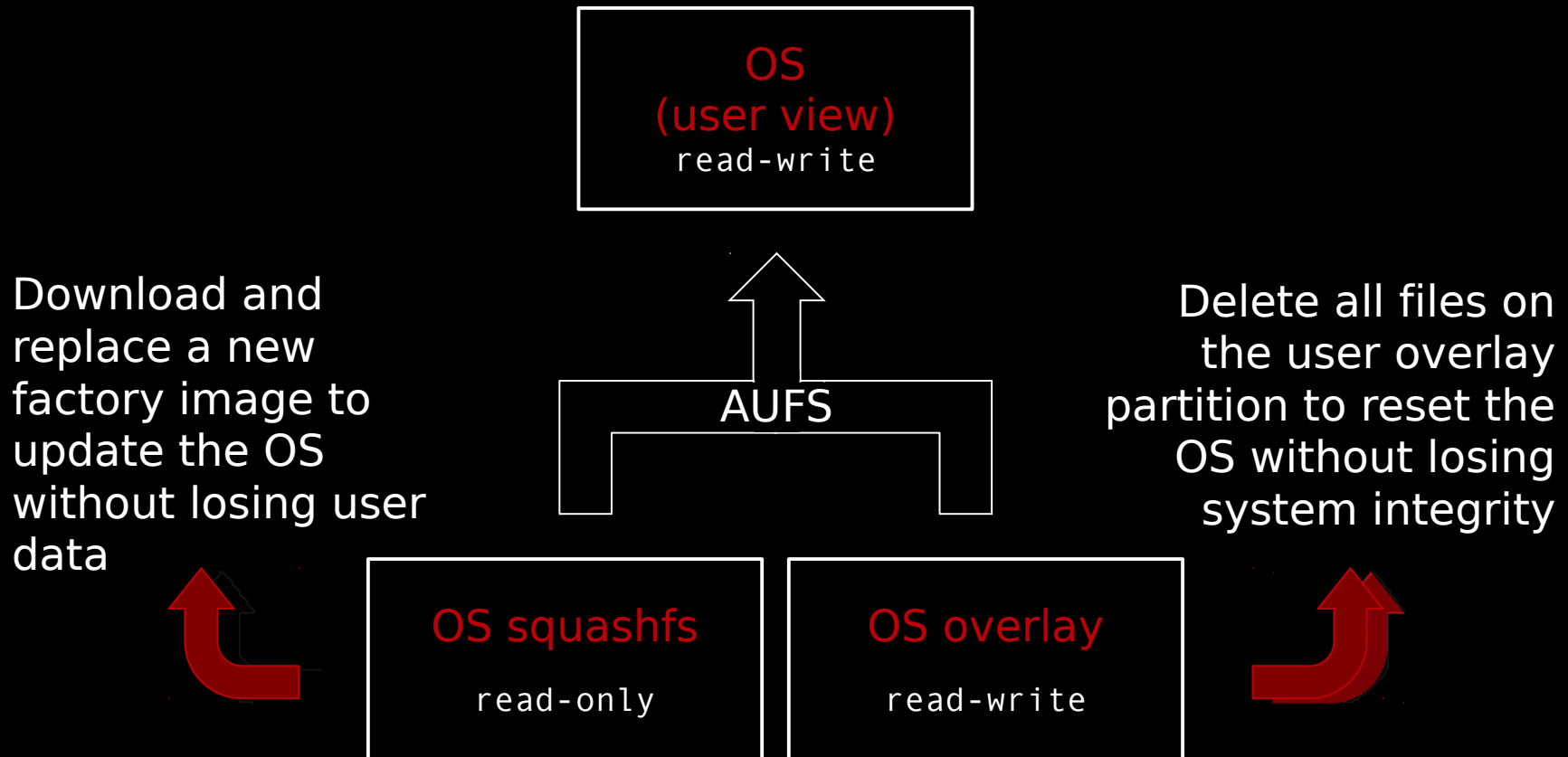
- One kernel, multiple ARM native root file systems
- Hot-switchable at **runtime**
- Much faster than a usual virtual machine architecture



...

Always Innovating
Linux Kernel

How to cleanly run the multiple chroots: squashfs + AUFS



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
 - splashscreen 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

ulmage

/dev/mmcblk0p3 (swap)

/dev/mmcblk0p2

.images/

ai-os.squashfs

android.squashfs

ubuntu.squashfs

chromium.squashfs

.overlay-ai-os/

.overlay-android/

.overlay-ubuntu/

.overlay-chromium/

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

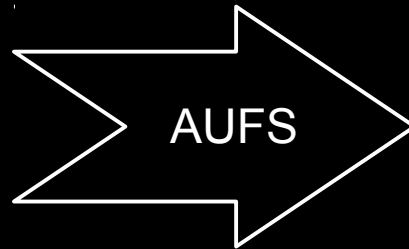
.images/os1.squashfs
read-only

.overlay-os1/
read-write

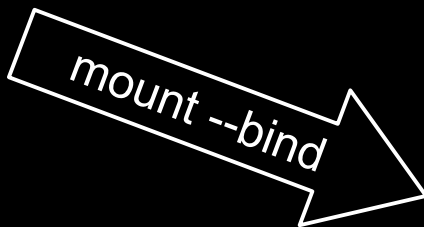
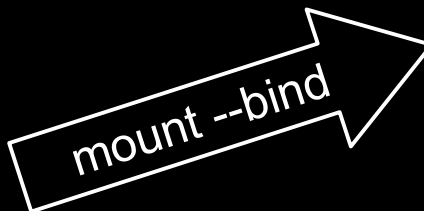
.shared/
read-write

.images/os2.squashfs
read-only

.overlay-os2/
read-write



OS 1 user view
read-write



OS 2 user view
read-write

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

Boot time

	<i>AIOS</i>	<i>Android</i>	<i>Ubuntu</i>	<i>ChromiumOS</i>
standalone	68 sec	55 sec	60 sec	46 sec
as a 2 nd OS	n/a	72 sec	36 sec	41 sec
as a 3 rd OS	n/a	118 sec	62 sec	48 sec
as a 4 th OS	n/a	237 sec	225 sec	211 sec

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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