Building a board farm: Continuous Integration and remote control

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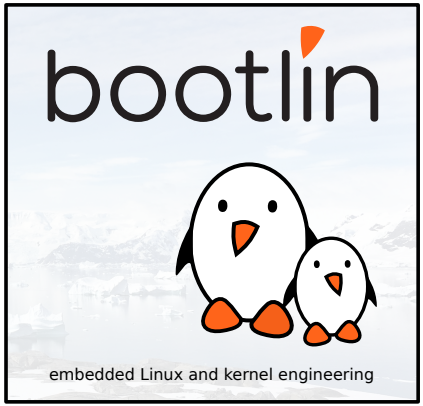

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- Embedded Linux engineer at **Bootlin**
- Former intern for creating a board farm for kernel continuous integration at **Bootlin**
  - Embedded Linux specialists.
  - Development, consulting and training (materials freely available under a Creative Commons license).
  - `http://bootlin.com`
- Living in **Toulouse**, south west of France.

Antoine Ténart

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- Embedded Linux engineer at **Bootlin**.
- Contributions
  - Kernel support for the Marvell Berlin ARM SoCs.
  - Kernel support for the Annapurna Labs ARM64 Alpine v2 platform.
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Introduction

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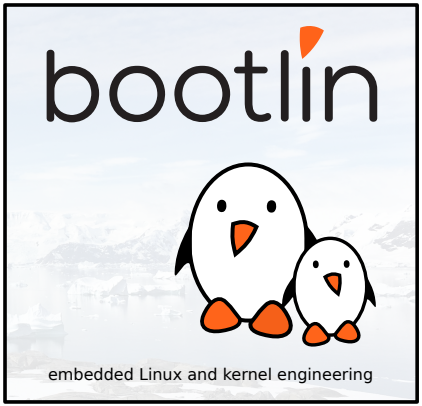

What is continuous integration?

- Continuous Integration (CI) is a software engineering practice in which isolated changes are immediately tested and reported on when they are added to a larger code base. The goal of CI is to provide rapid feedback so that if a defect is introduced into the code base, it can be identified and corrected as soon as possible.
- Three components: continuous builds, test automation and processing of the test results.

Source: TechTarget.com

Why does the kernel need it?

- Lots of different platforms (especially in the ARM world)
- Hard to test all the changes on all platforms
- Very frequent changes made by the community: new Linux release every two months, thousands of changes
- Need to detect regressions early
- Intel 0-day build bot is mainly for x86 platforms

Why do we need it?

- Bootlin contributes to ARM platforms upstream support
- Cooperation with several ARM processor vendors
- Many Bootlin engineers are maintainers of ARM and ARM64 platforms
  - Grégory Clement: Marvell EBU
  - Maxime Ripard: Allwinner
  - Alexandre Belloni: Atmel
  - Antoine Ténart: Annapurna Labs
- Keep track of modifications impacting the platforms we maintain

Components of continuous integration

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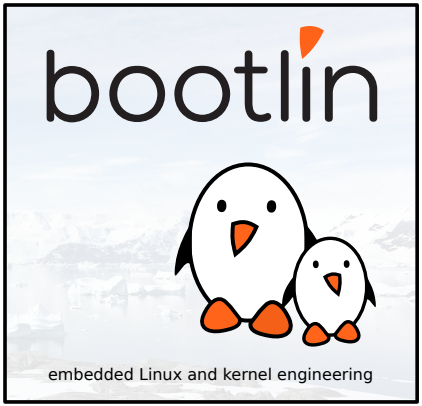
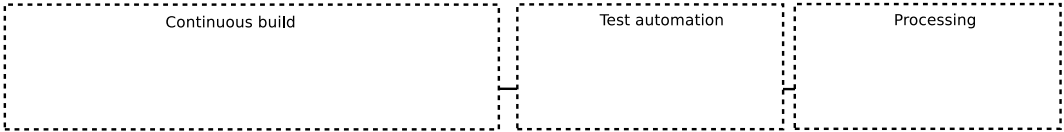


Components of continuous integration



KernelCI

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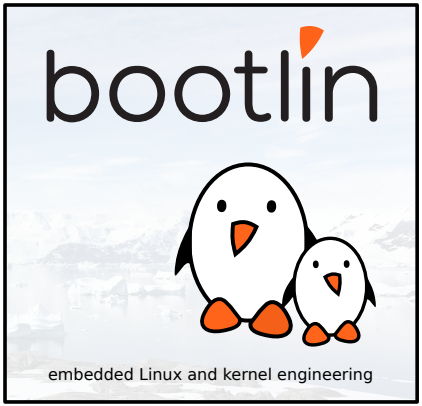
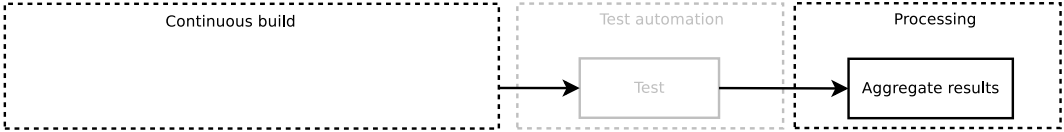
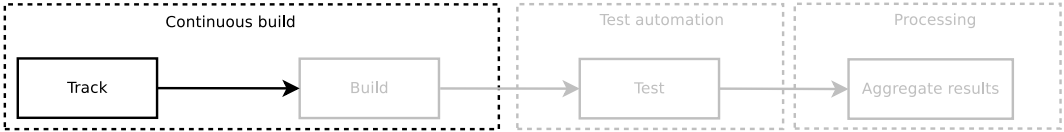


KernelCI - Overview



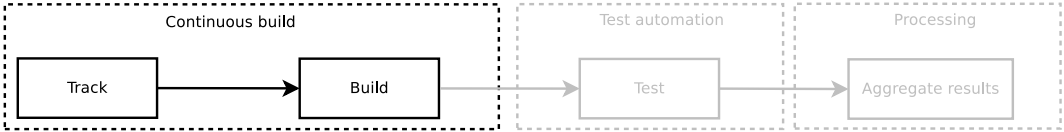
- `https://kernelci.org`
- Detects regressions before reaching users
- 2.000+ boot tests per day on 200+ unique boards

KernelCI - Tracker



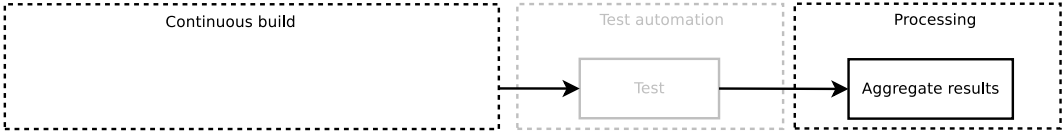
- Tracks ∼20 kernel git repositories for changes
  - torvalds/linux.git
  - arm/arm-soc.git
  - next/linux-next.git
  - davem/net-next.git
  - stable/linux-stable.git
  - ...

KernelCI - Builder



- Builds kernels from tracked repositories
- Automatically builds all defconfigs for ARM, ARM64 and x86 (and their associated device trees, if any)

KernelCI - Connection with test automation



- Works with contributing labs
- Sends boot tests to labs, collects result and notifies maintainers of failures

Test automation - Software

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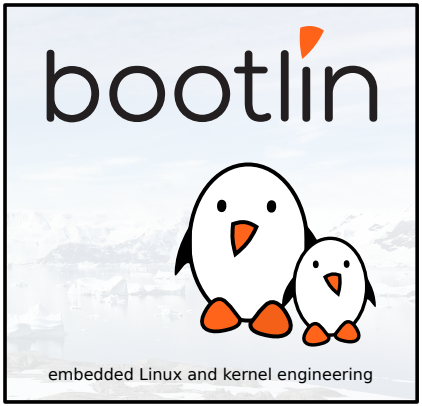
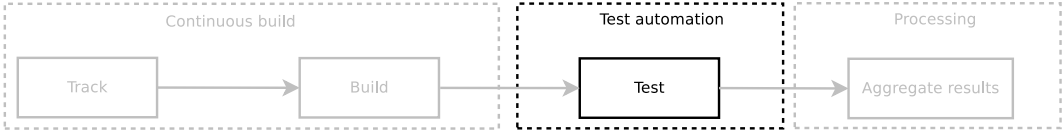


Test automation



- Controls boards
- Launches tests on the boards
- Validates the tests and gathers the results

Test automation - Software

LAVA

Software - LAVA 1/2

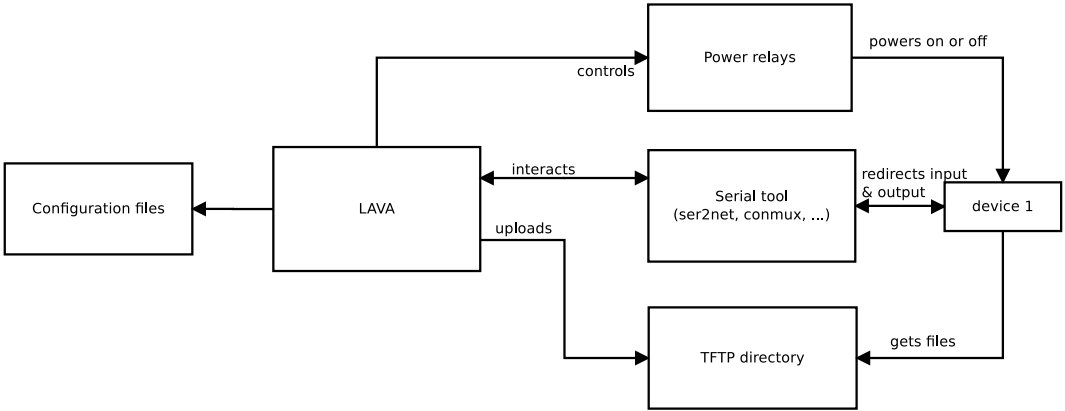
KernelCI labs should use Linaro Automated Validation Architecture (LAVA) which:

- Controls boards
- Automates boot, bootloader, user-space, ... testing
- Runs tests simultaneously on all boards
- Provides API for full automation
- Validates tests
- `https://wiki.linaro.org/LAVA`

Software - LAVA 2/2

- Organized in a master - dispatchers fashion
- Only 1 master working with N dispatchers
- The master controls the farm
  - It handles the API and receives the tests to run
  - It schedules the tests to run
- A given dispatcher handles a set of boards
  - It has the boards' configuration files
  - It is physically connected to the boards and controls them
  - It runs the tests
- We chose to host the master and our only dispatcher on the same machine

LAVA inner working



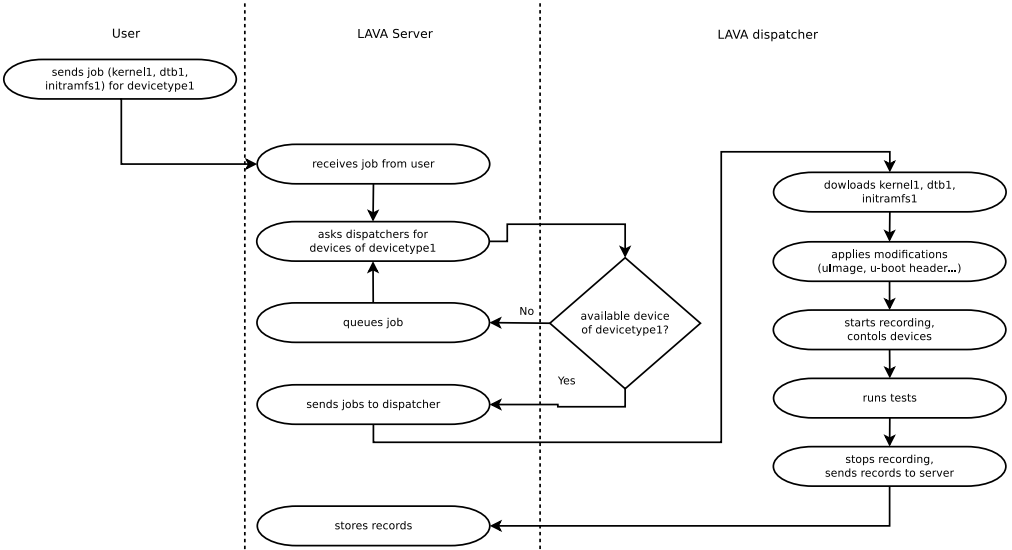
LAVA configuration files - Device

```
$ cat /etc/lava-dispatcher/devices/sun5i-r8-chip_01.conf
device_type = sun5i-r8-chip
hostname = sun5i-r8-chip_01
hard_reset_command = pduclient --daemon localhost --hostname drawer6
 ↪  --command reboot --port 03 --delay 2
power_off_cmd = pduclient --daemon localhost --hostname drawer6
 ↪  --command off --port 03 --delay 2
connection_command = telnet localhost 6063
```

LAVA configuration files - Device type

```
$ cat /etc/lava-dispatcher/device-types/sun5i-r8-chip.conf
client_type = bootloader
send_char = False

z_load_addrs =
    0x42000000
    0x43300000
    0x43000000

boot_cmds_ramdisk =
    setenv autoload no,
    setenv kernel_addr_r "'{KERNEL_ADDR}'",
    setenv initrd_addr_r "'{RAMDISK_ADDR}'",
    setenv fdt_addr_r "'{DTB_ADDR}'",
    setenv ethact "'asx0'",
    setenv loadkernel "'tftp ${kernel_addr_r} {KERNEL}'",
    setenv loadinitrd "'tftp ${initrd_addr_r} {RAMDISK}; setenv initrd_size ${filesize}'",
    setenv loadfdt "'tftp ${fdt_addr_r} {DTB}'",
    setenv bootargs "'console=ttyS0,115200 earlyprintk root=/dev/ram0 ip=dhcp'",
    setenv bootcmd "'usb start; dhcp; setenv serverip {SERVER_IP}; run loadkernel; run loadinitrd; run loadfdt; {BOOTX}'",
    boot

bootloader_prompt = =>

boot_options =
    boot_cmds

[boot_cmds]
default = boot_cmds
```

Test run in LAVA



Test automation - Hardware

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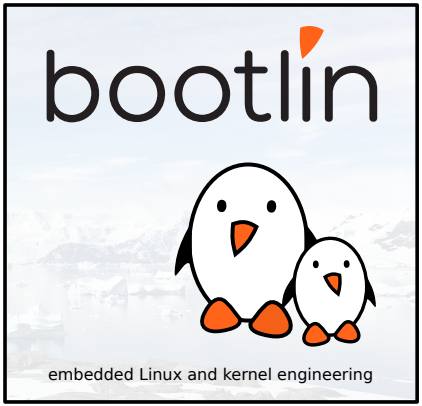


Power supply control

Hardware - Power supply control

We need remotely controlled power supplies:

Figure: Power Distribution Unit

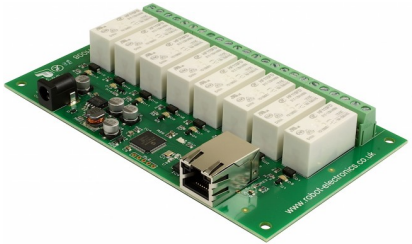
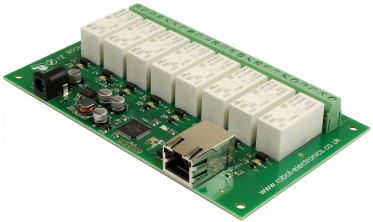


Figure: Remotely controlled relays

Figure: Network controlled multi-sockets

We chose remotely controlled relays because of:

- their cheap price
- the number of ports
- their small footprint
- their documented TCP protocol
- their support for virtually any power supply (you just need a wire)



Power supply

Hardware - Power supply

- Three different types of boards:
  - 5V powered boards
  - 12V powered boards
  - full ATX powered boards
- We separate those in two kinds:
  - non-ATX supplied boards
  - ATX supplied boards

Hardware - Power supply of non-ATX supplied boards

- Different input voltages, two solutions:
  - one power supply per voltage with enough amperage
  - one power supply for all voltages with enough amperage
- We chose ATX power supplies to get all voltages from one power supply

Corsair VS350 ATX Power Supply						
AC Input Rating	DC Output Rating					
AC Input: 200V - 240V	DC Output	+3.3V	+5V	+12V	-12V	+5Vsb
Current: 5A	Max Load	14A	14A	25A	0.3A	2.5A
Frequency: 47Hz - 63Hz	Maximum Combined Wattage	90W		300W	3.6W	12.5W
		Total Power: 350W				

Figure: ATX specifications

Figure: ATX power supply

Figure: TVS diode

Hardware - ATX power supply specifics

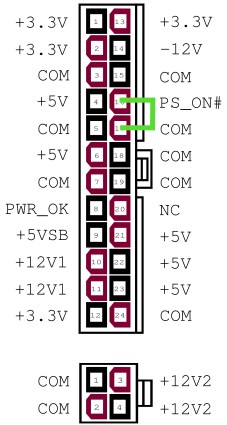


Figure: 24-pins ATX connector

- does not always supply power
- waits for a signal on #PS_ON or for #PS_ON to be put to the ground
- we need it to supply power all the time for non-ATX power supplied boards (the power from ATX power supply to the boards is controlled by per-board relays)
- we need to control when it supplies power to ATX power supplied boards

Interaction with boards

Hardware - Connect to serial

- Mostly USB cable to board
- Lots of USB hubs

Hardware - Get and send files to boards

- TFTP protocol
- need of switches and Ethernet cables

Actual building of the board farm

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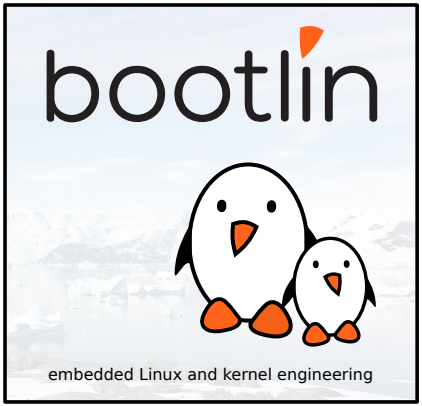
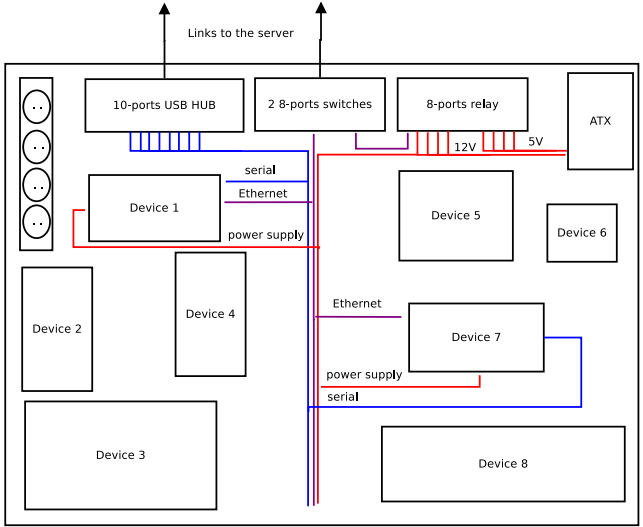


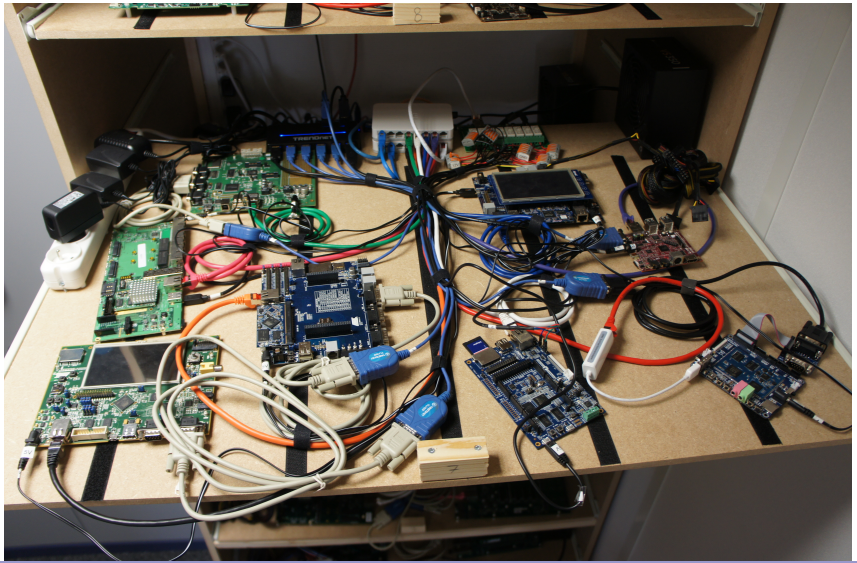
Board farm - Specifications

- Specific location (200*100*75cm)
- Harmless to boards (material choices)
- Easy to use
- Allowing evolution
- As many boards as possible

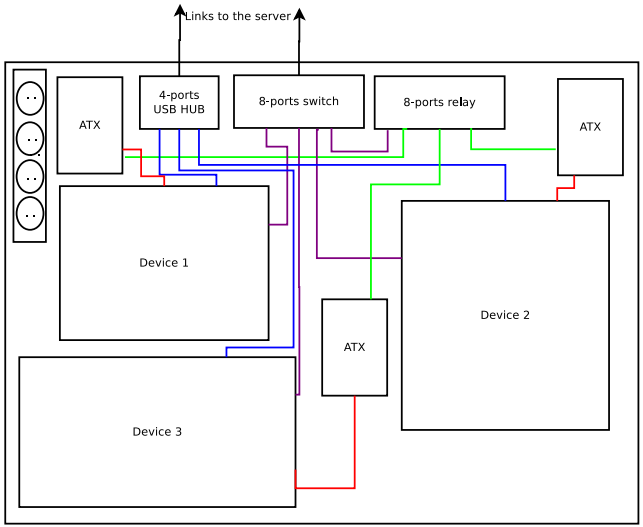
Board farm - Small drawers



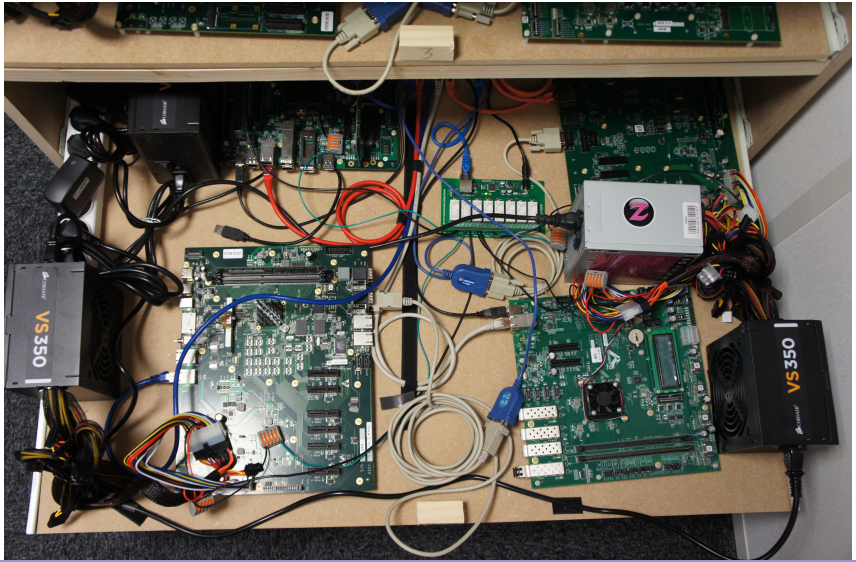
Board farm - Small drawers - IRL



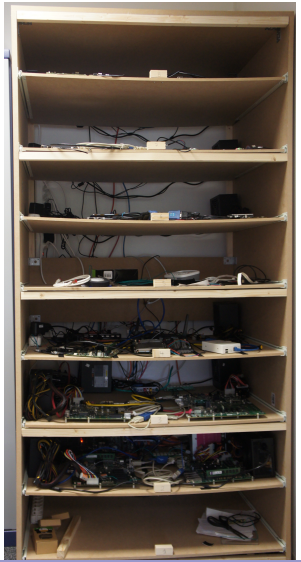
Board farm - Big drawers



Board farm - Big drawers - IRL



Board farm



Board farm - Feedback

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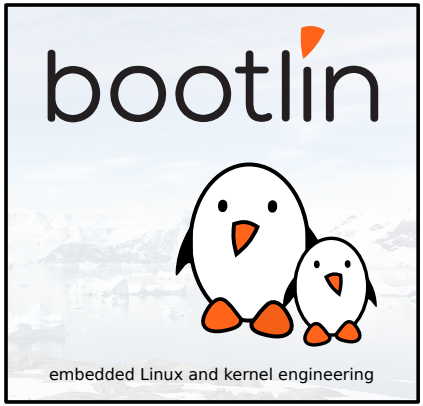

Board farm - Some numbers

- Launched on April 25th 2016
- Currently 35 boards (estimated capacity of 50)
- 160k+ tests run
- 30+ unique devices support added to KernelCI

Board farm - Some challenges

- Many devices connected to the LAVA server which may have limitations. We had to recompile the kernel on this machine!
- All boards are different: specific U-Boot configuration, h/w modifications needed to automate the boot, very old bootloaders (U-Boot 1.1.1 from 2004)...
- Expect everything to fail: buggy serial connections, s/w services or machine configuration...
- LAVA assumptions may not match the hardware capabilities

Board farm - Documentation

- LAVA: `https://validation.linaro.org/static/docs/index.html`
- KernelCI: `http://wiki.kernelci.org/`
- Configure LAVA to receive tests from KernelCI: `https://github.com/kernelci/lava-ci#configure-lava`
- Adding a board to KernelCI: `https://github.com/kernelci/lava-ci#add-board-to-kernelci`
- Our articles on the matter: `http://bootlin.com/blog/tag/lab/`

Remote control

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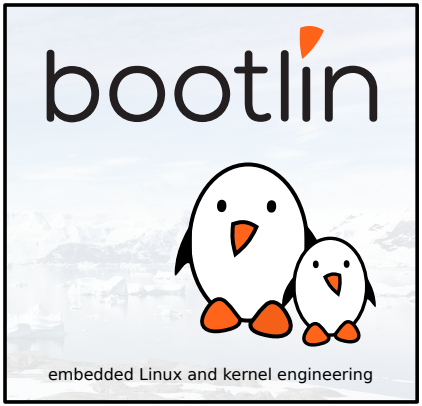

Why?

- Our farm knows how to handle boards, has a lot of them. . . but:
  - There is no direct access to the boards
  - Only tests sent to LAVA can perform actions on the boards
- Some boards owned only once
- Working remotely

LAVA Board Overseer

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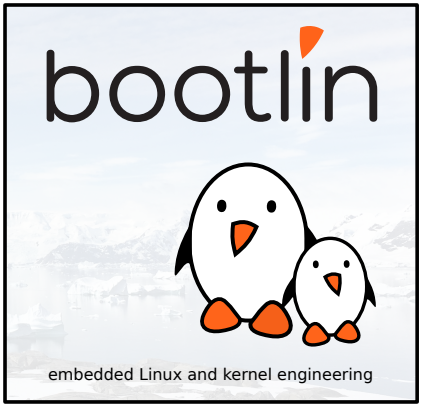
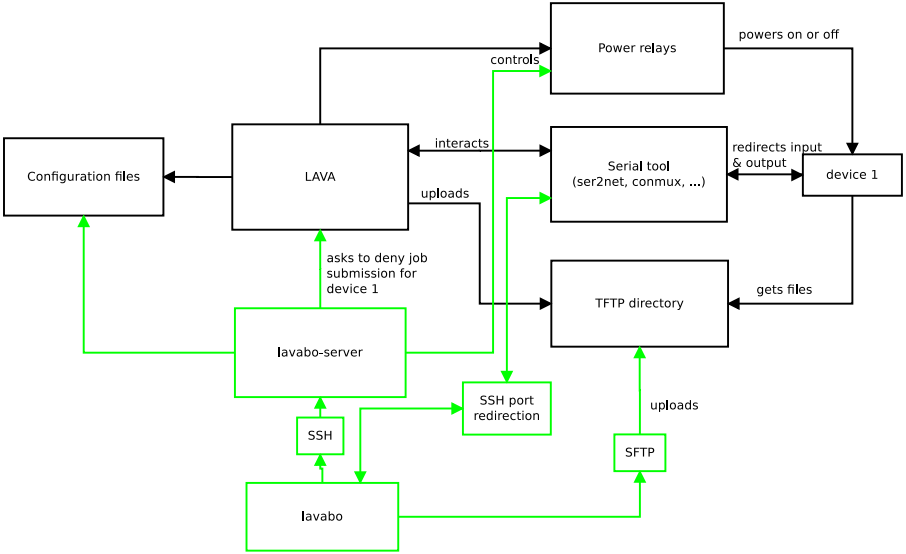


Lavabo

- Reuses the same tools LAVA uses
- Takes full control
- Authenticates users
- Interacts with LAVA

Lavabo reuses LAVA tools



Lavabo's architecture

- client-server model
- server must be on the same machine as where LAVA server is hosted
- no support for multi-node LAVA
- one dedicated SSH user on the server
- one SSH key per lavabo real user
- LAVA's `connection_command` for all devices must be telnet
- no support for rootfs on NFS

Typical workflow

```
$ lavabo list
status      job  offline_since             hostname                              offline_by
--------  -----  ------------------------  ------------------------------------  ------------
idle                                       alpine-db_01
offline          Tue Oct  4 14:23:51 2016  alpine-v2-evp_01                      antoine
idle                                       armada-370-db_01
offline          Wed Jul 13 09:13:37 2016  armada-370-rd_01                      quentin
offline          Wed Sep 21 15:46:56 2016  armada-3720-db_01                     omar
[...]
idle                                       sun5i-r8-chip_01
idle                                       sun8i-a33-sinlinx-sina33_01
idle                                       sun8i-a83t-allwinner-h8homlet-v2_01

$ lavabo reserve sun5i-r8-chip_01
$ lavabo upload mykernel sun5i-r8-chip.dtb myrootfs
File(s) successfully sent to lavabo-server.
$ lavabo reset sun5i-r8-chip_01
```

Typical workflow

```
$ lavabo serial sun5i-r8-chip_01
Try 1 to connect to serial failed. 4 attempts remaining.
You have now access to the serial of sun5i-r8-chip_01.
Escape character is '^]'.
U-Boot SPL 2016.01-g67a66a1-dirty (Mar 09 2016 - 12:04:29)
DRAM: 512 MiB
CPU: 1008000000Hz, AXI/AHB/APB: 3/2/2
Trying to boot from NAND

U-Boot 2016.01-g67a66a1-dirty (Mar 09 2016 - 12:04:29 +0100) Allwinner Technology
CPU:   Allwinner A13 (SUN5I)
I2C:   ready
DRAM:  512 MiB
NAND:  8192 MiB
video-mode 720x480-24@60 not available, falling back to 1024x768-24@60
Setting up a 720x480i composite-ntsc console (overscan 40x20)
[...]
Hit any key to stop autoboot:  0
=>
$ lavabo power-off sun5i-r8-chip_01
$ lavabo release sun5i-r8-chip_01
```

Lavabo - Conclusion

- Some limitations
- GNU GPLv2 licensed
- `https://github.com/bootlin/lavabo`
- Let's play!

Thanks! Questions?

http://bootlin.com/pub/conferences/2016/elce/schulz-tenart-building-boards-farm/