

Ghosting the hardware

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Who am I?

- Rémi Duraffort
- Principal Tech Lead at Linaro

- OSS developer since 2007
 - VLC media player
 - v8 js engine
 - PRoot/CARE
 - LAVA, lavacli, meta-lava, DummySys, lavafed, ...
 - TuxRun, Tuxsuite, ...
 - Kisscache



LAVA

Linaro Automated Validation Architecture

LAVA

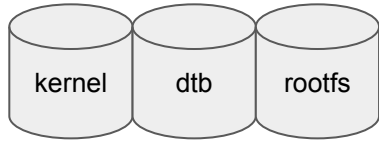
- **Linaro Automated Validation Architecture**
- Test execution system: testing software on real hardware
 - **Deploy, Boot and Test**
- Usages
 - Boot testing: kernelci
 - System level testing: LKFT
 - Bootloader/firmware testing
- Supports 364 device-types



LAVA

linaro.org/lava

Without LAVA



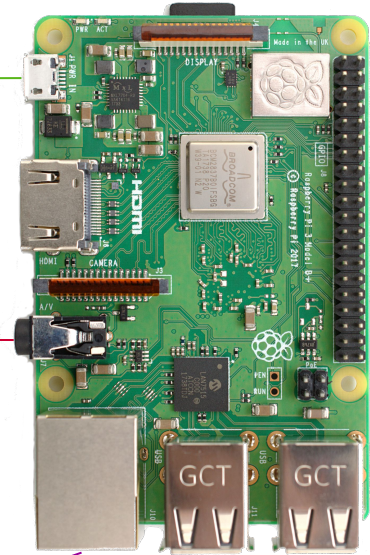
```
zsh % _
```

```
% power on board  
% telnet localhost 2000  
<enter>  
=> dhcp  
=> setenv serverip 10.3.1.1  
=> [...]   
=> bootm 0x01000000 - 0x03f00000  
[...]  
raspberrypi3 login: root  
# run-test.sh  
[...]  
% power off board
```

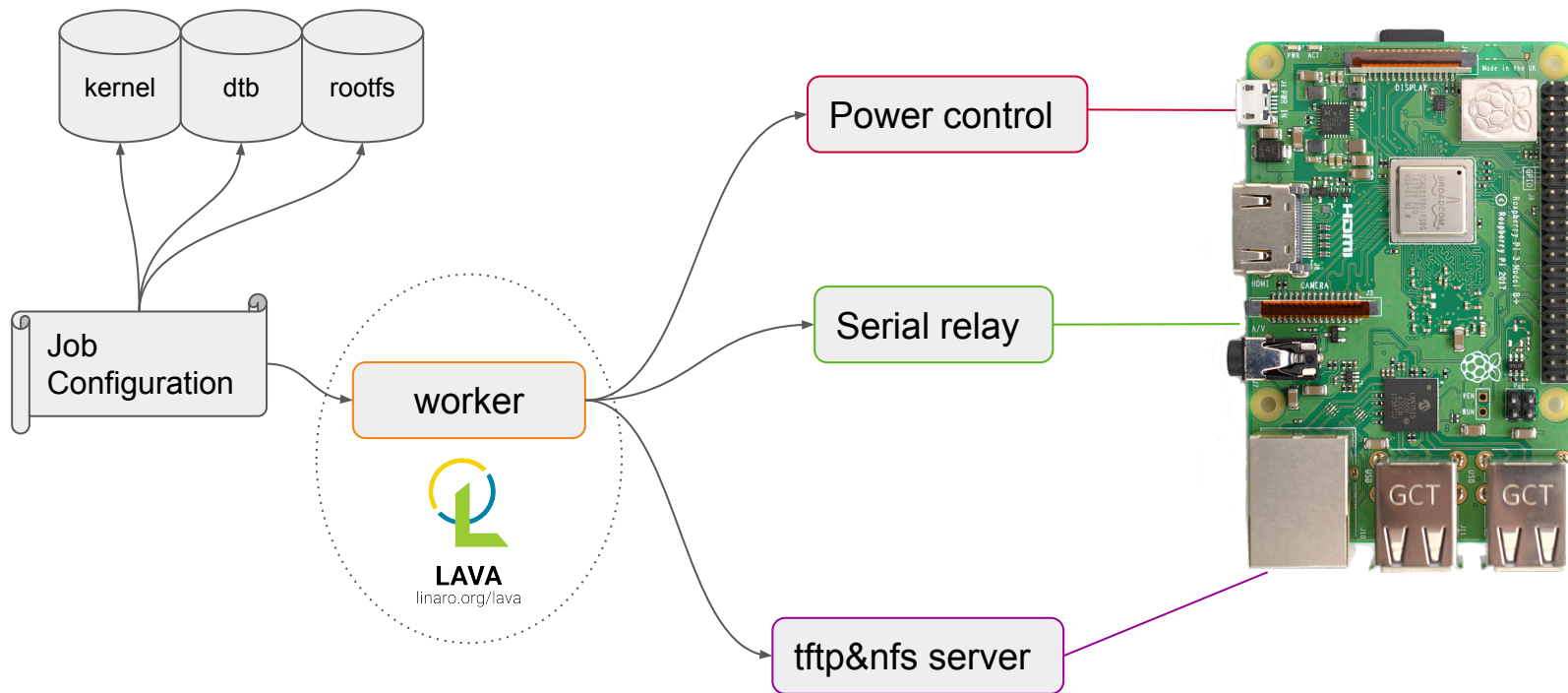
Serial relay

Power control

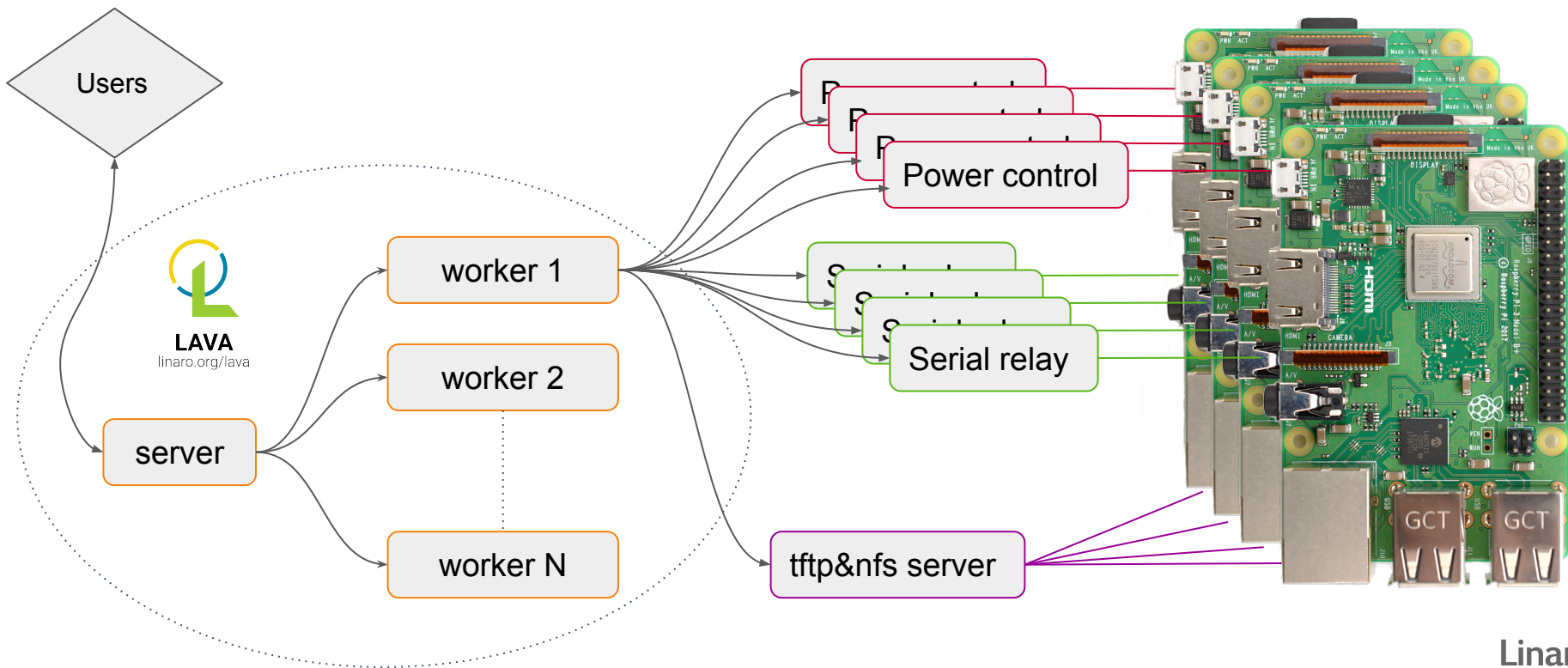
tftp&nfs server



With LAVA



With LAVA



Roles

Server

- Web UI and APIs
- Visible to user
- Not connected to DUTs

- Storing logs/jobs/results/...
- Scheduling jobs
- Sending notifications
- ...

Workers

- Control the DUTs
- Not accessed by LAVA users

- Deploy resources
- Power on/off
- Interact with serial
- ...

Supported device-types: 364

aaeon-UPN-EHLX4RE-A10-0864 acer-cb317-1h-c3z6-dedede acer-cbv514-1h-34uz-brya acer-chromebox-cxi4-puff acer-chromebox-cxi5-brask acer-cp514-2h-1130g7-volteer acer-cp514-2h-1160g7-volteer acer-cp514-3wh-r0qs-guybrasher acer-n20q11-r856ltn-p1s2-nissa acer-R721T-grunt adb-nuc alpine-db am335x-sandloud-bbe am437x-idx-vm am57xx-beagle-x15 am6 apq8016-sbc-uboot ar9331-dpt-module arduino101 arduino-nano-33-ble armada-370-db armada-370-rd armada-3720-db armada-3720-espressobin armada-375-db armada-385-db ap armada-388-clearfog-pro armada-388-gp armada-398-db armada-7040-db armada-8040-db armada-xp-db armada-xp-gp armada-xp-linksys-mamba armada-xp-openblocks-ax3-4 arndale asus-C433TA-AJ0005-rammus asus-C436FA-Flip-hatch asus-C523NA-AV2005T-coral asus-CK1400CXA-dalboz asus-cx9400-volteer at91rm9200ek at91sam9261ek at91sam9g20ek at91sam9m10g45ek at91sam9x25ek at91sam9x35ek at91-sama5d2_xplained at91-sama5d4_xplained ava avenger96 avh b2120h410 b2260 bcm2711-rpi-4-b bcm2835-rpi-b-rev2 bcm2836-rpi-2-b bcm2837-rpi-3-b-32 bcm2837-rpi-3-b beaglebone-black-barebox beaglebone-black beagle-xm b-u585i-iot02a cc13x2-launchpad cc3220SF cubietruck cy8ckit-064s0s2-4343w d02 d03 d2500cc da850-lcdk de0-nano-soc dell-latitude-3445-7520c-skyrim dell-latitude-5300-8145U-arcada dell-latitude-5400-4305U-sarien dell-latitude-5400-8665U-sarien disco-l475-iot1 docker dove-cubox dra7-evm dragonboard-410c dragonboard-820c dragonboard-845c e850-96 frdm-k64f frdm-kw41z fsl-ls1012a-rdb fsl-ls1028a-rdb fsl-ls1043a-rdb fsl-ls1046a-frwy fsl-ls1046a-rdb fsl-ls1088a-rdb fsl-ls2088a-rdb fsl-lx2160a-rdb fsl-lx2162a-qds fsl-s32v234sbc fvp hi6220-hikey-bl hi6220-hikey hi6220-hikey-r2 hi960-hikey hifive-unleashed-a00 hifive-unmatched-a00 highbank hip07-d05 hp-11A-G6-EE-grunt hp-14b-na0052xx-zork hp-14-db0003na-grunt hp-x360-12b-ca0010nr-n4020-octopus hp-x360-12b-ca0500na-n4000-octopus hp-x360-14a-cb0001xx-zork hp-x360-14-G1-sona hsdk i945gsex-q5 ifc6410 imx23-olinuxino imx27-phytec-phycard-s-rdk imx28-duckbill imx53-qsr imx6dl-riotboard imx6dl-sabreauto imx6dl-sabresd imx6dl-udoo imx6q-nitrogen6x imx6q-sabreauto imx6q-sabresd imx6q-wandboard-revd1 imx6q-sabreauto imx6q-sabrelet imx6q-sabresd imx6q-udoo imx6q-var-dt6customboard imx6sl-evk imx6sll-evk imx6sx-sdb imx6ul-14x14-evk imx6ull-14x14-evk imx6ull-evk imx6ul-pico-hobbit imx6ulz-14x14-evk imx6ulz-lite-evk imx7-d-sdb imx7s-warp imx7ulp-evk imx8dcl-ddr3l-evk imx8dcl-evk imx8dcl-phantom-mek imx8dx-mek imx8mm-ddr4-evk imx8mm-evk imx8mm-innocent-vb15-evk imx8mn-ddr3l-evk imx8mn-ddr4-evk imx8mn-evk imx8mp-ab2 imx8mp-ddr4-evk imx8mp-evk imx8mp-verdin-nonwifi-dahlia imx8mq-evk imx8mq-wevk imx8mq-zii-ultra-zest imx8qm-mek imx8qxp-mek imx8ulp-9x9-evk imx8ulp-evk imx91p-11x11-evk imx91p-9x9-qsb imx93-11x11-evk imx93-11x11-evk pmic-pf0900 imx93-9x9-qsb imx95-19x19-evk intel-ixp42x-welltech-epbx100 jetson-tk1 jh7100-beaglev-starlight jh7100-starfive-visionfive-v1 jh7100-visionfive juno juno-uboot juno-uefi k3-am625-sk kirkwood-db-88f6282 kirkwood-openblocks_a7 kontron-bl-imx8mm kontron-kbox-a-230-ls kontron-kswitch-d10-mmt-6g-2gs kontron-kswitch-d10-mmt-8g kontron-pitx-imx8m kontron-sl28-var3-ads2 kv260 kvm lava-slave-docker lenovo-hr330a-7x33cto1ww-emag lenovo-TPad-C13-Yoga-zork lpcxpresso55s69 ls1021a-twr lxc mediatek-8173 meson8b-ec100 meson8b-odroidc1 meson-axg-s400 meson-g12a-sei510 meson-g12a-u200 meson-g12a-x96-max meson-g12b-a311d-khadas-vim3 meson-g12b-a311d-libretech-cc meson-g12b-odroid-n2 meson-gxbb-nanopi-k2 meson-gxbb-p200 meson-gxl-s805x-libretech-ac meson-gxl-s805x-p241 meson-gxl-s905d-p230 meson-gxl-s905x-khadas-vim meson-gxl-s905x-libretech-cc meson-gxl-s905x-p212 meson-gxm-khadas-vim2 meson-gxm-q200 meson-sm1-khadas-vim3l meson-sm1-odroid-c4 meson-sm1-s905d3-libretech-cc meson-sm1-sei610 mimxrt1050_evk minnowboard-max-E3825 minnowboard-turbot-E3826 moonshot-m400 morello mps mt8173-elm-hana mt8183-kukui-jacuzzi-juniper-sku16 mt8186-corsola-steelix-sku131072 mt8192-asurada-rev1 mt8192-asurada-spherion-r0 mt8195-cherry-tomato-r2 musca-a musca-b musca musca-s mustang-grub-efi mustang-uefi n1sdp nexus10 nexus4 nexus5x nexus9 nrf52-nitrogen nucleo-l476rg nxp-ls2088 odroid-n2 odroid-x2 odroid-xu3 orion5x-rd88f5182-nas override ox820-clouddines-pogoplug-series-3 panda pc-k10n78 peach-pi pixel poplar qcom-qdf2400 qcs404-evb-1k qcs404-evb-4k qemu-aarch64 qemu qrb5165-rb5 r8a7742-iwg21d-q7 r8a7743-iwg20d-q7 r8a7744-iwg20d-q7 r8a7745-iwg22d-sodium r8a77470-iwg23s-sbc r8a774a1-hihopec-rzg2m-ex r8a774b1-hihopec-rzg2m-ex r8a774c0-ek874 r8a774e1-hihopec-rzg2h-ex r8a7791-porter r8a77950-ulcb r8a7795-h3ulcb-kf r8a7795-salvator-x r8a7796-m3ulcb r8a7796-m3ulcb-kf r8a779m1-ulcb rk3288-miqi rk3288-rock2-square rk3288-veyron-fq rk3328-rock64 rk3399-gru-kevin rk3399-khadas-edge-v rk3399-puma-haikou rk3399-rock-pi-4b rk3399-roc-pc rk3588-rock-5b rzn1d s32v234-evb sama5d3 sama5d34ek sama5d36ek sc7180-trogdor-kingoftown sc7180-trogdor-lazor-limozeen sdm845-mtp seco-b68 seco-c61 sharkl2 sm8150-mtp sm8250-mtp sm8350-hdk sm8350-mtp snow soca9 socfgpa-cyclone5-socrates ssh stm32-carbon stm32l562e-dk stm32mp157a-dhcor-avenger96 stm32mp157c-dk2 stm32mp157c-lxa-mc1 stm32mp15x-eval sun4i-a10-olinuxino-lime sun50i-a64-bananapi-m64 sun50i-a64-pine64-plus sun50i-h5-libretech-all-h3-cc sun50i-h5-nanopi-neo-plus2 sun50i-h6-orangepi-3 sun50i-h6-orangepi-one-plus sun50i-h6-pine-h64 sun50i-h6-pine-h64-model-b sun5i-a13-olinuxino-micro sun5i-gr8-chip-pro sun5i-r8-chip sun6i-a31-app4-evb1 sun7i-a20-cubieboard2 sun7i-a20-olinuxino-lime2 sun7i-a20-olinuxino-micro sun8i-a23-evb sun8i-a33-olinuxino sun8i-a33-sinlinx-sina33 sun8i-a83t-allwinner-h8homlet-v2 sun8i-a83t-bananapi-m3 sun8i-h2-plus-bananapi-m2-zero sun8i-h2-plus-libretech-all-h3-cc sun8i-h2-plus-orangepi-r1 sun8i-h2-plus-orangepi-zero sun8i-h3-bananapi-m2-plus sun8i-h3-libretech-all-h3-cc sun8i-h3-orangepi-cc sun8i-r40-bananapi-m2-ultra sun9i-a80-cubieboard4 synquacer-acpi synquacer-dttb synquacer synquacer-uboot tc2 tegra124-nyan-big thunderx2 thunderx upsquare vexpress x15-bl x15 x86-atom330 x86-celeron x86 x86-pentium4 x86-x5-z8350 xilinx-zcu102

Supported methods

deploy:

- tftp
- nbd
- flasher
- fastboot
- mps
- docker
- vexpress ums
- ...

boot

- cmsis
- dfu
- uboot
- pyocd
- fastboot
- docker
- qemu
- grub
- iso installer
- ...

test

- git repository
- interactive
- minimal
- multinode
- docker shell

Why testing LAVA?

CI in the CI

Why testing LAVA

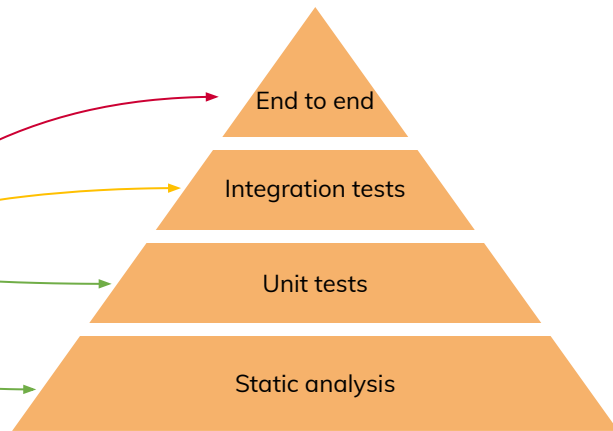
- Should be obvious
 - It's a (complex) software => It has bugs
- CI should be reliable
 - CI software should be rock solid
 - Bugs in CI
 - False positive
 - Loose developer trust
 - Developers ignore the CI
 - False negative
 - Not reporting errors
 - Shipping buggy (but tested) software

Testing LAVA?

CI in the CI

Testing strategy

- While developing
 - Manual testing
 - `./ci-run`
- Each merge request
 - Gitlab CI
- Once a day
 - meta-lava
 - federated testing
 - staging.v.l.o



A combinatorial issue

	364 boards
×	16 deploy
×	26 boot
×	5 test
<hr/>	
	757 120 combinations*

* Most case are useless but that's still huge

Considering a donation?

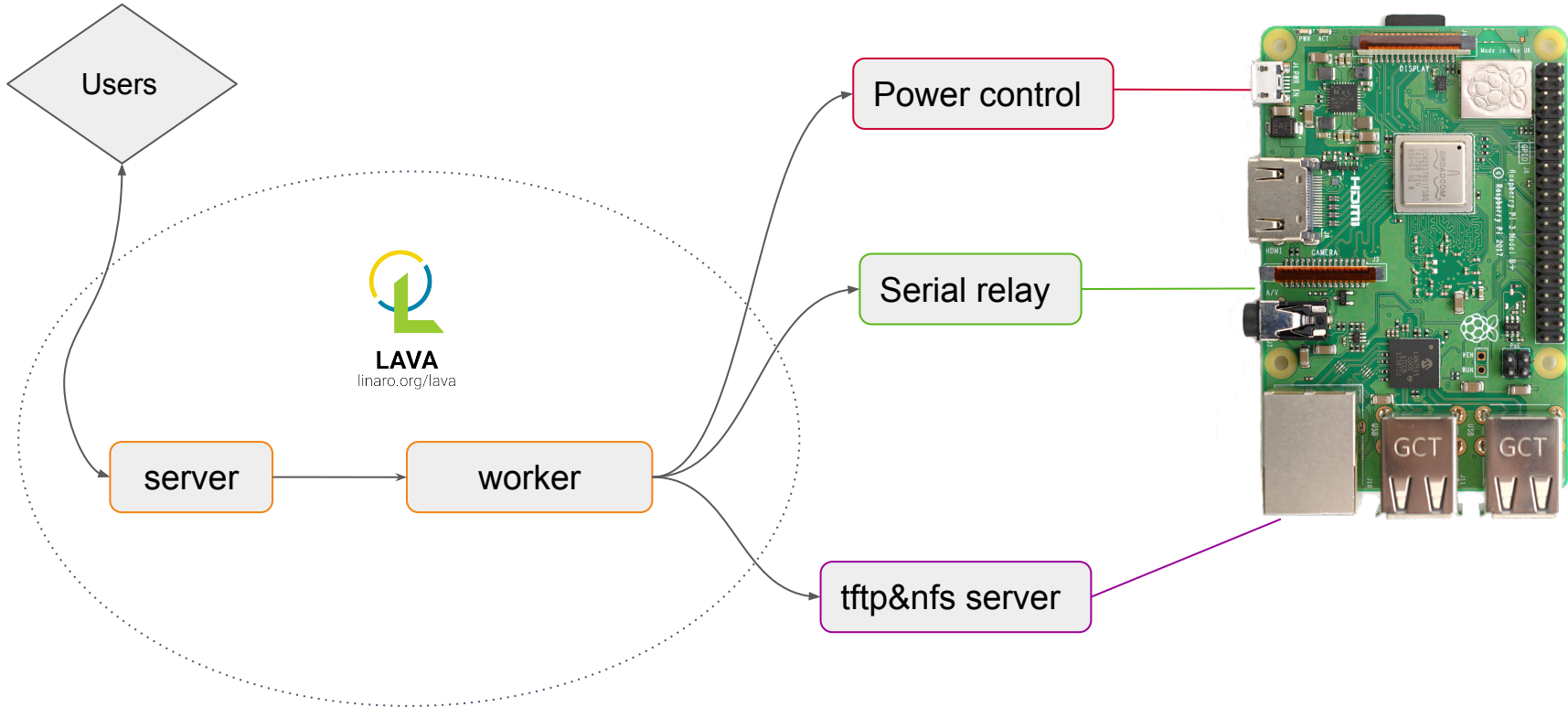
Considering faking DUTs?

Testing LAVA: meta-lava

- Goal
 - Testing the full system: from the user, back to the user
 - Including board interaction
 - Without any board
 - Fast & cheap

- Solutions
 - Board emulation
 - CPU intensive
 - Expensive and slow
 - Ghosting the boards!

LAVA architecture (again)



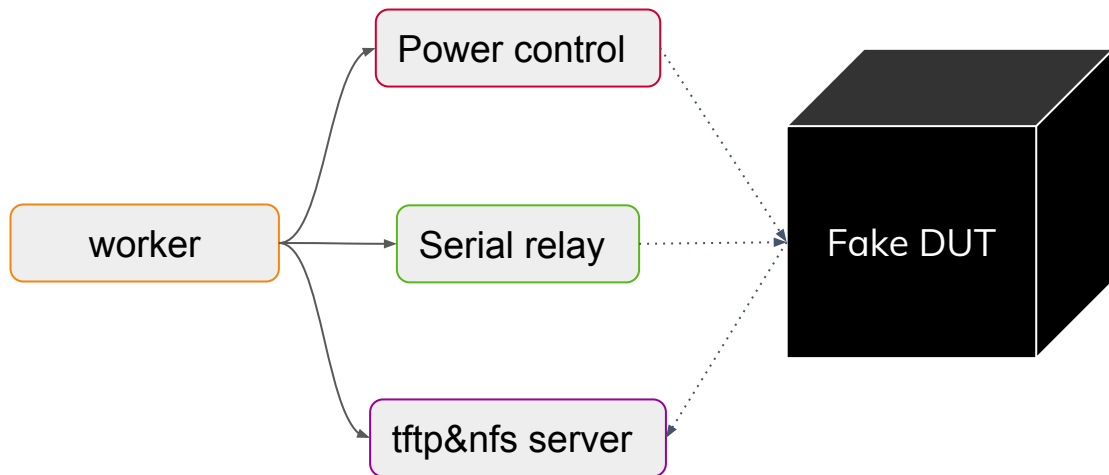
Ghosting the hardware

- A **fake DUT** should
 - Feel like a DUT
 - Look like a DUT
 - Smell like a DUT
 - Sounds like a DUT
 - Taste like a DUT

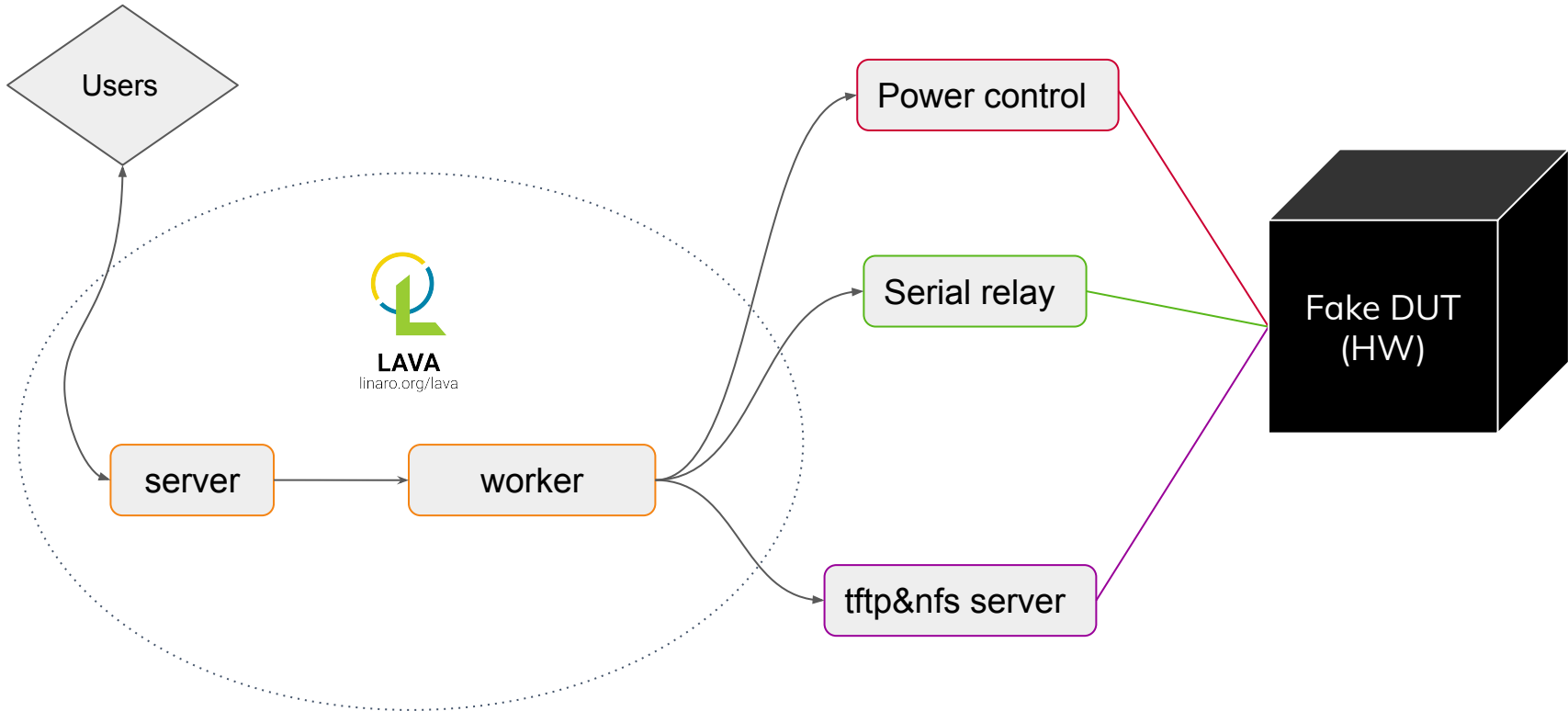
- But that's not enough:
 - From the **fake DUT point-of-view**, **LAVA** should:
 - Feel like LAVA
 - Look like LAVA
 - Smell like LAVA
 - Sounds like LAVA
 - Taste like LAVA

What are the inputs and outputs?

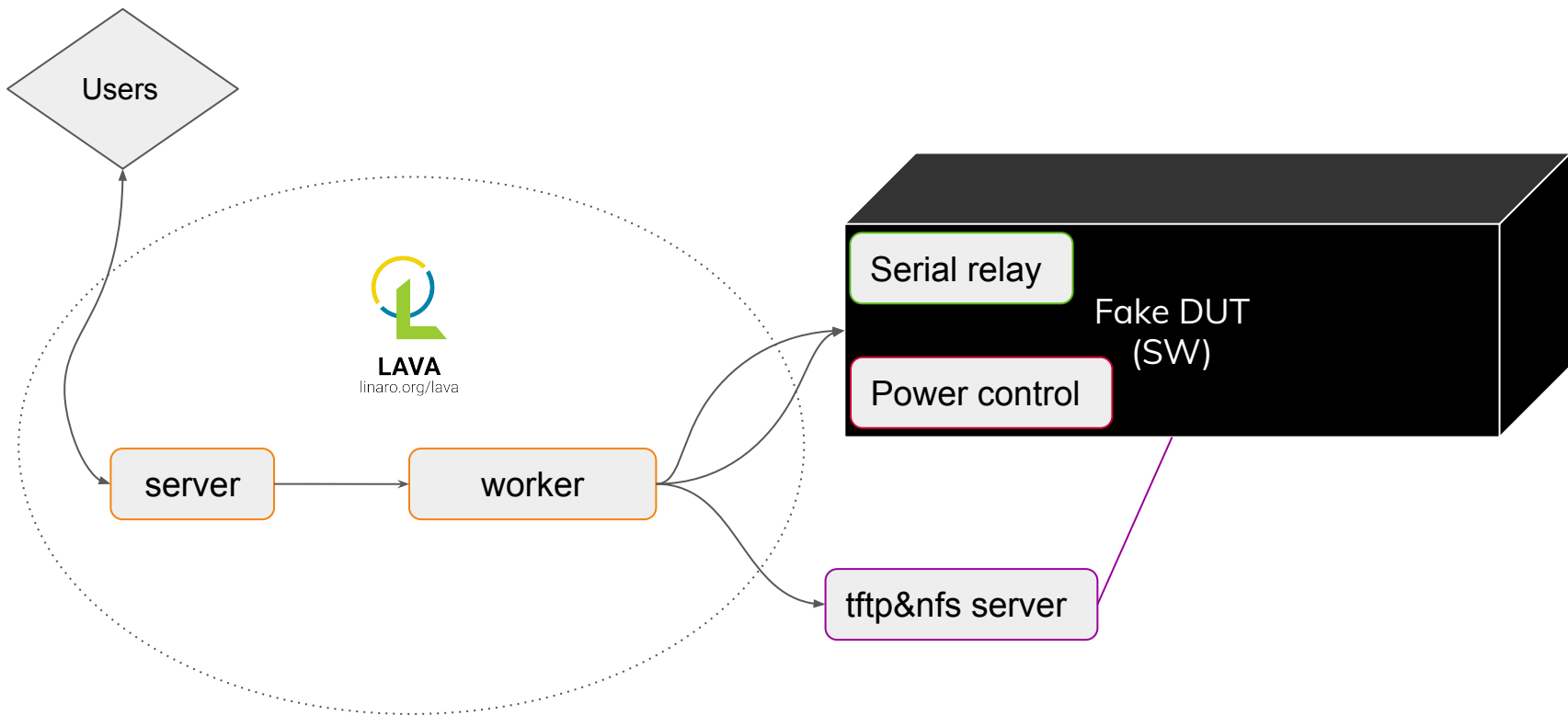
- Power control
 - LAVA: just a command to run
 - DUT: check this was called
- Serial relay
 - LAVA execute a command and read/write to/from stdin/stdout
- tftp/nfs server
 - The DUT should connect to tftp and NFS and check the content.



Where to mock?



Where to mock?



Ghosting the hardware

- Software implementation
- [DummySYS](#)
 - Output
 - Like a real board
 - Input
 - Expect the exact sequence
 - Fail if the sequence changed
 - Use tftp&NFS resources
 - Download kernel/dtb/ramdisk
 - Mount NFS rootfs
 - Checksum some files

Demo

meta-lava

- meta-lava
 - Server docker container
 - Worker docker container
 - With DummySYS

- Testing master every morning
 - 28 device-types
 - Including boards that I've never seen
 - Testing board failures
 - Bootloader errors
 - DummySYS can “fail at bootloader” on every run
 - dhcp failures
 - ...

meta-lava

- System mocking is fun
 - Test on fake hardware
 - Even hardware that you don't own
 - **Contributions welcomed !!**
 - Run benchmarks
 - ...
- Can find many bugs that unittest won't
- Not that difficult
 - Be creative!
 - Look at the boundaries

Questions?

Thank you

<https://linaro.org>

