Setting up development infrastructure for Petalinux projects and Zynq MPSoC/RFSoC based hardware utilizing continuous integration and deployment techniques

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CERN SoC Interest Group Meeting

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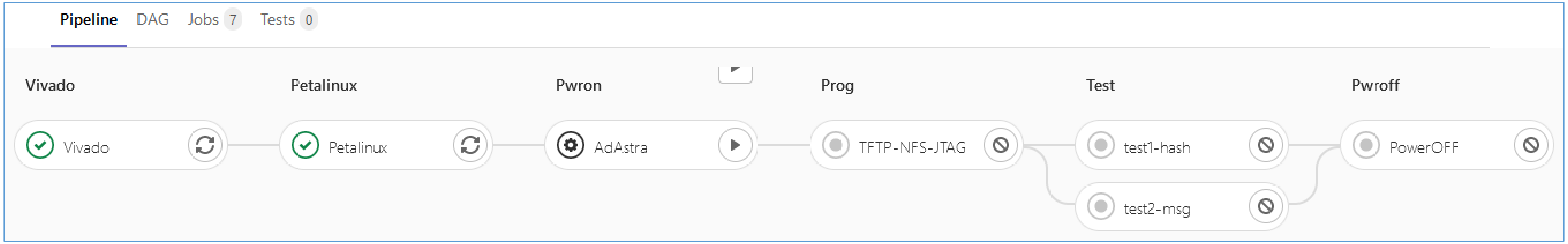
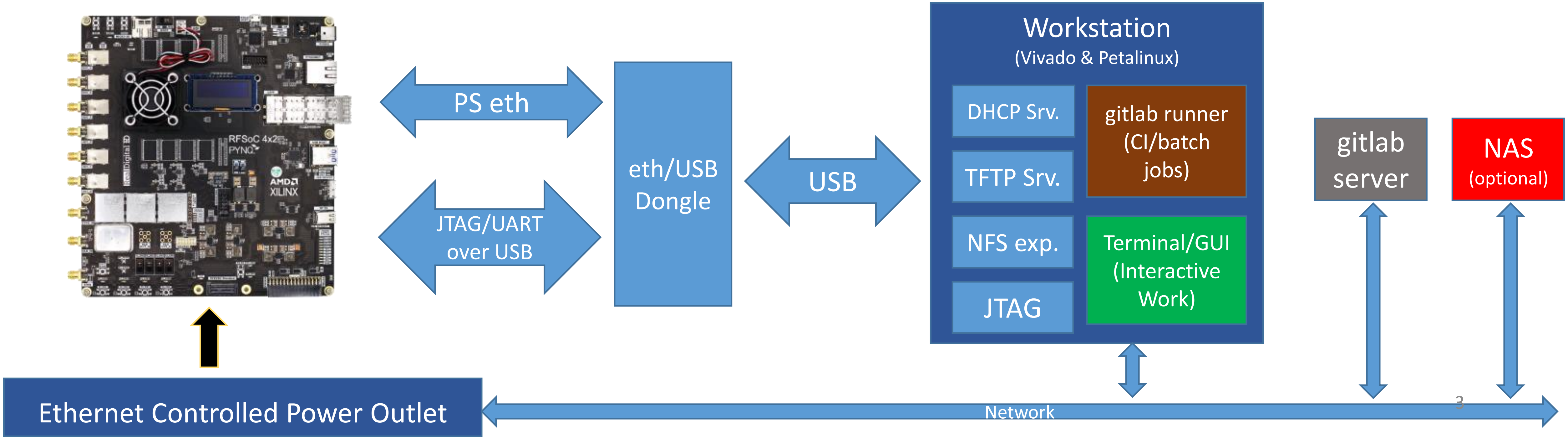
Abstract

- In this tutorial we demonstrate how to setup basic Petalinux development and continuous integration and deployment (CI/CD) infrastructure for MPSoC/RFSoC based projects.
- We start by showing how to organize a workstation so that it could be used at the same time for interactive and batch (gitlab CI based) Petalinux compilation jobs.
- In the next step we extend the setup with an example RFSoC board to show how to perform continuous deployment of Petalinux images directly to the hardware utilizing network boot and how to execute and organize basic tests utilizing features of gitlab CI server.
- Tutorial relies on standard components which can be enabled in Petalinux/yocto (like docker and kubernetes) and provides low level information when necessary so that attendees could rather easily reuse all or part of the demonstrated content on their own premises.

i.e. in this presentation we mainly focus on Petalinux CI/CD

Agenda in pictures





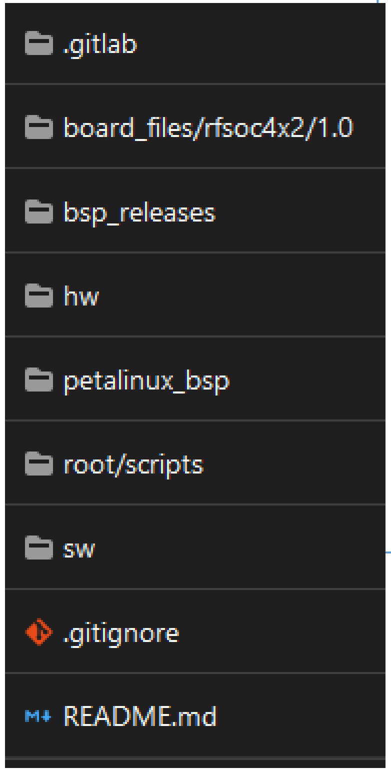
Agenda in words

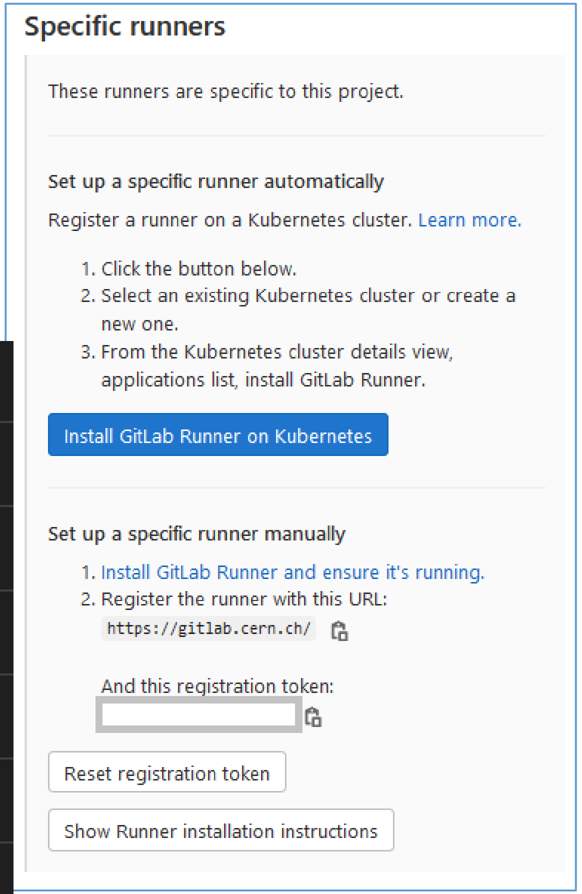
- Initial requirements.
- Setting up a workstation for Zynq development and (batch) CI jobs execution.
- Setting up Petalinux CI build.
- Basic Petalinux CI flow.
- Continous Deployment to hardware (Xilinx XUP RFSoC 4x2 board).
- Gitlab CI support of junit reports, and coloring of merge requests

Gitlab CI – first step

What is required to enable gitlab CI jobs execution ?

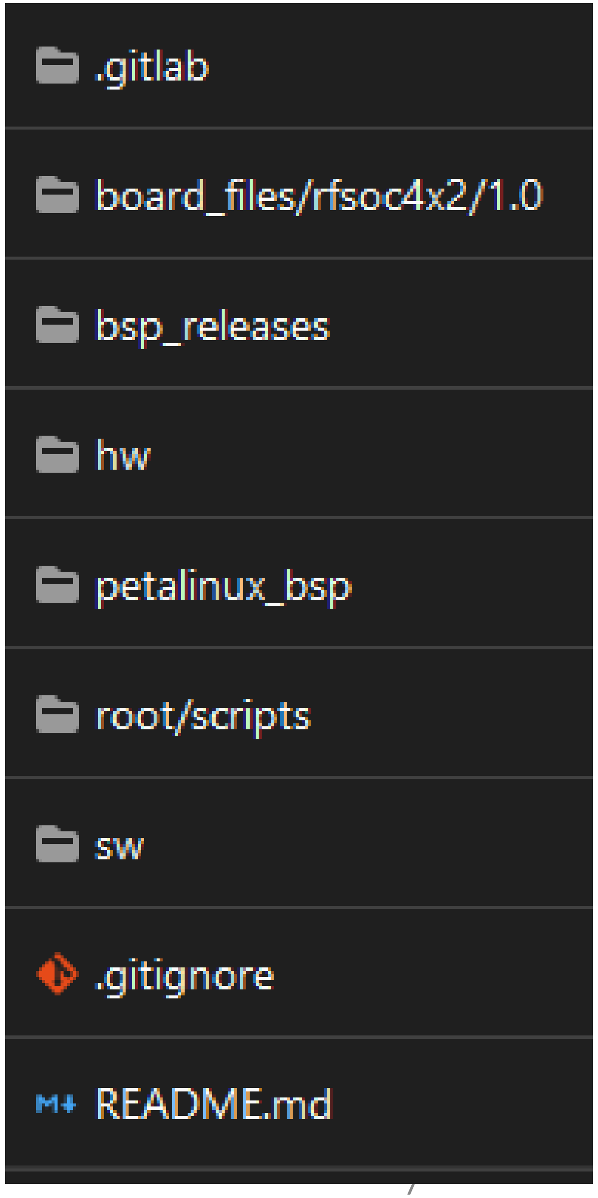
- Gitlab repository:
  - https://gitlab.cern.ch/
  - gitlab server at your Home Institute
  - home installation
  - …
- Gitlab Runner(s) attached to your project (from gitlab web UI: Settings -> CI/CD -> Runners). Your own (project specific) or shared.
- **.gitlab-ci.yml** file controls what is happening on/with your runners when events related to your reposistory are occuring (push, merge, web [Run Pipeline], etc.)
- In this tutorial we will use a private runner - workstation connected to a self hosted gitlab server (VirtualBox) – just for fun and learning purposes.

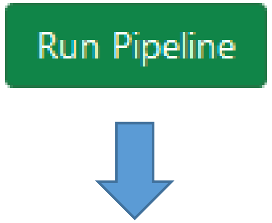




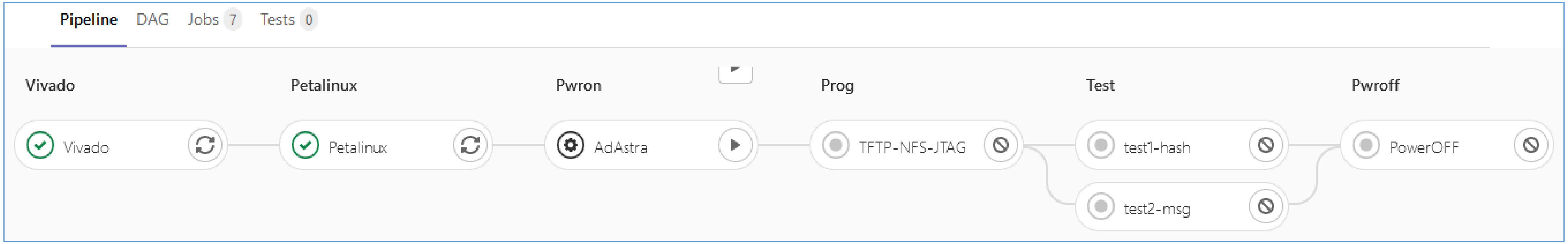
Tutorial folder structure

- In this tutorial we utilize github RFSoC 4x2 repository which we extend with our own recipes, build scripts and gitlab CI control files.
  - Original repo available here: https://github.com/RealDigitalOrg/RFSoC4x2-BSP
  - The above repository contains Petalinux BSP file, but don’t utilize it – instead we build everything with our own recipes (for learning purposes).
- Above repo extended with:
  - Zynq PL code:
    - Makefile to execute Vivado.
  - Petalinux:
    - Recipes and scripts.
  - CI flow related
    - Scripts.
    - Tools.





Our gitlab CI control file (gitlab-ci.yml)




```yaml
stages:
  - vivado
  - petalinux
  - pwron
  - prog
  - test
  - pwroff
  - tag-cp
  - tag-pr
```

```yaml
Vivado:
  stage: vivado
  script:
    - bash
    - echo ${ZYNQ_BSP}
    - . /opt/xilinx/v20202/Vitis/2020.2/settings64.sh
    - mkdir ${ART_STORAGE}
    - mkdir work
    - cd work
    - make xsa
  tags:
    - VIVADO
  rules:
    - if: '$CI_PIPELINE_SOURCE == "web" && $ZYNQ_BSP =~ /^.*basic.*/'
    - if: '$CI_PIPELINE_SOURCE == "web" && $ZYNQ_BSP =~ /^.*docker.*/'
    - if: '$CI_PIPELINE_SOURCE == "web" && $ZYNQ_BSP =~ /^.*k8s.*/'
```

```yaml
Petalinux:
  stage: petalinux
  needs: ["Vivado"]
  script:
    - bash
    - mkdir work
    - cd work
    - echo ${ZYNQ_BSP}
    - . /opt/xilinx/v20202/petalinux/settings.sh
    - make -f ../petalinux_bsp/${ZYNQ_BSP}_tftp_nfs/Makefile configure_prj
    - petalinux-build --project peta20202 > status.log
    - mkdir -p ${ART_STORAGE}/peta20202/images/
    - mkdir -p ${ART_STORAGE}/peta20202/project-spec/
    - rsync --info=progress2 -r --prune-empty-dirs peta20202/images/*
    - rsync --info=progress2 -r --prune-empty-dirs peta20202/.petalinux/*
    - rsync --info=progress2 -r --prune-empty-dirs peta20202/project-spec/*
    - rsync --info=progress2 -r --prune-empty-dirs peta20202/config.project
    - tree -L 4 ${ART_STORAGE}
  tags:
    - PETALINUX
  rules:
    - if: '$CI_PIPELINE_SOURCE == "web"'
```

```yaml
AdAstra:
  stage: pwron
  needs: ["Petalinux"]
  script:
    - bash
    - curl "${NETIO_IPADDR}/netio.cgi?pass=
    - sleep 5s
    - curl "${NETIO_IPADDR}/netio.cgi?pass=
    - sleep 5s
  tags:
    - PROG
  rules:
    - if: '$CI_PIPELINE_SOURCE == "web"'
#      when: manual
```

```yaml
TFTP-NFS-JTAG:
  stage: prog
  needs: ["AdAstra"]
  script:
    - bash
    - . ./scripts/env/env_setup.sh LAB1 confi
    - . /opt/xilinx/v20192/petalinux/settings
    - make -e --always-make peta-eos-get-img
    - sudo /tftpboot/clean.sh
    - cp -f ${MCI_FLOW_DEST_PETA}/images/linu
    - cp -f ${MCI_FLOW_DEST_PETA}/images/linu
    - sudo /tftpboot/fillnfs.sh
    - cd ${MCI_FLOW_DEST_PETA}/images/linux/
    - petalinux-boot --jtag --uboot --fpga --
    - sleep 45s
  environment:
    name: DANGER-ZONE
    url: http://192.168.1.166/pynq-z2/hello-c
  tags:
    - PROG
  rules:
    - if: '$CI_PIPELINE_SOURCE == "web"'
```

```yaml
test1-hash:
  stage: test
  needs: ["TFTP-NFS-JTAG"]
  script:
    - bash
    - sleep 5s
    - export RESP=$(ssh -q -o StrictHostK
    - echo ${RESP}
    - export TST1=${CI_COMMIT_REF_SLUG}
    - echo $TST1
    - export TST2=${CI_COMMIT_SHA:0:8}
    - echo $TST2
    - export EXPECTED=($TST1-$TST2)
    - echo $EXPECTED
    - if [[ "$RESP" == "$EXPECTED" ]]; th
  tags:
    - PROG
  rules:
    - if: '$CI_PIPELINE_SOURCE == "web"'
      allow_failure: true
```

Ho to launch a CI/CD pipeline

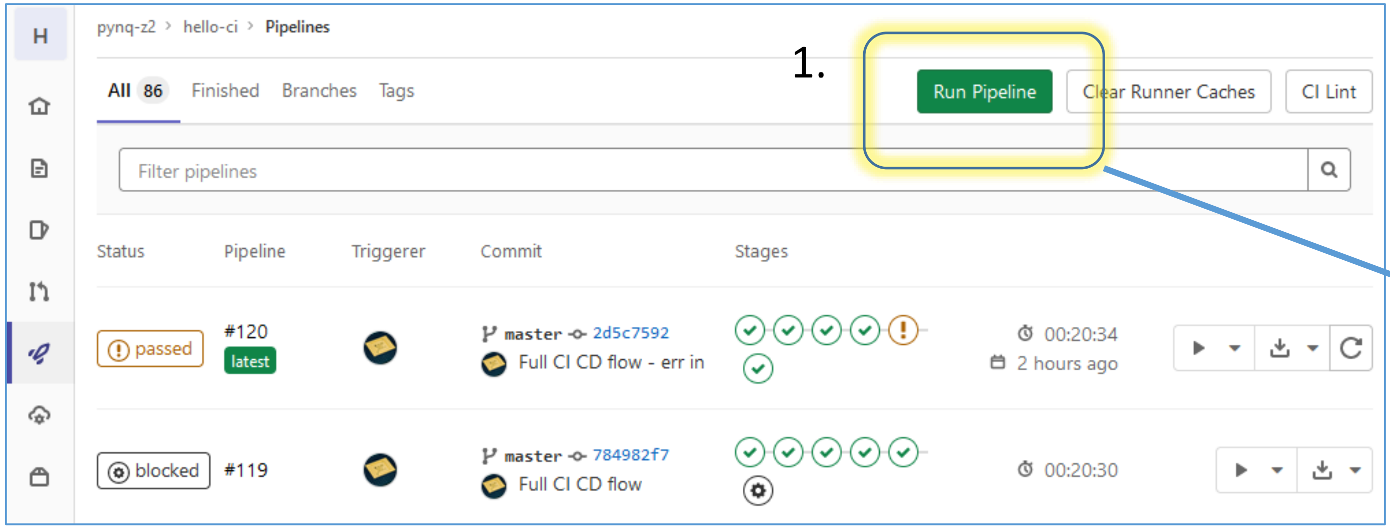
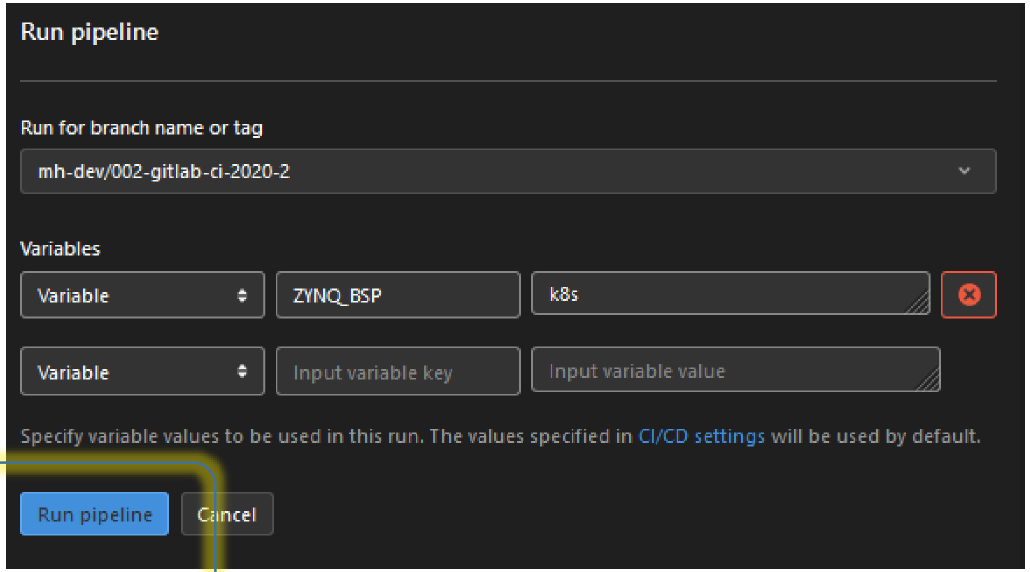


Image taken from the previous talk about Pynq-Z2

2.



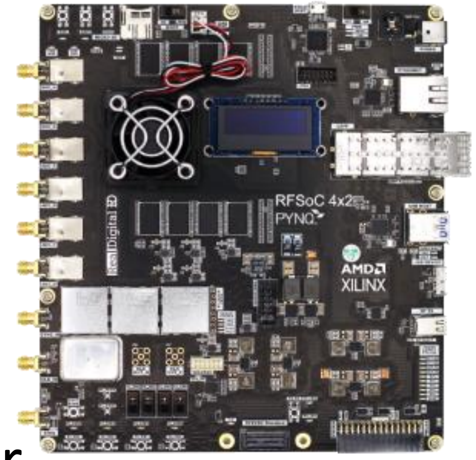
1. Navigate to Pipelines view of your repository (CI/CD -> Pipelines) and click “Run Pipeline”
2. Launch a “web” pipeline (with default values from branch - freshest branch and ZYNQ_BSP=k8s) by clicking “Run Pipeline”.

Setting up a workstation for Zynq development and gitlab CI jobs execution.

Setting up a workstation for Zynq development and CI jobs execution

- Overview of HW and SW used for this tutorial
- Installing Vivado and Petalinux 2020.2
- Setting up a „Service account”
- A not so „Basic” gitlab runner installation
- RFSoC net boot services: DHCP, TFTP, and NFS

HW and SW used for testing



- Intel (Skull Canyon) NUC workstation:
  - Will be attached to our gitlab repository as a project specific runner.
  - Used for local compilations and gitlab-runner (shell executor), OS: Ubuntu LTS 18.04.6, 32 GB RAM, Intel i7-6770HQ (4c/8t).
  - Configured with NFS export, TFTD, and DHCP servers.
  - USB dongle with JTAG and internal network connected to RFSoC 4x2 board.
  - Petalinux 2020.2 (no BSP file used).

- RFSoC 4x2 board:
  - Configured for JTAG boot, no SD card used/inserted.
  - Powered from power outlet controlled over Ethernet.

Installing Vivado and Petalinux 2020.2

- Instructions provided by Xilinx:
  - https://www.xilinx.com/support/documentation/sw_manuals/xilinx2020_2/ug973-vivado-release-notes-install-license.pdf
  - https://www.xilinx.com/support/installer/installer-info-2020-2.html
- Don’t forget to install dependency packages listed by Petalinux:
  - https://www.xilinx.com/support/answers/72950.html
  - https://www.xilinx.com/support/answers/73296.html
- Configure licensing if running with non Webpack devices:
  - Webpack Features: https://www.xilinx.com/products/design-tools/vivado/vivado-webpack.html#webpack
  - Webpack Devices: https://www.xilinx.com/products/design-tools/vivado/vivado-webpack.html#architecture
- Tutorial references tools installed into /opt/Xilinx/v2020 folder

Setting up a „Service account” on the workstation

- We will add a „Service account” on our workstation.
  - Local home directory (/home/**soc-usr**)
  - This account will be used to run CI jobs, place TFTP and NFS images into service folders, and communicate with hardware over password less ssh.
- add soc-usr to sudoers
  - enable passwordless sudo (visudo -> soc-usr ALL=(ALL) NOPASSWD: ALL)
  - we will use sudo access to unpack rootfs and to be able to re-start TFTP and NFS services.
  - You could limit sudo access only to the commands which are nesscessary in your scripts.
- generate private+public key (ssh-keygen -t rsa -b 4096)
  - We will inject public key into Petalinux rootfs so that we can easily communicate with RFSoC board and to execute scripts remotely.

Default gitlab-runner installation

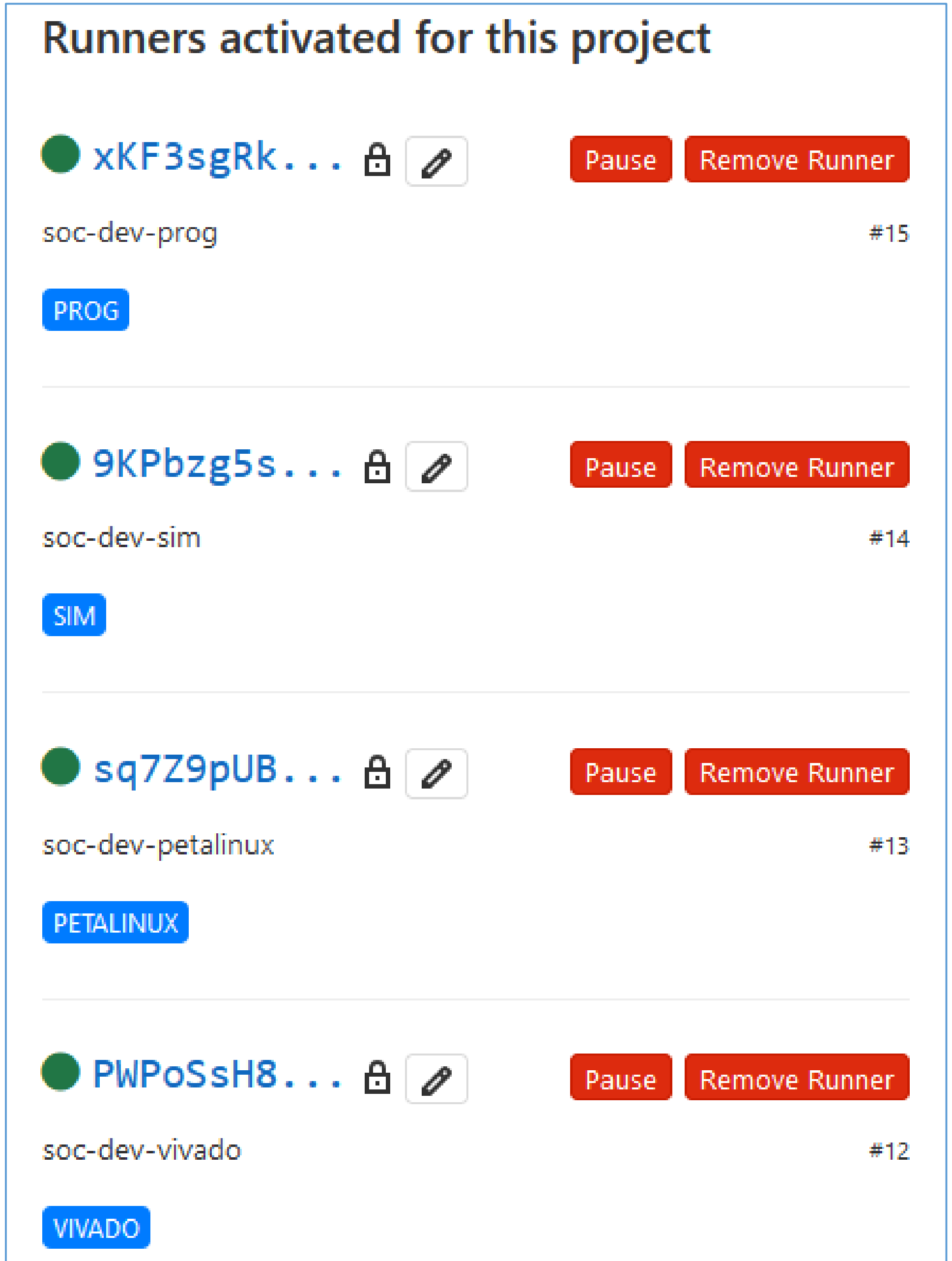
- Instructions provided on this website:
  - https://docs.gitlab.com/runner/install/linux-repository.html
- By default – installs gitlab-runner into default folder (/home/gitlab-runner), uses signle config file for all registered projects, and executes gitlab CI jobs with gitlab-runner account (also added to sudoers).
- We will replace default gitlab-runner account with our „service account" and register multiple services each with different control files.
  - Unique control files per each service – control of jobs concurrency (shell executor)
  - Multiple services – each with its own control file, and its own control of work/execution folder (SATA vs. NVMe Gen4, RAID vs. splitting storage traffic).
  - NOTE: You can use multiple services pattern for sharing a single computing node among many users, having some control over QoS (concurrency) and accounting (unique user names)

Not so basic gitlab runner installation

- We will create 4 gitlab-runner services:
  - gitlab-runner-vivado (concurrency 4 jobs).
  - gitlab-runner-petalinux (concurrency 1 job).
  - gitlab-runner-sim (concurrency 8 jobs).
  - gitlab-runner-prog (concurrency 1 job).
- Each service to be executed with our service account „soc-usr".
  - Password less sudo, private+public ssh key. Temporary storage on NVMe drive.
  - Example:
    - sudo gitlab-runner install -n gitlab-runner-petalinux -d "**/opt/gitlab-ci-tmp/petalinux**" -c "/home/soc-usr/.gitlab-runner/**config-petalinux.toml**" -u **soc-usr**
    - sudo service gitlab-runner-petalinux restart
- We register runners with our gitlab repository as shell executors:
  - Example:
    - gitlab-runner register -c /home/soc-usr/.gitlab-runner/**config-petalinux.toml**

Our workstation in our gitlab repository

- Our single workstation with 4 gitlab-runner services.
- Each service with:
  - More meanningful account
  - Behind a single tag
  - With job conccurency controll and
  - Full storage location control



DHCP for internal network

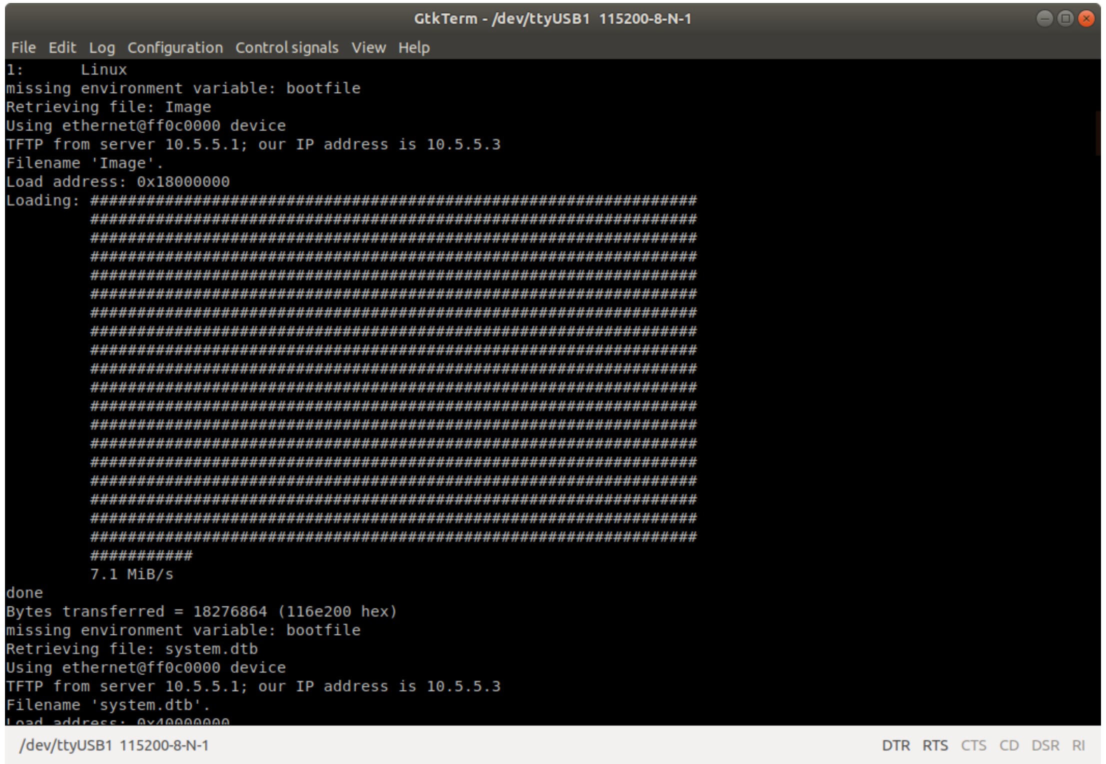
- The DHCP server will serve internal network 10.5.5.x (Eth from USB dongle, directly connected to RFSoC board)
- sudo service isc-dhcp-server start

```
↳ dhcp-lease-list
Reading leases from /var/lib/dhcp/dhcpd.leases
MAC                IP              hostname       valid until         manufacturer
===============================================================================================
00:0a:35:00:1e:53  10.5.5.6        -NA-           2020-10-06 20:45:09 Xilinx
00:0a:35:00:1e:60  10.5.5.11       -NA-           2020-10-06 18:45:16 Xilinx
00:0a:35:00:1e:61  10.5.5.12       -NA-           2020-10-06 19:40:38 Xilinx
00:0a:35:00:1e:65  10.5.5.13       -NA-           2020-10-06 21:13:21 Xilinx
 /tftpboot
↳ ping 10.5.5.13
PING 10.5.5.13 (10.5.5.13) 56(84) bytes of data.
64 bytes from 10.5.5.13: icmp_seq=1 ttl=64 time=0.288 ms
64 bytes from 10.5.5.13: icmp_seq=2 ttl=64 time=0.365 ms
64 bytes from 10.5.5.13: icmp_seq=3 ttl=64 time=0.365 ms
```

```
IP-Config: Complete:
     device=eth0, hwaddr=00:0a:35:00:1e:65, ipaddr=10.5.5.13, mask=255.255.255.0, gw=10.5.5.254
     host=10.5.5.13, domain=example.org, nis-domain=(none)
     bootserver=10.5.5.1, rootserver=10.5.5.1, rootpath=
     nameserver0=10.5.5.10
```

TFTP to serve Linux kernel

- sudo service tftpd-hpa start
- Service tied to dongle eth interface (/etc/default/tftpd-hpa)
- Folder to store Petalinux generated Image:
  - /tftpboot
  - soc-user has write permissions to that folder - used by CI to deploy images.



NFS export to serve Linux root file system

- NFS export:
  /tftpboot/nfsroot *(rw,sync,no_root_squash,no_subtree_check,crossmnt)
- sudo service nfs-kernel-server start
- Petalinux bootargs:
  - console=ttyPS0,115200n8 earlyprintk ip=dhcp root=/dev/nfs rootfstype=nfs nfsroot=10.5.5.1:**/tftpboot/nfsroot**,port=2049,**nfsvers=3**,tcp rw
- soc-user uses sudo permissions to unpack Petalinux generated rootfs.tar.gz into /tftpboot/nfsroot

```
Kernel command line: console=ttyPS0,115200n8 earlyprintk ip=dhcp root=/dev/nfs rootfstype=nfs nfsroot=10.5.5.1:/tftpboot/nfsroot,port=2049,nfsvers=3,tcp rw
```

```
VFS: Mounted root (nfs filesystem) on device 0:12.
```

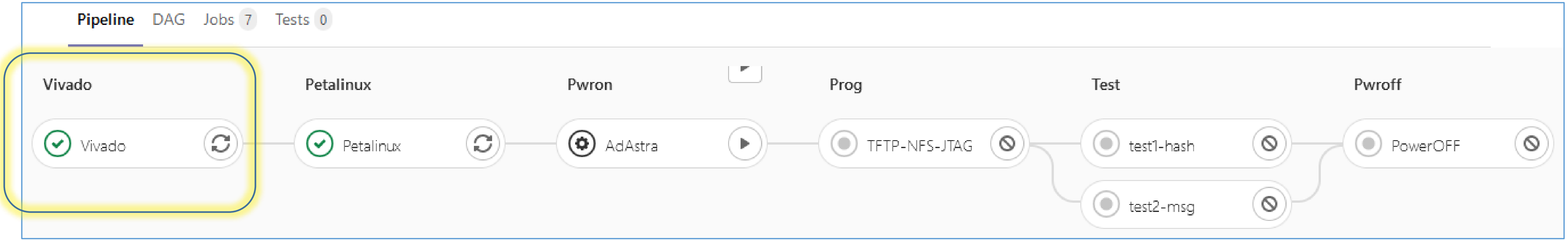
Forcing NFS server to work with specific version.

- sudo vim /etc/default/nfs-kernel-server
  - Was: # RPCNFSDCOUNT=8
  - Is: RPCNFSDCOUNT="8 --no-nfs-version 4“
- sudo cat /proc/fs/nfsd/versions
  -2 **+3** -4 -4.0 -4.1 -4.2

Zynq PL Vivado CI flow

Not so important for this presentation

„Vivado” stage



Zynq PL related elements

- gitlab-ci.yml (Vivado stage)
- Makefile (Vivado project mode flow commands)
- Original github Zynq PL design kept as a Vivado/IPI exported design.
- We just add a makefile:
  - make xsa

```yaml
Vivado:
  stage: vivado
  script:
    - bash
    - echo ${ZYNQ_BSP}
    - . /opt/xilinx/v20202/Vitis/2020.2/settings64.sh
    - mkdir ${ART_STORAGE}
    - mkdir work
    - cd work
    - make xsa
  tags:
    - VIVADO
  rules:
    - if: '$CI_PIPELINE_SOURCE == "web" && $ZYNQ_BSP =~ /^.*basic.*/'
    - if: '$CI_PIPELINE_SOURCE == "web" && $ZYNQ_BSP =~ /^.*docker.*/'
    - if: '$CI_PIPELINE_SOURCE == "web" && $ZYNQ_BSP =~ /^.*k8s.*/'
```

make xsa

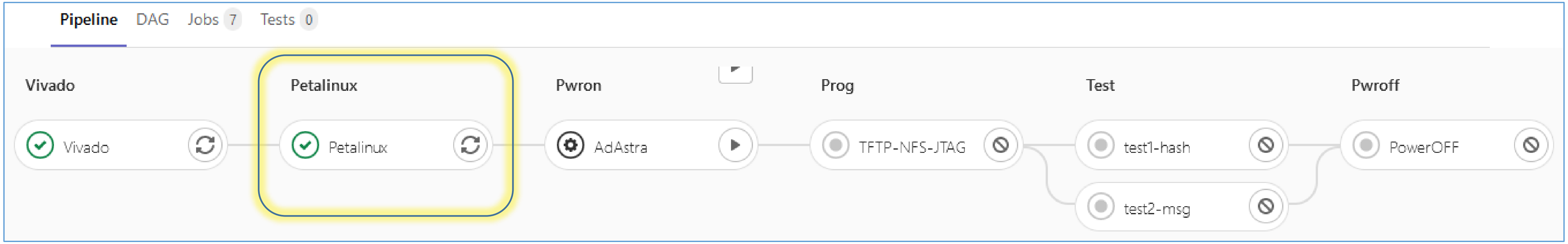
```
Michal Husejko, 3 weeks ago | 1 author (Michal Husejko)
all: clean

clean:
	rm -rf hw/ vivado* .Xil/ *.xsa

xpr:
	vivado -mode batch -source design_1.tcl

xsa:
	vivado -mode batch -source vscripts/build_xsa.tcl
```

```
Michal Husejko, 3 weeks ago | 1 author (Michal Husejko)
set overlay_name "hw"

open_project ./${overlay_name}/${overlay_name}.xpr

# set platform properties
set_property platform.default_output_type "sd_card" [current_project]
set_property platform.design_intent.embedded "true" [current_project]
set_property platform.design_intent.server_managed "false" [current_project]
set_property platform.design_intent.external_host "false" [current_project]
set_property platform.design_intent.datacenter "false" [current_project]

launch_runs impl_1 -to_step write_bitstream -jobs 6
wait_on_run impl_1

write_hw_platform -force -include_bit ./${overlay_name}.xsa
validate_hw_platform ./${overlay_name}.xsa
```

- … but this tutorial utilizes XSA (with bit file) available from the github repo.

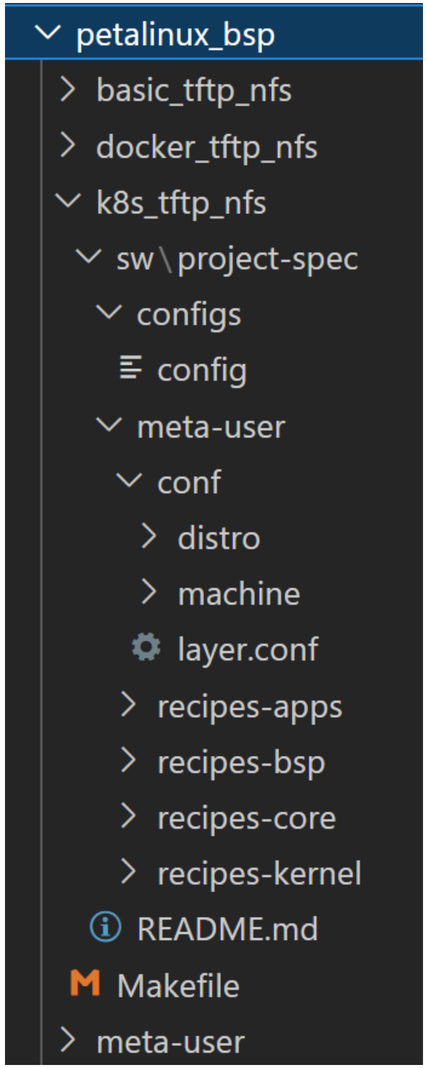
Basic Petalinux CI flow

„Petalinux” stage



We have three different “BSP” avaiable

- basic:
  - Really basic BSP with TFTP+NFS+JTAG boot.
- docker:
  - Basic + docker
- k8s:
  - Basic+docker+kubernetes
- Selction of the BSP to build is done using ZYNQ_BSP variable.
  - Example to build k8s:
    - Run pipeline with ZYNQ_BSP=k8s



```
configure_prj: import_xsa
    cp ../petalinux_bsp/${MK_BSP_NAME}/sw/project-spec/configs/config peta202
    perl -i -pe 's/\bMK_CONFIG_SUBSYSTEM_HOSTNAME\b/${MK_EXPECTED_HOSTNAME}/g
    perl -i -pe 's/\bMK_BSP_NAME\b/${MK_BSP_NAME}/g' ./peta20202/project-spec
    cp -R ../petalinux_bsp/${MK_BSP_NAME}/sw/project-spec/meta-user/conf/ pet
    cp ../petalinux_bsp/${MK_BSP_NAME}/sw/project-spec/meta-user/recipes-bsp/
    cp ../petalinux_bsp/${MK_BSP_NAME}/sw/project-spec/meta-user/recipes-bsp/
    mkdir -p ./peta20202/project-spec/meta-user/recipes-kernel/linux/
    cp -R ../petalinux_bsp/${MK_BSP_NAME}/sw/project-spec/meta-user/recipes-k
    echo "DL_DIR = \"/home/soc-usr/ycache/v20202/downloads\"" >> peta20202/pr
    echo "SOURCE_MIRROR_URL = \"file:///home/soc-usr/ycache/v20202/downloads\
    echo "SSTATE_DIR = \"/home/soc-usr/ycache/v20202/sstate_local\"" >> peta2
    petalinux-config --project peta20202 --silentconfig
    mkdir -p ./peta20202/project-spec/meta-user/recipes-core/images/
    cp ../petalinux_bsp/${MK_BSP_NAME}/sw/project-spec/meta-user/recipes-core
    petalinux-create --project peta20202 --type apps --template install --nam
    rm ./peta20202/project-spec/meta-user/recipes-apps/trojan/files/*
    cp ../petalinux_bsp/${MK_BSP_NAME}/sw/project-spec/meta-user/recipes-apps
    petalinux-create --project peta20202 --type apps --template install --nam
    rm ./peta20202/project-spec/meta-user/recipes-apps/mhcicd/files/*
    rm ./peta20202/project-spec/meta-user/recipes-apps/mhcicd/mhcicd.bb
    cp ../petalinux_bsp/${MK_BSP_NAME}/sw/project-spec/meta-user/recipes-apps
    cp ../petalinux_bsp/${MK_BSP_NAME}/sw/project-spec/meta-user/recipes-apps
```

1. Setup environment

2. Use the XSA available in the repo.

3. Create basic petalinux project (no BSP used)

4. Copy pre-generated project-spec files (kernel and rootfs configs)
   - generation explained on next slides

5. Adjust settings using perl script and echo commands:
   - inject branch name and short gith hash as a RFSoC hostname
   - add download/sstate/sstate_local cache repositories

6. Apply recipe to add soc-usr local account, inject public key, and create custom application which we will use during CD/test phase.

7. Build Petalinux project

8. Store artifacts

More details on simple petalinux flow

- Get XSA file from storage
- Create basic Zynq(-7000) project using “zynqMP” template – no BSP used
  - **petalinux-create** --type project --template zynqMP --name **peta20202**
- Ingest XSA file into basic project
  - **petalinux-config** --project peta20202 --get-hw-description=./../sw/design_1_wrapper.xsa --silentconfig
- Configure newly created project to match your (CI) needs:
  - details on the next slides – 3 different methods to configure Petalinux from lowest to highest complexity
- Apply new config:
  - **petalinux-config** --project peta20202 –silentconfig
- Build the project:
  - **petalinux-build** --project peta20202
- Store artifacts in the storage (to be used by programming stage)
  - In principle push whole ./peta20202/images/linux repo to the storage.

Initial project-spec configs – generate on your workstation using menuconfig then push to git and use as a baseline

- DTG Settings -> Kernel Bootargs -> generate boot args automaticaly []
  - Disable
- DTG Settings -> Kernel Bootargs -> user set kernel bootargs
  - earlycon console=ttyPS0,115200n8 clk_ignore_unused earlyprintk rootwait root=/dev/nfs rw nfsroot=10.5.5.1:/tftpboot/nfsroot,port=2049,nfsvers=3,tcp ip=dhcp
- Image Packaging Configuration -> Root filesystem type -> (NFS)
  - Chose NFS
- Enable TFTP boot
- Image Packaging Configuration -> Location of NFS root directory (/tftpboot/nfsroot)
- Image Packaging Configuration -> tftpboot directory (/tftpboot)
- Firmware Version Configuration -> (MK_CONFIG_SUBSYSTEM_HOSTNAME) Hostname
- Firmware Version Configuration -> (MK_BSP_NAME) Product name
- Firmware Version Configuration -> (1.00) Firmware Version

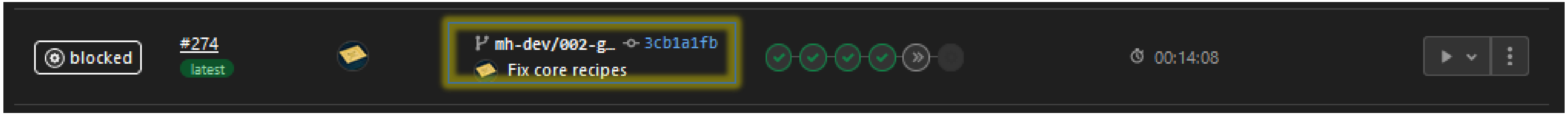
- Store config in repository and then apply within CI flow as a base line – from our yaml file:
  - cp ../petalinux_bsp/${MK_BSP_NAME}/sw/project-spec/configs/config peta20202/project-spec/configs/config

Adjust settings using perl script and echo commands

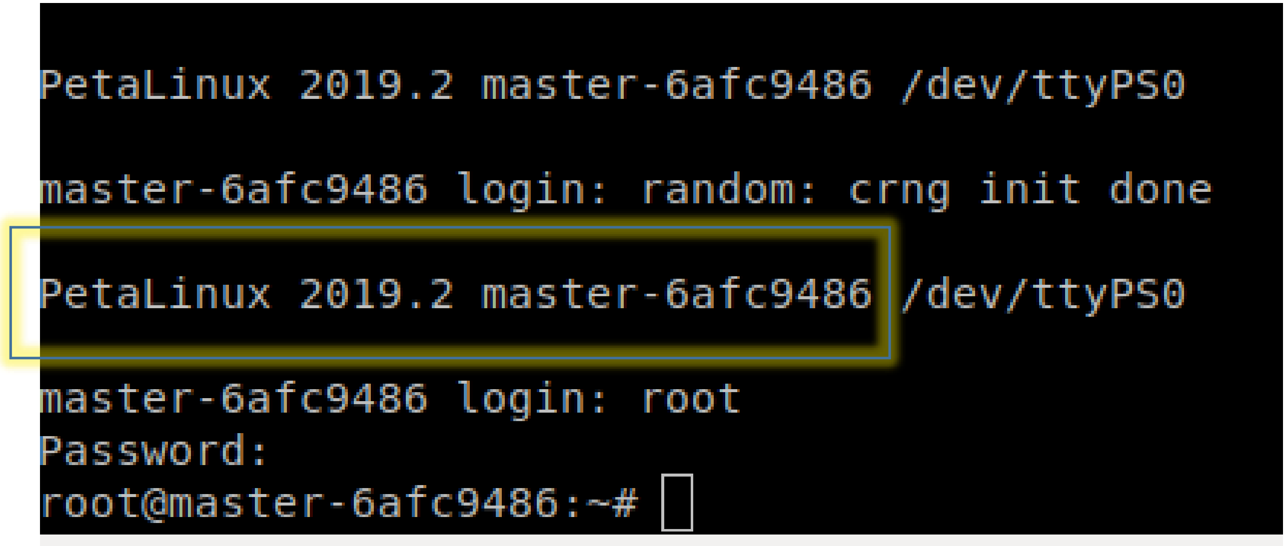
- Two examples below:
- perl -i -pe 's/\bMK_CONFIG_SUBSYSTEM_HOSTNAME\b/${MK_EXPECTED_HOSTNAME}/g' ./peta20202/project-spec/configs/config
- echo "DL_DIR = \"/home/soc-usr/ycache/v20202/downloads\"" >> peta20202/project-spec/meta-user/conf/petalinuxbsp.conf

Firmware Version Configuration -> (MK_CONFIG_SUBSYSTEM_HOSTNAME) Hostname (perl)

- Hostname name used to help visualize traceability – inject branch name and git sha into it (replace MK_CONFIG_SUBSYSTEM_HOSTNAME project name)



Images taken from the previous talk about Pynq-Z2



Apply recipe to add soc-usr local account, inject public key, and create custom application (1/3)

- mkdir -p ./peta/project-spec/meta-user/recipes-core/images/
- cp ${MCI_FLOW_ROOT_DIR}/recipes/recipes-core/images/petalinux-user-image.bbappend ./peta/project-spec/meta-user/recipes-core/images/

```
# petalinux-image-minimal.bbappend content

inherit extrausers

EXTRA_USERS_PARAMS = "\
     usermod -P * root; \
     useradd -P * soc-usr; \
     usermod -aG docker soc-usr; \
     "
```

Apply recipe to add soc-usr local account, inject public key, and create custom application (2/3)

- `petalinux-create --project peta20202` **`--type apps --template install`** `--name mhcicd --enable --force`
- `rm ./peta/project-spec/meta-user/recipes-`**`apps`**`/mhcicd/files/*`
- `rm ./peta/project-spec/meta-user/recipes-`**`apps`**`/mhcicd/mhcicd.bb`
- `cp ${MCI_FLOW_ROOT_DIR}/recipes/recipes-`**`apps`**`/mhcicd/files/id_rsa.pub ./peta/project-spec/meta-user/recipes-`**`apps`**`/mhcicd/files`
- `cp ${MCI_FLOW_ROOT_DIR}/recipes/recipes-`**`apps`**`/mhcicd/mhcicd.bb ./peta/project-spec/meta-user/recipes-apps/mhcicd`

Apply recipe to add soc-usr local account, inject public key, and create custom application (2/3)

```
SUMMARY = "Simple mhcicd application"
SECTION = "PETALINUX/apps"
LICENSE = "MIT"
LIC_FILES_CHKSUM =
"file://${COMMON_LICENSE_DIR}/MIT;md5=0835ade698e0bcf8506ecda2f7b4f302"
SRC_URI = "file://id_rsa.pub \        "
S = "${WORKDIR}"
USER="soc-usr"
do_install() {
        install -d ${D}/home/${USER}/.ssh/
        install -m 0755 ${S}/id_rsa.pub ${D}/home/${USER}/.ssh/
        install -m 0755 ${S}/id_rsa.pub ${D}/home/${USER}/.ssh/authorized_keys}
FILES_${PN} += "/home/${USER}/.ssh/*"
```

Apply recipe to add soc-usr local account, inject public key, and create custom application (3/3)

- `petalinux-create --project peta` **`--type apps --template install`** `--name trojan --enable –force`
- `rm ./peta/project-spec/meta-user/recipes-apps/trojan/files/*`
- `cp ${MCI_FLOW_ROOT_DIR}/recipes/recipes-apps/trojan/files/trojan ./peta/project-spec/meta-user/recipes-apps/trojan/files`

trojan 41 Bytes

```
#!/bin/sh

echo "been here. Tony Halik"

```

Enable docker and kubernetes (k8s)

- CONFIG_YOCTO_MACHINE_NAME="docker-zynqmp-generic"

RFSoC4x2-BSP > petalinux_bsp > docker_tftp_nfs > sw > project-spec > meta-user > conf > machine > docker-zynqmp-generic.conf

You, 1 second ago | 2 authors (Michal Husejko and others)

```
# @TYPE: Machine
# @NAME: docker-zynqmp-generic
# @DESCRIPTION: Machine support for RFSoC 4x2 Evaluation Board.
#

SOC_VARIANT = "dr"

require conf/machine/zynqmp-generic.conf

IMAGE_INSTALL_append = " docker docker-ce-contrib"
# Add extra space (in KB) for Docker images (10Gib)
IMAGE_ROOTFS_EXTRA_SPACE = "10485760"
```

Speed up the Petalinux compilation

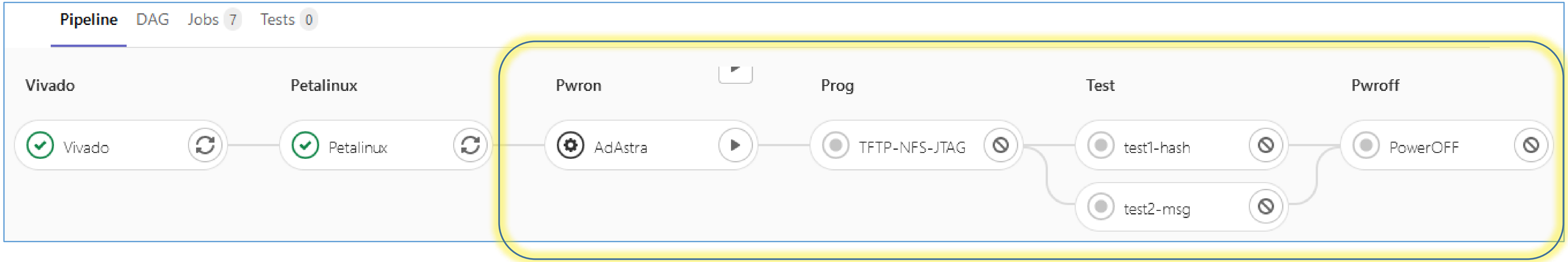
- echo "DL_DIR = \"/home/soc-usr/ycache/v20202/downloads\"" >> peta20202/project-spec/meta-user/conf/petalinuxbsp.conf

- echo "SOURCE_MIRROR_URL = \"file:///home/soc-usr/ycache/v20202/downloads\"" >> peta20202/project-spec/meta-user/conf/petalinuxbsp.conf

- echo "SSTATE_DIR = \"/home/soc-usr/ycache/v20202/sstate_local\"" >> peta20202/project-spec/meta-user/conf/petalinuxbsp.conf

```
#
# Local sstate feeds settings
#
CONFIG_YOCTO_LOCAL_SSTATE_FEEDS_URL="/home/soc-usr/ycache/v20202/sstate_aarch64_2020.2/aarch64"
CONFIG_YOCTO_NETWORK_SSTATE_FEEDS=y
```

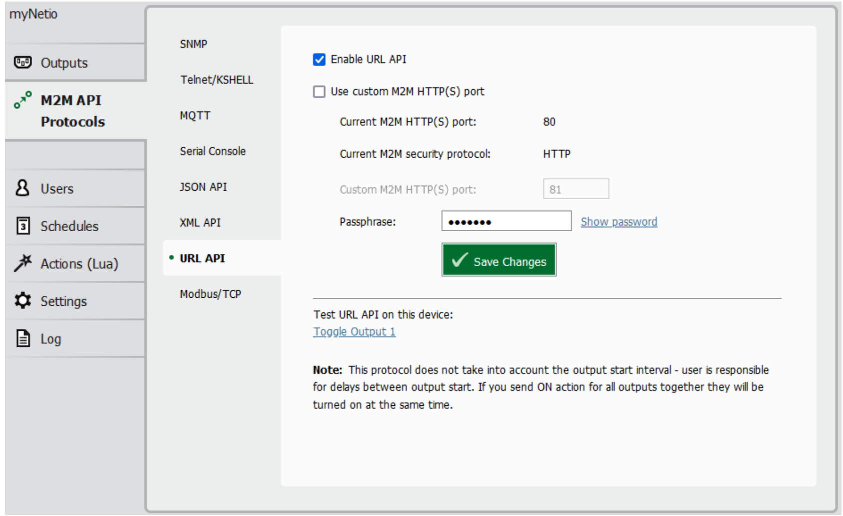
Continous Deployment to hardware


Pipeline
DAG
Jobs 7
Tests 0
Vivado
Petalinux
Pwron
Prog
Test
Pwroff
Vivado
Petalinux
AdAstra
TFTP-NFS-JTAG
test1-hash
test2-msg
PowerOFF

Power outlet controlled over Ethernet

- **Netio PowerPDU** 4PS
  - Around 220 CHF on galaxus.ch
- Commands send using curl
  - More sophisticated APIs available.
  - JSON and status checking would be better.
- Command constructed using gitlab CI Variables (Settings->CI/CD->Variables)

Variable	NETIO_IPADDR	**********************
Variable	NETIO_OUTPUT	**********************
Variable	NETIO_PASS	**********************



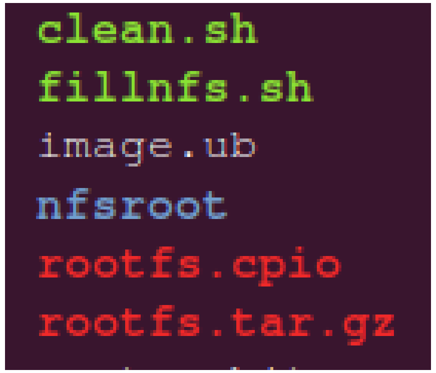
```yaml
AdAstra:
  stage: pwron
  needs: ["Petalinux"]
  script:
    - bash
    - curl "${NETIO_IPADDR}/netio.cgi?pass=${NETIO_PASS}&${NETIO_OUTPUT}=0"
    - sleep 5s
    - curl "${NETIO_IPADDR}/netio.cgi?pass=${NETIO_PASS}&${NETIO_OUTPUT}=1"
    - sleep 10s
    - sudo service isc-dhcp-server restart
    - sudo service nfs-kernel-server restart
    - sudo service tftpd-hpa restart
    - sudo service isc-dhcp-server status
    - sudo service nfs-kernel-server status
    - sudo service tftpd-hpa status
  tags:
    - PROG
  rules:
    - if: '$CI_PIPELINE_SOURCE == "web"'
      when: manual
```

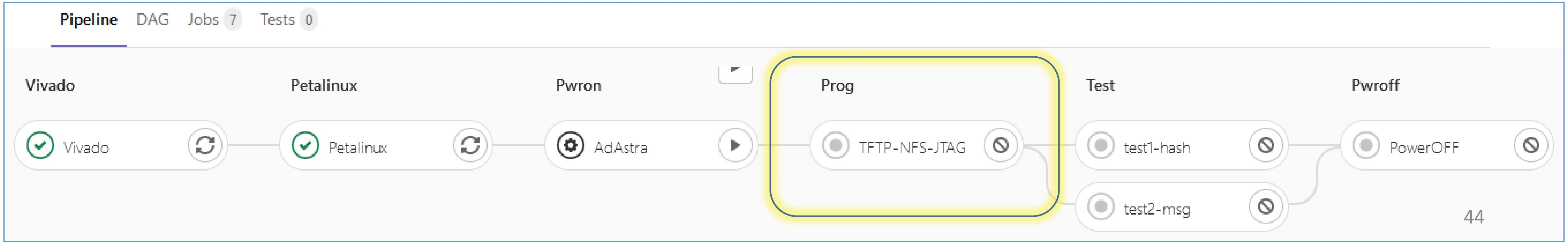
```
$ curl "${NETIO_IPADDR}/netio.cgi?pass=${NETIO_PASS}&${NETIO_OUTPUT}=0"
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
100     2  100     2    0     0   1000      0 --:--:-- --:--:-- --:--:--  1000
OK$ sleep 5s
$ curl "${NETIO_IPADDR}/netio.cgi?pass=${NETIO_PASS}&${NETIO_OUTPUT}=1"
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
100     2  100     2    0     0    666      0 --:--:-- --:--:-- --:--:--   666
OK$ sleep 10s
```

```
$ sudo service isc-dhcp-server restart
$ sudo service nfs-kernel-server restart
$ sudo service tftpd-hpa restart
```

Programming flow (1/4)

- Executed automatically after power ON.
- Extract content of ./peta20202/images/linux from storage
- Populate /tftpboot and /tftpboot/nfsroot with content from above
  - Image.ub -> /tftpboot
  - rootfs -> unpack to /tftpboot/nfsroot





Deploy to the DANGER-ZONE

```yaml
TFTP-NFS-JTAG:
  stage: prog
  needs: ["AdAstra"]
  script:
    - bash
    - . /opt/xilinx/v20202/petalinux/settings.sh
    - sudo /tftpboot/clean.sh
    - tree -L 2 /tftpboot
    - cd ${ART_STORAGE}/peta20202/images/linux
    - cp -R Image system.dtb rootfs.tar.gz pxelinux.cfg/ /tftpboot/
    - sudo /tftpboot/fillnfs.sh
    - tree -L 2 /tftpboot
    - cd ${ART_STORAGE}/peta20202/images/linux
    - petalinux-boot --jtag --uboot --fpga --bitstream system.bit
  environment:
    name: DANGER-ZONE
  tags:
    - PROG
  rules:
    - if: '$CI_PIPELINE_SOURCE == "web"'
#       when: manual
```

```
$ tree -L 2 /tftpboot
/tftpboot
├── clean.sh
├── fillnfs.sh
├── Image
├── nfsroot
│   ├── bin
│   ├── boot
│   ├── dev
│   ├── etc
│   ├── home
│   ├── lib
│   ├── media
│   ├── mnt
│   ├── opt
│   ├── proc
│   ├── run
│   ├── sbin
│   ├── sys
│   ├── tmp
│   ├── usr
│   └── var
├── pxelinux.cfg
│   └── default
├── rootfs.tar.gz
└── system.dtb

18 directories, 6 files
```

Programming flow (2/4)

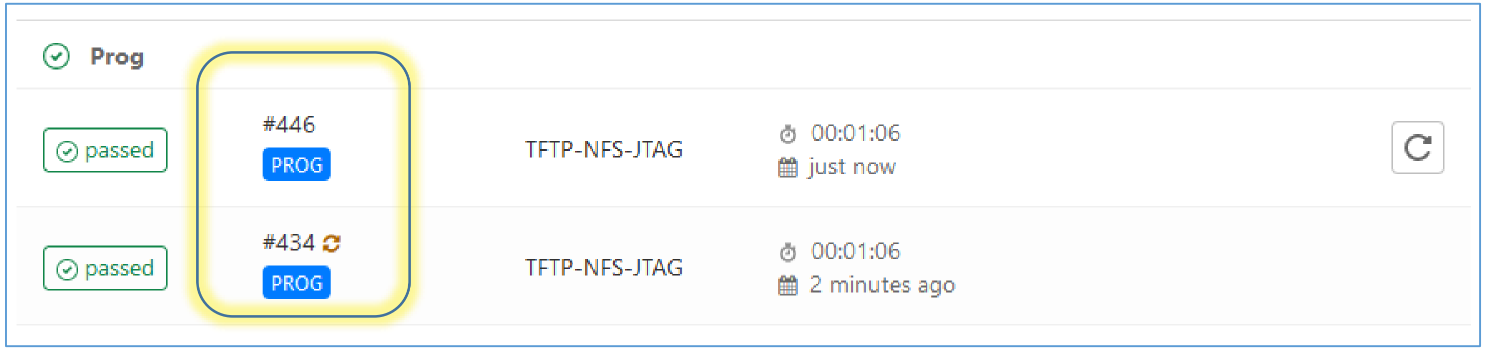
- Remaining necessary contents of the ./peta20202/images/linux pushed over jtag:
  - **petalinux-boot** --jtag --uboot --fpga --bitstream system.bit

```
$ petalinux-boot --jtag --uboot --fpga --bitstream system.bit
INFO: Sourcing build tools
INFO: Launching XSDB for file download and boot.
INFO: This may take a few minutes, depending on the size of your image.
INFO: Configuring the FPGA...
INFO: Downloading bitstream: system.bit to the target.
INFO: Downloading ELF file: /eos/cicd/soc-usr/cf8fa0f9/peta20202/images/linux/pmufw.elf to the target.
INFO: Downloading ELF file: /eos/cicd/soc-usr/cf8fa0f9/peta20202/images/linux/zynqmp_fsbl.elf to the target.
INFO: Loading image: /eos/cicd/soc-usr/cf8fa0f9/peta20202/images/linux/system.dtb at 0x00100000
INFO: Downloading ELF file: /eos/cicd/soc-usr/cf8fa0f9/peta20202/images/linux/u-boot.elf to the target.
INFO: Downloading ELF file: /eos/cicd/soc-usr/cf8fa0f9/peta20202/images/linux/bl31.elf to the target.
```

Programming flow (3/4)

- Push button image redeployment with full gitlab hash traceability

Image taken from the previous talk about Pynq-Z2



Programming flow (4/4)

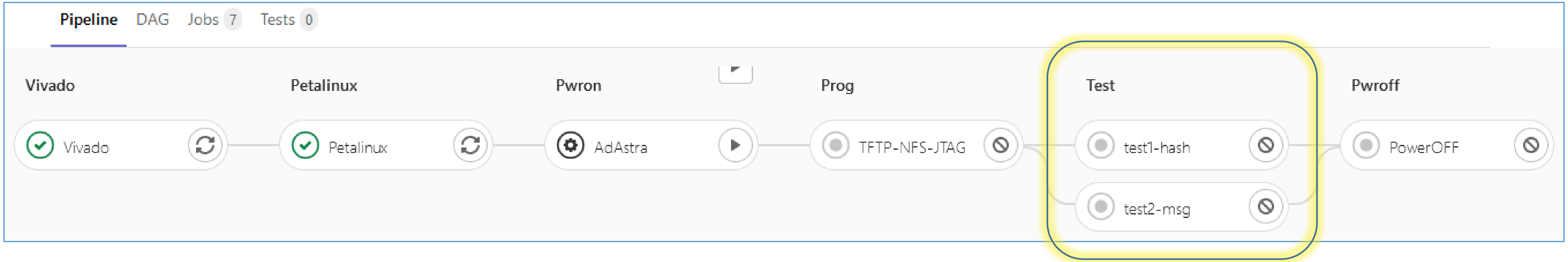
- Push button image redeployment with full gitlab hash traceability

```
eth0: ethernet@e000b000
U-BOOT for master-784982f7

ethernet@e000b000 Waiting for PHY auto negotiation to complete....... done
BOOTP broadcast 1
BOOTP broadcast 2
BOOTP broadcast 3
DHCP client bound to address 10.5.5.2 (1253 ms)
Hit any key to stop autoboot:  3
```

Image taken from the previous talk about Pynq-Z2

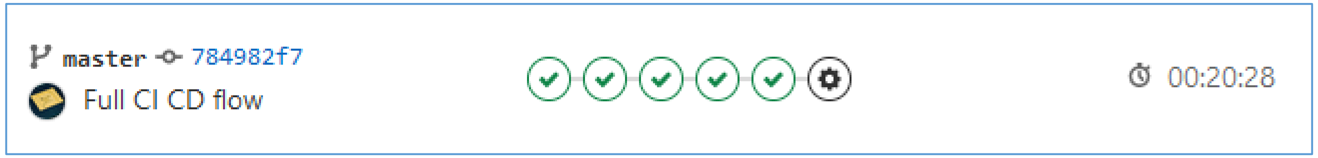
```
PetaLinux 2019.2 master-784982f7 /dev/ttyPS0

master-784982f7 login:
```

Basic testing


Pipeline
DAG
Jobs 7
Tests 0
Vivado
Petalinux
Pwron
Prog
Test
Pwroff
Vivado
Petalinux
AdAstra
TFTP-NFS-JTAG
test1-hash
test2-msg
PowerOFF

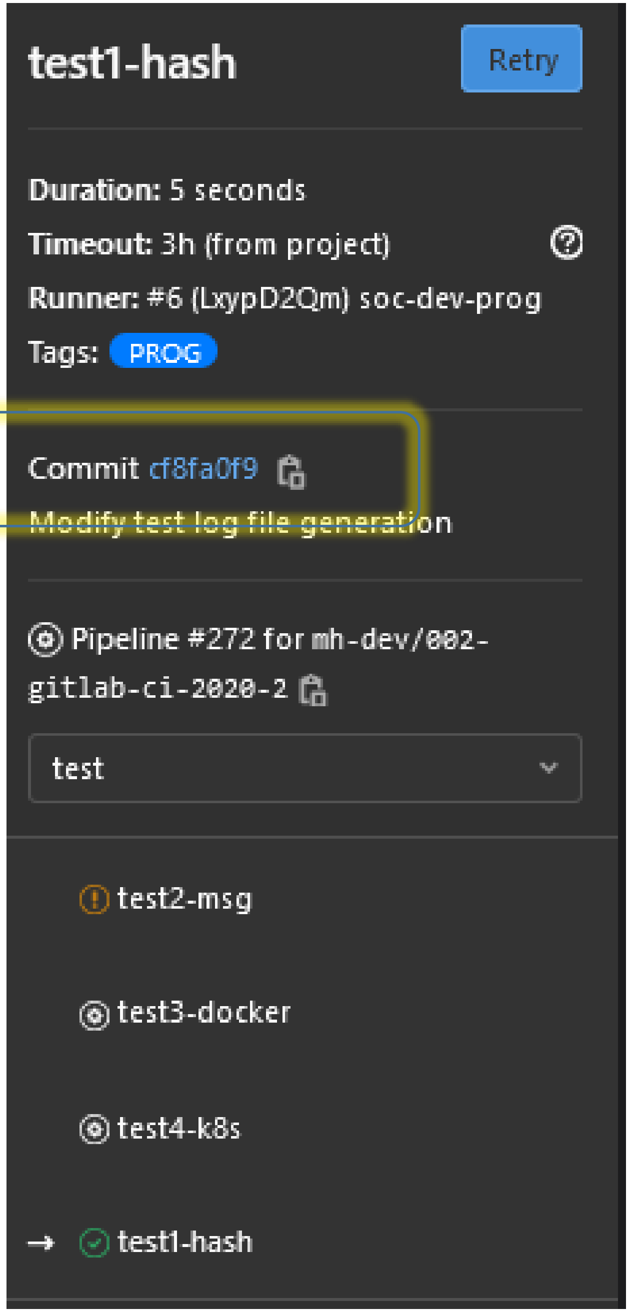
Four example tests (trivial)

- Check if the git hash injected into petalinux images matches pipeline commit hash
  - Parse result of “hostname” command (we injected hostname and and short git hash into ./peta20202/project-spec/configs/config file at build time).
- Execute basic script and check if the returned value matches expected response.
  - Parse result returned by our “trojan” command (we can adjust the message to inject errors: modify the file, commit && push, and observe test passing/failing).
- Check docker version and compare against expected value.
- Display kubectl version.
- All tests executed through password less ssh.



```yaml
test1-hash:
  stage: test
  needs: ["TFTP-NFS-JTAG"]
  script:
    - bash
    - sleep 5s
    - export RESP=$(ssh -q -o StrictHostKeyChecking=no -o UserKnownHostsFile=/dev/null 10.5.5.2 'hostname')
    - echo ${RESP}
    - export TST1=${CI_COMMIT_REF_SLUG}
    - echo $TST1
    - export TST2=${CI_COMMIT_SHA:0:8}
    - echo $TST2
    - export EXPECTED=($TST1-$TST2)
    - echo $EXPECTED
    - if [[ "$RESP" == "$EXPECTED" ]]; then echo "Test OK"; else echo "Test NOT passed" && exit 1; fi
  tags:
    - PROG
  rules:
    - if: '$CI_PIPELINE_SOURCE == "web"'
      allow_failure: true
```

```
$ export RESP=$(ssh -q -o StrictHostKeyChecking=no -o UserKnownHostsFile=/dev/null 10.5.5.3 'hostname')
$ echo ${RESP}
rfsoc4x2-cf8fa0f9
$ export TST1="rfsoc4x2"
$ echo $TST1
rfsoc4x2
$ export TST2=${CI_COMMIT_SHA:0:8}
$ echo $TST2
cf8fa0f9
$ export EXPECTED=($TST1-$TST2)
$ echo $EXPECTED
rfsoc4x2-cf8fa0f9
$ if [[ "$RESP" == "$EXPECTED" ]]; then echo "SUCCESS" > status.log; cat status.log; else echo "FAILED" > status.log; cat status.log; exit 1; fi
SUCCESS
Job succeeded
```



```yaml
test2-msg:
  stage: test
  needs: ["TFTP-NFS-JTAG"]
  script:
    - bash
    - sleep 5s
    - export RESP=$(ssh -q -o StrictHostKeyChecking=no -o UserKnownHostsFile=/dev/null 10.5.5.2 'trojan')
    - echo $RESP
    - if [[ $RESP == *"been here. Tony Halik"* ]]; then echo "Test OK"; else echo "Test NOT passed" && exit 1; fi
  tags:
    - PROG
  rules:
    - if: '$CI_PIPELINE_SOURCE == "web"'
      allow_failure: true
```

```
$ export RESP=$(ssh -q -o StrictHostKeyChecking=no -o UserKnownHostsFile=/dev/null 10.5.5.3 'trojan')
$ echo $RESP
been here. Tony Montana
$ if [[ $RESP == *"been here. Tony Halik"* ]]; then echo "SUCCESS" > status.log; cat status.log; else echo "FAILED" > status.log; cat status.log; exit 1; fi
FAILED
ERROR: Job failed: exit status 1
```

test2-msg

Retry

New issue

Duration: 5 seconds

Timeout: 3h (from project)

Runner: #6 (LxypD2Qm) soc-dev-prog

Tags: PROG

Commit cf8fa0f9

Modify test log file generation

Pipeline #272 for mh-dev/002-gitlab-ci-2020-2

test

→ test2-msg

test3-docker

test4-k8s

test1-hash

- from our recipes/recipes-apps/trojan/files/trojan

trojan 41 Bytes

```sh
#!/bin/sh

echo "been here. Tony Halik"

```

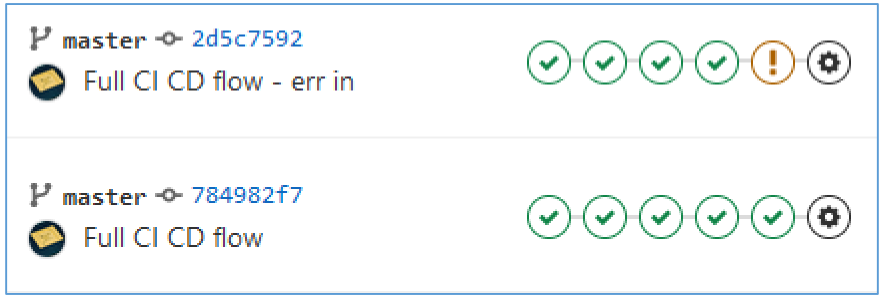
Lets inject some problems – Tony Montana back in Town !

- Modify `recipes/recipes-apps/trojan/files/trojan`
- Commit && rebuild

trojan 43 Bytes

```
#!/bin/sh

echo "been here. Tony Montana"

```

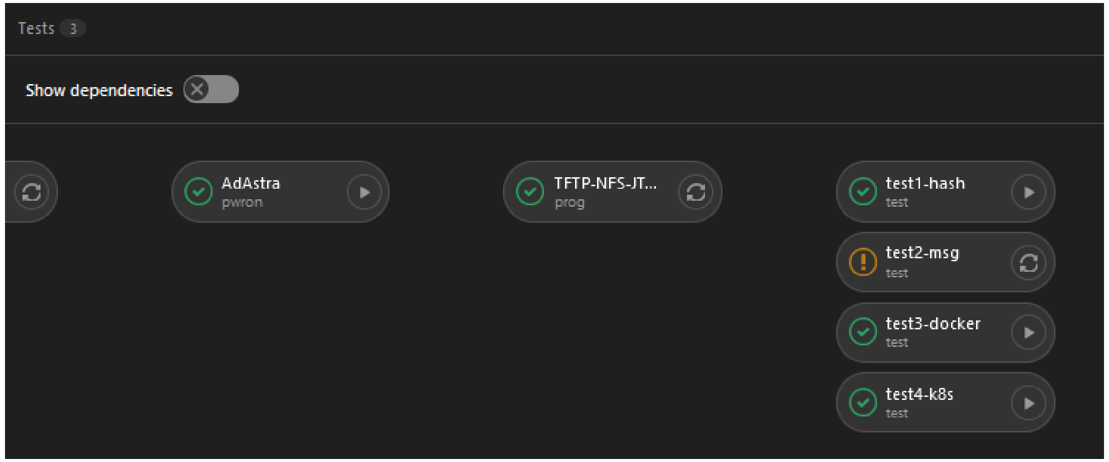
```
$ export RESP=$(ssh -q -o StrictHostKeyChecking=no -o UserKnownHostsFile=/dev/null 10.5.5.2 'trojan')
$ echo $RESP
been here. Tony Montana
$ if [[ $RESP == *"been here. Tony Halik"* ]]; then echo "Test OK"; else echo "Test NOT passed" && exit 1; fi
Test NOT passed
ERROR: Job failed: exit status 1
```



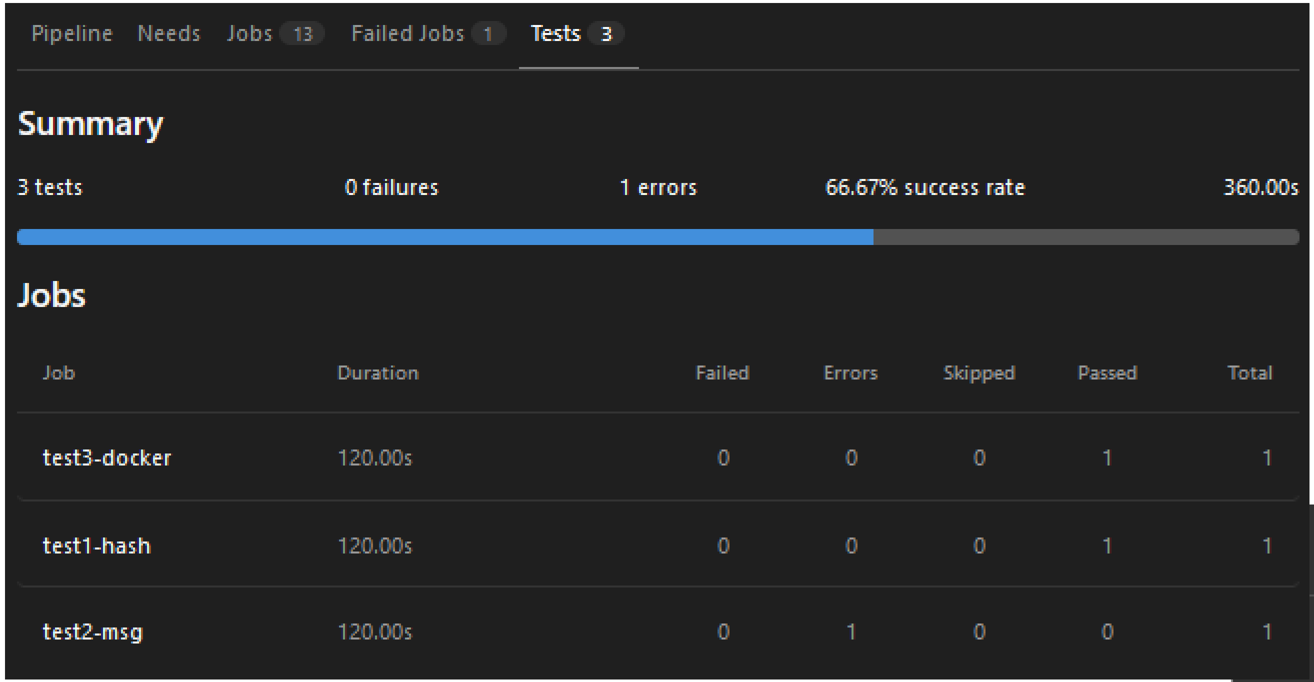
Gitlab CI test tab

- Lets use gitlab CI server backend to organize our testing reports.
- We will use junit reporting supported by gitlab CI.
- Each test (we have 4 of them) generates report.xml (in junit format).
- Junit report stored as an artifact – all per job reports combined into a single table.

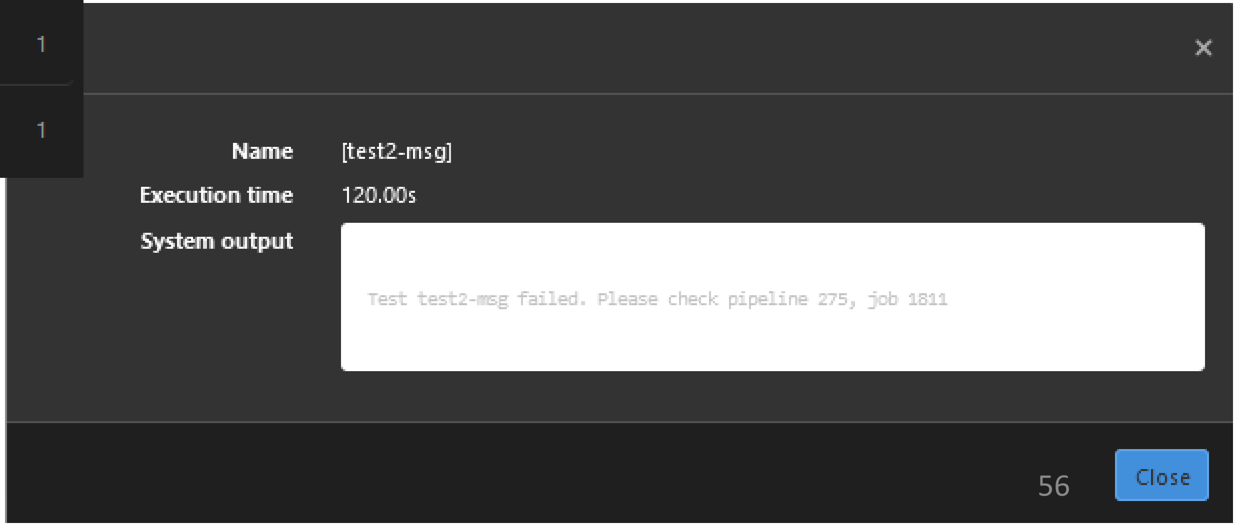
```
  - if [[ "$RESP" == "$EXPECTED" ]]; then echo "SU
  - source ./.gitlab/scripts/generate-junit-xml.sh
tags:
  - PROG
rules:
  - if: '$CI_PIPELINE_SOURCE == "web"'
    allow_failure: true
    when: manual
artifacts:
  when: always
  reports:
    junit:
      - report.xml
```



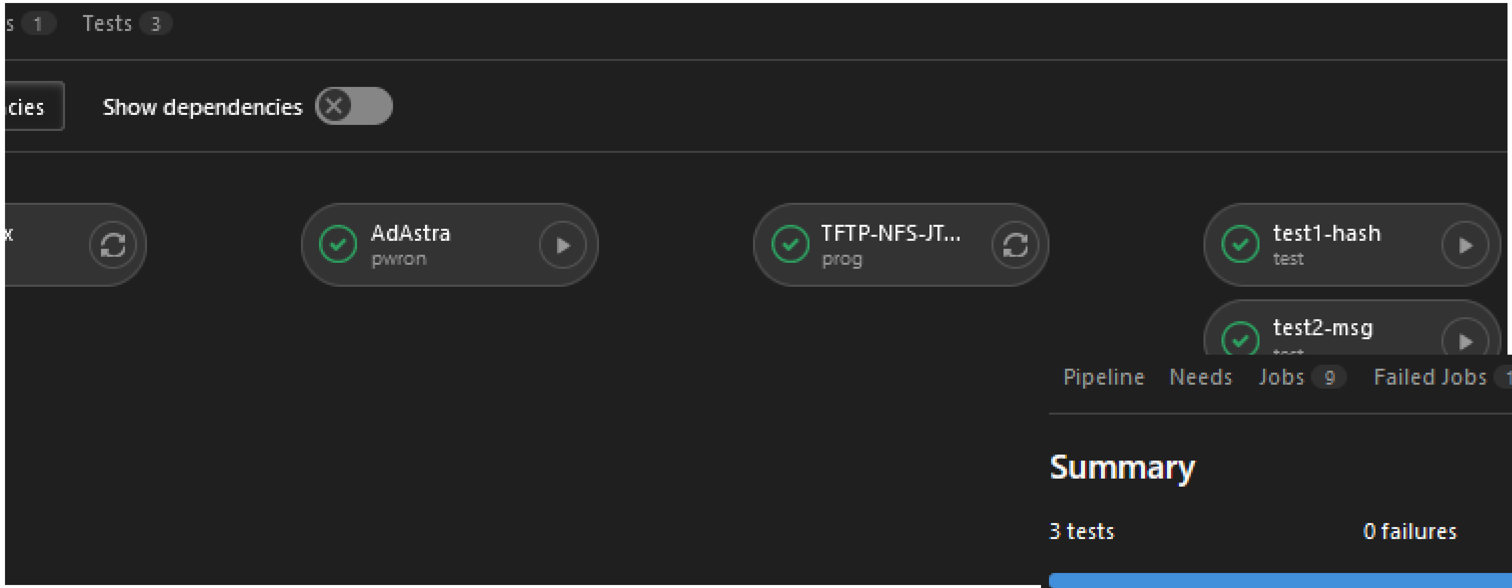
Combined test report and error details

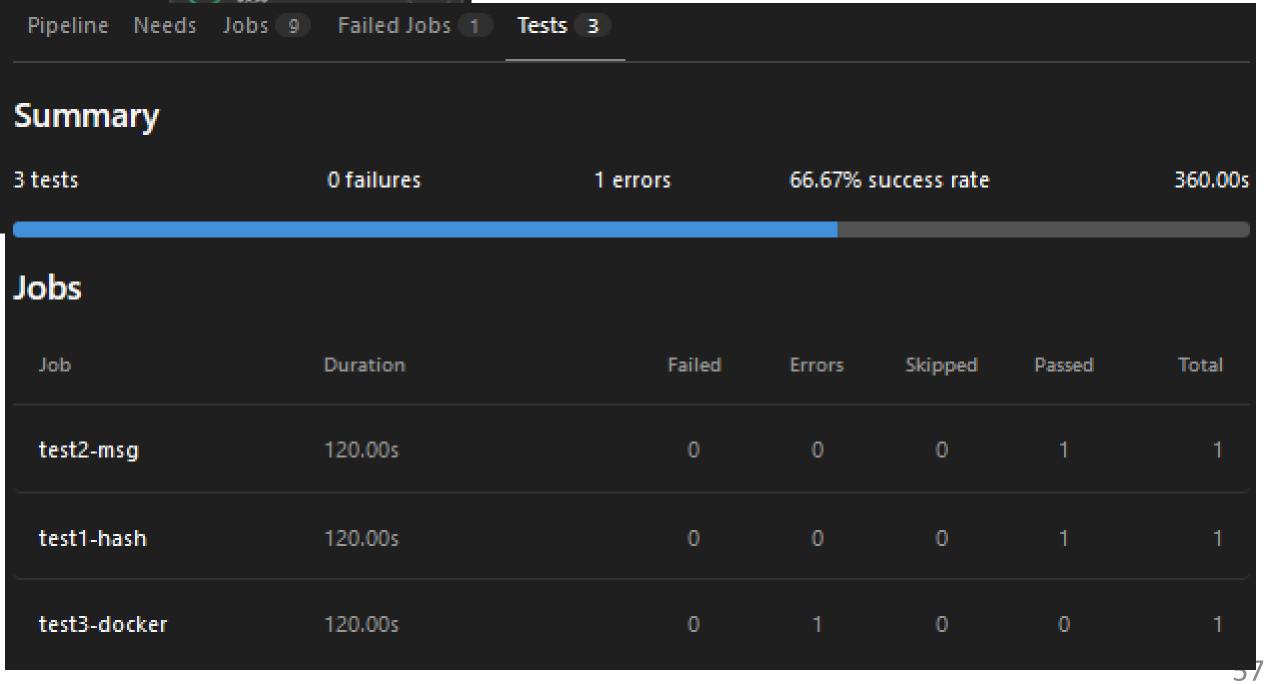


Job	Duration	Failed	Errors	Skipped	Passed	Total
test3-docker	120.00s	0	0	0	1	1
test1-hash	120.00s	0	0	0	1	1
test2-msg	120.00s	0	1	0	0	1



Fix the tst2

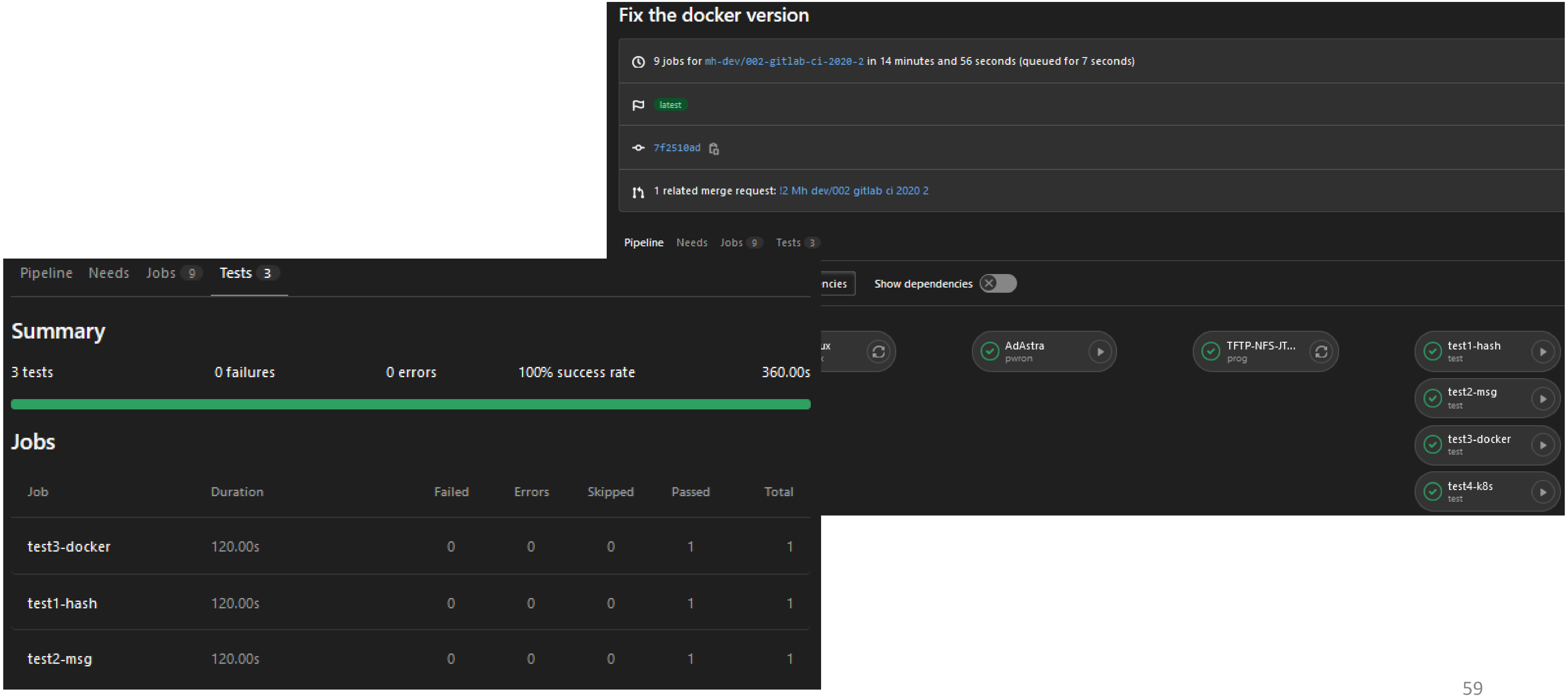




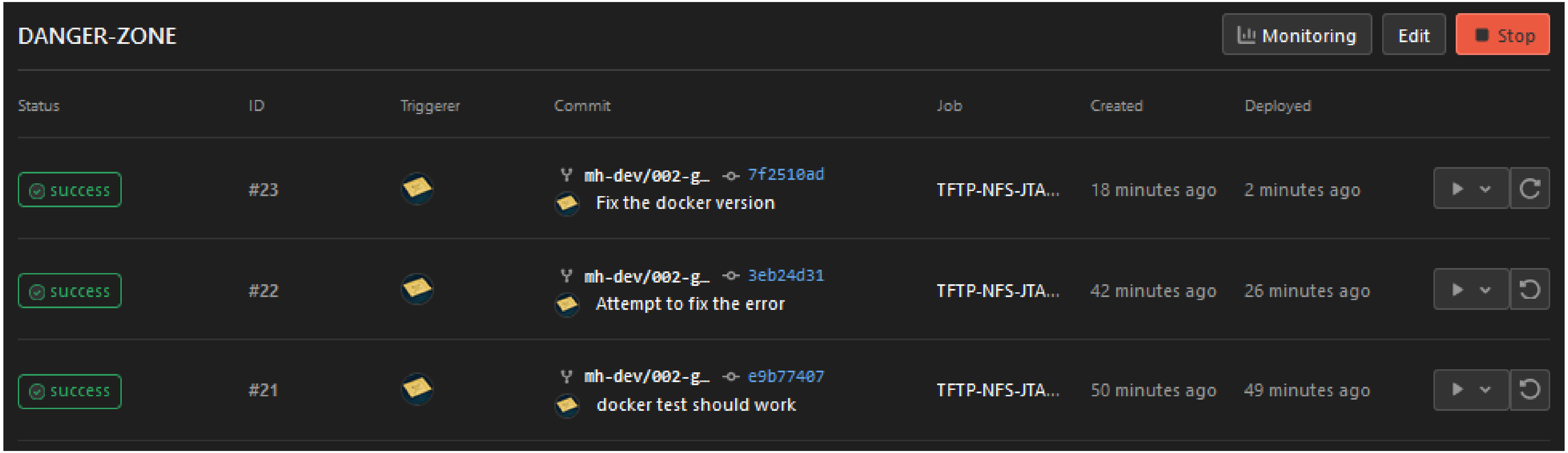
Job	Duration	Failed	Errors	Skipped	Passed	Total
test2-msg	120.00s	0	0	0	1	1
test1-hash	120.00s	0	0	0	1	1
test3-docker	120.00s	0	1	0	0	1

Gitlab environments – tracability of deployments to the DANGER-ZONE

3 times a charm – fix the errors



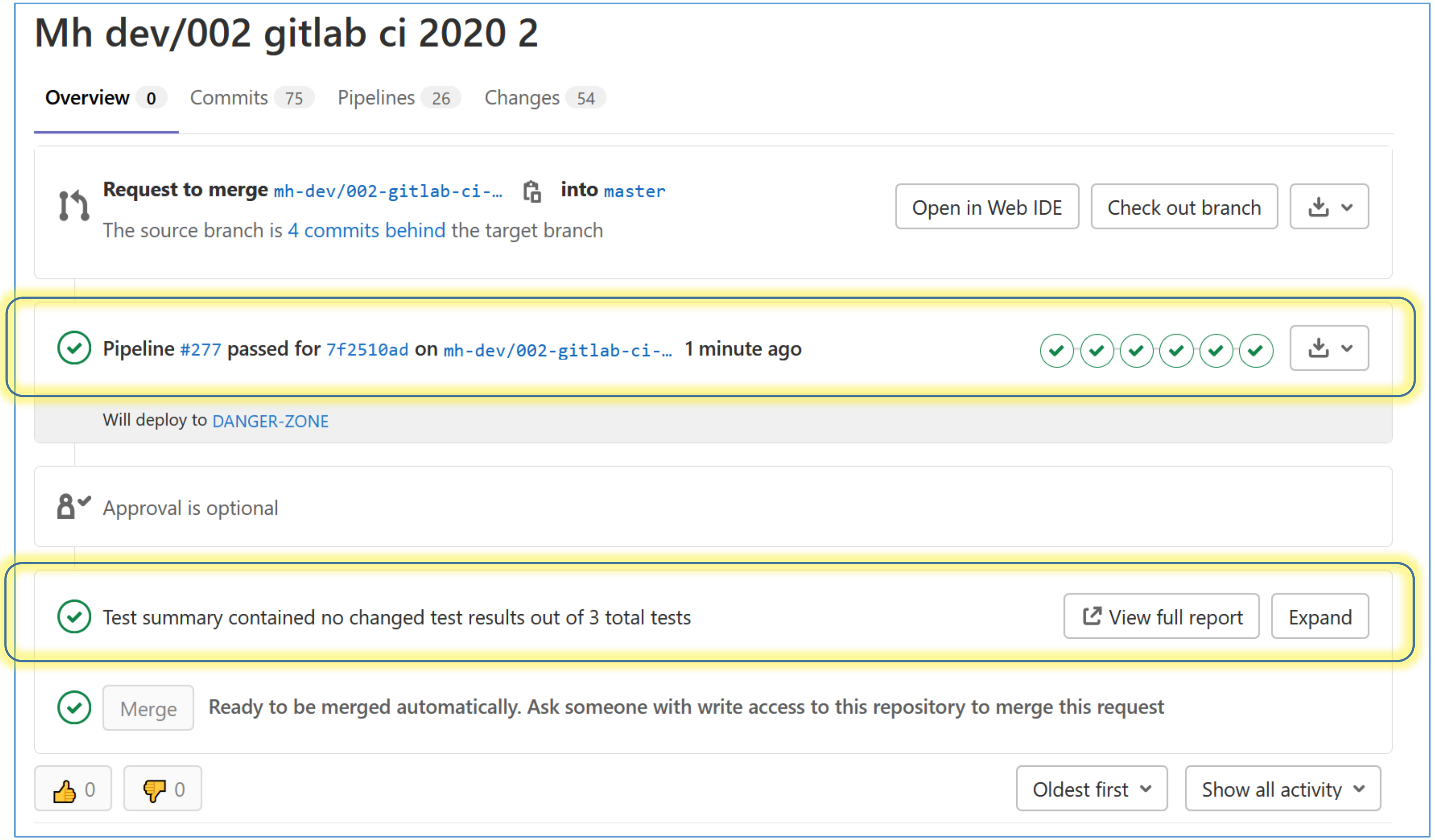
Gitlab Environments – tracing deployments


DANGER-ZONE

Monitoring Edit Stop

Status	ID	Triggerer	Commit	Job	Created	Deployed
success	#23		mh-dev/002-g… 7f2510ad Fix the docker version	TFTP-NFS-JTA…	18 minutes ago	2 minutes ago
success	#22		mh-dev/002-g… 3eb24d31 Attempt to fix the error	TFTP-NFS-JTA…	42 minutes ago	26 minutes ago
success	#21		mh-dev/002-g… e9b77407 docker test should work	TFTP-NFS-JTA…	50 minutes ago	49 minutes ago

Utlize test reports on merge requests



Next steps

- Clean the code and release it on gitlab.cern.ch
- Extend tutorial with a k3s cluster built out of the workstation (primary controller/tainted) and the dev kit (computing node).