Embedded Systems

Week 4: Embedded Linux Toolchain

Fenerbahçe University

Professor & TAs

Prof: Dr. Vecdi Emre Levent

Office: 311

Email: emre.levent@fbu.edu.tr

TA: Arş. Gör. Uğur Özbalkan

Office: 311

Email: ugur.ozbalkan@fbu.edu.tr

Petalinux ToolChain

- PetaLinux is an embedded Linux development solution for Xilinx ZYNQ chips as well as for MicroBlaze designs implemented in fully FPGA chips.
- Petalinux tool chain requires linux based host compilation environment

Petalinux ToolChain

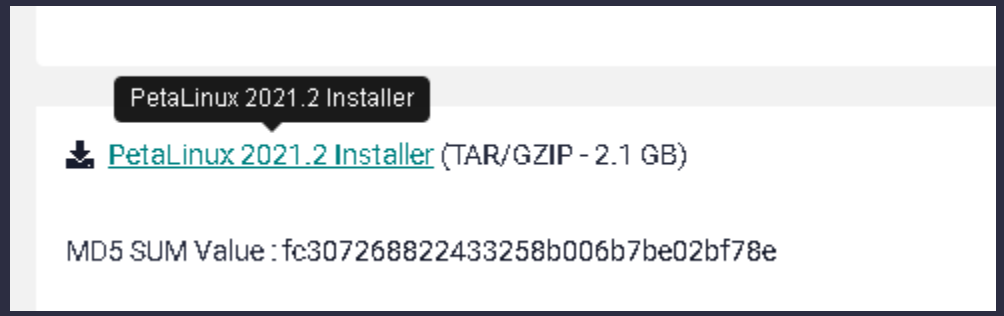
Suggested environment:

- Ubuntu 18.04 or 20.04
- 100 GB free disk space
- Petalinux 2021.2

Petalinux ToolChain

Download Petalinux:

- https://www.xilinx.com/support/download/index.html/content/xilinx/en/downloadNav/embedded-design-tools.html
- IMPORTANT: You need to download Petalinux version with same as your Vivado Version



- Click and Download

Petalinux ToolChain

Download Petalinux:

- Once you download you will find

  petalinux-v202X.X-final-installer.run file

```
emre@emre-VirtualBox:~/Downloads$ ls
petalinux-v2021.2-final-installer.run
pynq-supported-board-file-master.zip
Xilinx_Unified_2021.2_1021_0703_Lin64.bin
```

Petalinux ToolChain

Install Petalinux:

- Authorize for execution

  chmod u+x petalinux-v202.X.X-final-installer.run

```
emre@emre-VirtualBox:~/Downloads$ sudo chmod u+x petalinux-v2021.2-final-install
er.run
emre@emre-VirtualBox:~/Downloads$ ls -al
total 2483188
drwxr-xr-x  2 emre emre       4096 Oca 22 16:42 .
drwxr-xr-x 41 emre emre       4096 Oca 22 16:34 ..
-rwxrw-r--  1 emre emre 2255897193 Ara 16 15:13 petalinux-v2021.2-final-installe
r.run
-rw-rw-r--  1 emre emre     812456 Ara 16 20:59 pynq-supported-board-file-master
.zip
-rwxrw-r--  1 emre emre  286051682 Ara 16 15:09 Xilinx_Unified_2021.2_1021_0703_
Lin64.bin
```

Petalinux ToolChain

Install Petalinux:

- Execute petalinux-v202.X.X-final-installer.run

or

- ./petalinux-v<petalinux-version>-final-installer.run --dir <Path>

```
emre@emre-VirtualBox:~/Downloads$ ./petalinux-v2021.2-final-installer.run
INFO: Checking installation environment requirements...
WARNING: This is not a supported OS
INFO: Checking free disk space
INFO: Checking installed tools
INFO: Checking installed development libraries
INFO: Checking network and other services
WARNING: No tftp server found - please refer to "UG1144  PetaLinux Tools Documentation Reference Guide" for
its impact and solution
INFO: Checking installer checksum...
INFO: Extracting PetaLinux installer...

LICENSE AGREEMENTS

PetaLinux SDK contains software from a number of sources.  Please review
the following licenses and indicate your acceptance of each to continue.

You do not have to accept the licenses, however if you do not then you may
not use PetaLinux SDK.

Use PgUp/PgDn to navigate the license viewer, and press 'q' to close

Press Enter to display the license agreements
```

Petalinux ToolChain

Install Petalinux:

- Accept License Agreement with type enter and Q and Y with 2 times

```
emre@emre-VirtualBox:~/Downloads$ ./petalinux-v2021.2-final-installer.run
INFO: Checking installation environment requirements...
WARNING: This is not a supported OS
INFO: Checking free disk space
INFO: Checking installed tools
INFO: Checking installed development libraries
INFO: Checking network and other services
WARNING: No tftp server found - please refer to "UG1144  PetaLinux Tools Documentation Reference Guide" for
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INFO: Checking installer checksum...
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Press Enter to display the license agreements
```

Petalinux ToolChain

Install Petalinux:

- Petalinux will ask install location

```
WARNING: By default, it will be installed in your working directory: /home/emre/Downloads
******************************************
Please input "y" to proceed the installation, "n" to exit otherwise:y
```

Petalinux ToolChain

Install Petalinux:

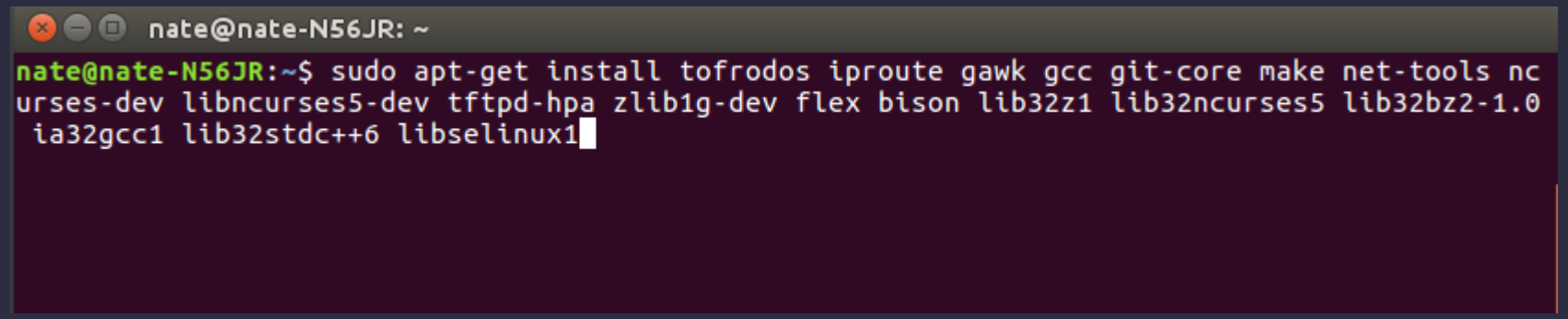
- After successfully installation, you will get below infos

```
INFO: Checking PetaLinux installer integrity...
INFO: Installing PetaLinux SDK to "/home/emre/Downloads/."
INFO: Installing buildtools in /home/emre/Downloads/./components/yocto/buildtools
INFO: Installing buildtools-extended in /home/emre/Downloads/./components/yocto/buildtools_extended
INFO: PetaLinux SDK has been installed to /home/emre/Downloads/.
```

Petalinux ToolChain

Install Petalinux:

- Before using petalinux you need to install depended packages

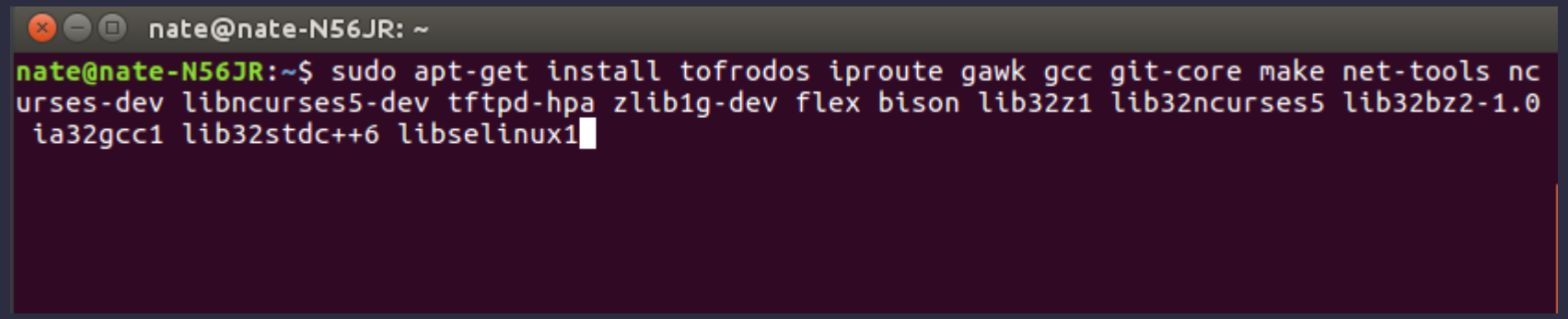


There can be more package to install, check error logs and install required packages

Petalinux ToolChain

Install Petalinux:

- Before using petalinux you need to install depended packages



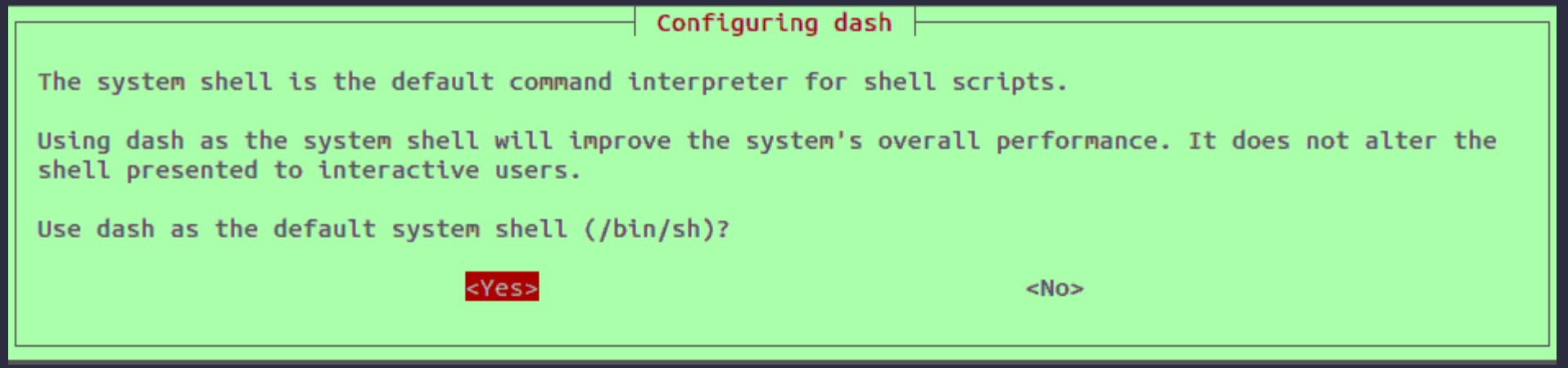
There can be more package to install, check error logs and install required packages

Petalinux ToolChain

Install Petalinux:

- Your shell need to be "bash", set your shell to bash

sudo dpkg-reconfigure dash



Type no

Petalinux ToolChain

Install Petalinux:

- Call petalinux settings.sh file, this file setups petalinux tools for current terminal

source <petalinuxPath>/settings.sh

```
emre@emre-VirtualBox:~/Downloads$ source /tools/Xilinx/petalinux/settings.sh
PetaLinux environment set to '/tools/Xilinx/petalinux'
WARNING: This is not a supported OS
INFO: Checking free disk space
INFO: Checking installed tools
INFO: Checking installed development libraries
INFO: Checking network and other services
WARNING: No tftp server found - please refer to "UG1144 2021.2 PetaLinux Tools Documentation Reference Guide
" for its impact and solution
```

Petalinux ToolChain

Install Petalinux:

- Verifying petalinux settings are correct

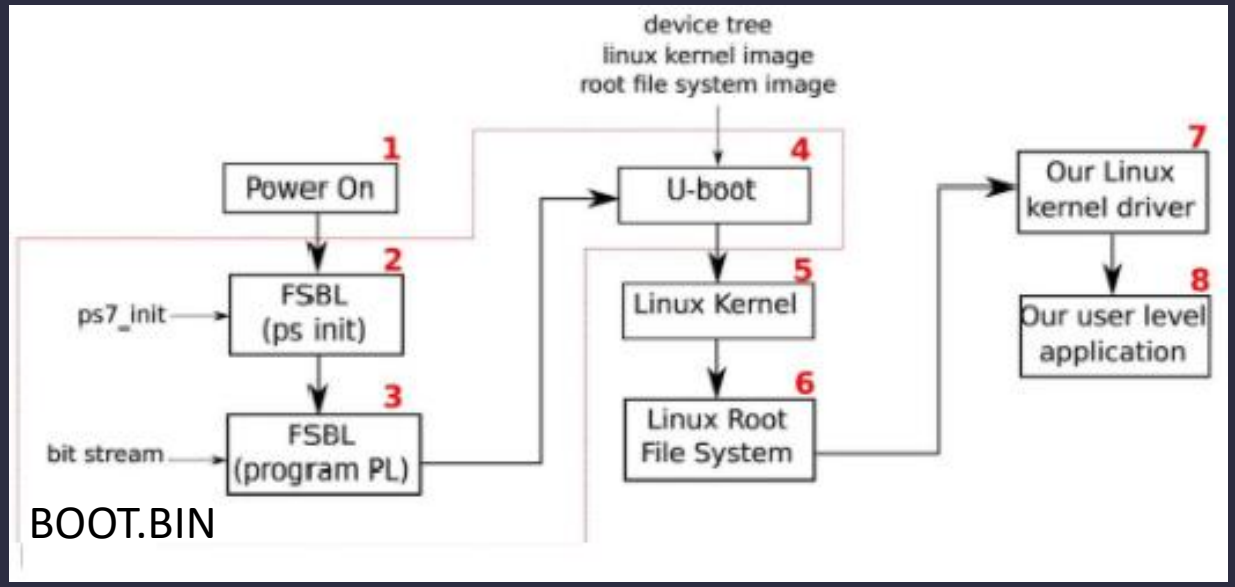
```
emre@emre-VirtualBox:~/Downloads$ echo $PETALINUX
/tools/Xilinx/petalinux
```

Petalinux ToolChain

Petalinux Bootup Sequence

Boot process:

- Internal BootROM code is executed on CPU0 (APU).
- Configures the system and fetches the First State Boot Loader to OCM.
- Starts executing the FSBL
- Program PL
- Execute U-Boot
- Load Kernel
- Load FS



Petalinux ToolChain

Petalinux toolchain table

Design Flow Step	Tool
Create a PetaLinux project	petalinux-create -t project
Initialize a PetaLinux project (for custom hardware only)	petalinux-config --get-hw-description
Configure system-level options	petalinux-config
Configure U-Boot	petalinux-config -c u-boot
Configure the Linux kernel	petalinux-config -c kernel
Configure the root filesystem	petalinux-config -c rootfs
Build the system	petalinux-build
Package for deploying the system	petalinux-package
Boot the system for testing	petalinux-boot

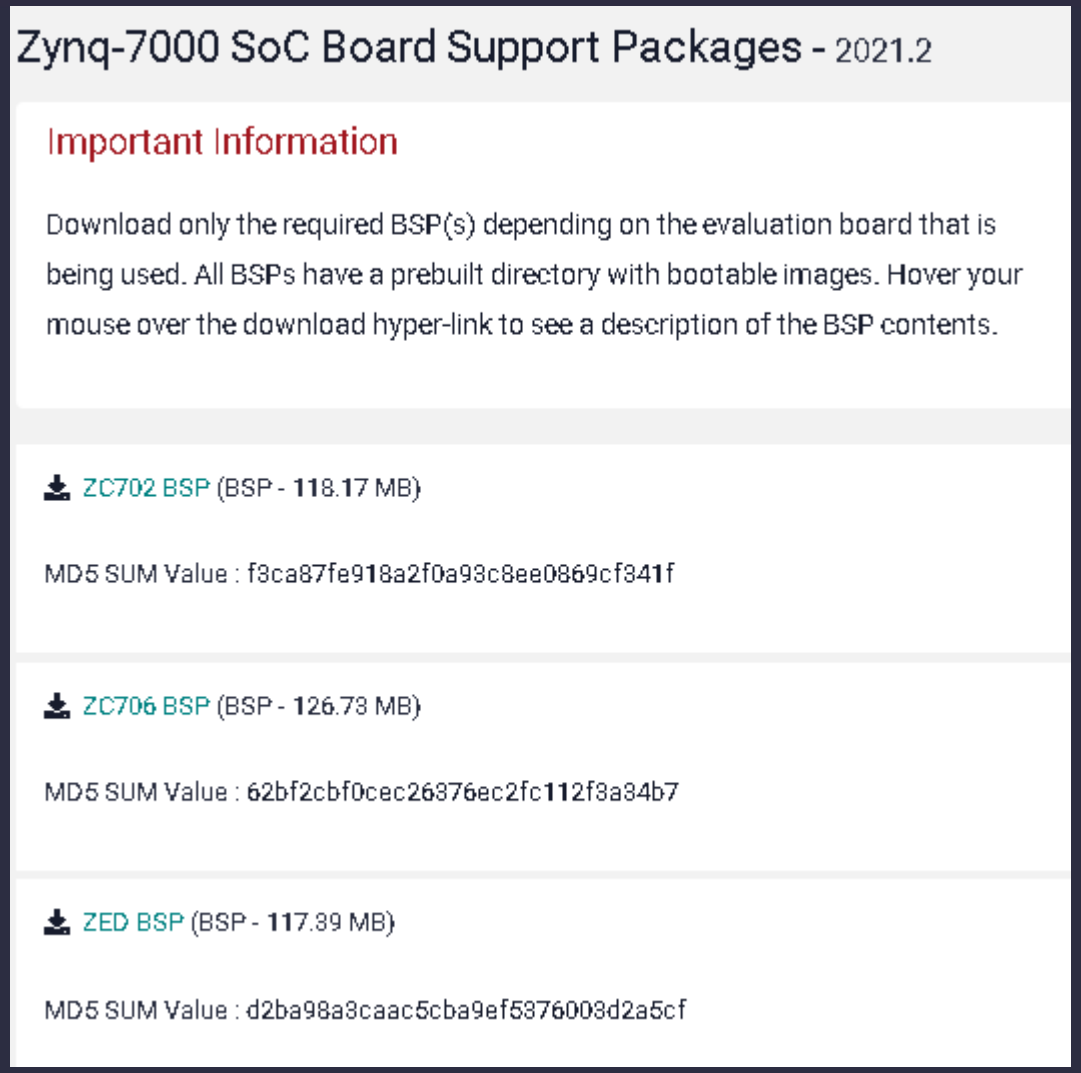
Petalinux ToolChain

Creating a petalinux project

petalinux-create -t project -s test.bsp

BSP download address:

https://www.xilinx.com/support/download/index.html/content/xilinx/en/downloadNav/embedded-design-tools.html



Petalinux ToolChain

Creating a petalinux project

petalinux-create --type project --template <PLATFORM> --name <PROJECT_NAME>

petalinux-create --type project --template zynq --name projectName

Available platforms:

- versal (for Versal ACAP)
- zynqMP (for Zynq UltraScale+ MPSoC)
- zynq (for Zynq-7000 devices)
- microblaze (for MicroBlaze™ processor)

Petalinux ToolChain

Creating a petalinux project

```
emre@emre-VirtualBox:~/Downloads$ petalinux-create --type project --template zynq --name test
INFO: Create project: test
INFO: New project successfully created in /home/emre/Downloads/test
emre@emre-VirtualBox:~/Downloads$
emre@emre-VirtualBox:~/Downloads$ cd test
emre@emre-VirtualBox:~/Downloads/test$ ls
config.project  project-spec
```

Petalinux ToolChain

Petalinux Configuration

After creating petalinux project, you need to configure linux kernel setting with exported XSA file

petalinux-config --get-hw-description <PATH-TO-XSA Directory>

On the given path, there must be only one XSA file, otherwise petalinux tool will give error

```
emre@emre-VirtualBox:~/Downloads/test$ petalinux-config --get-hw-description ../../project_11/
[INFO] Sourcing buildtools
INFO: Getting hardware description...
INFO: Renaming design_1_wrapper.xsa to system.xsa
[INFO] Generating Kconfig for project
```

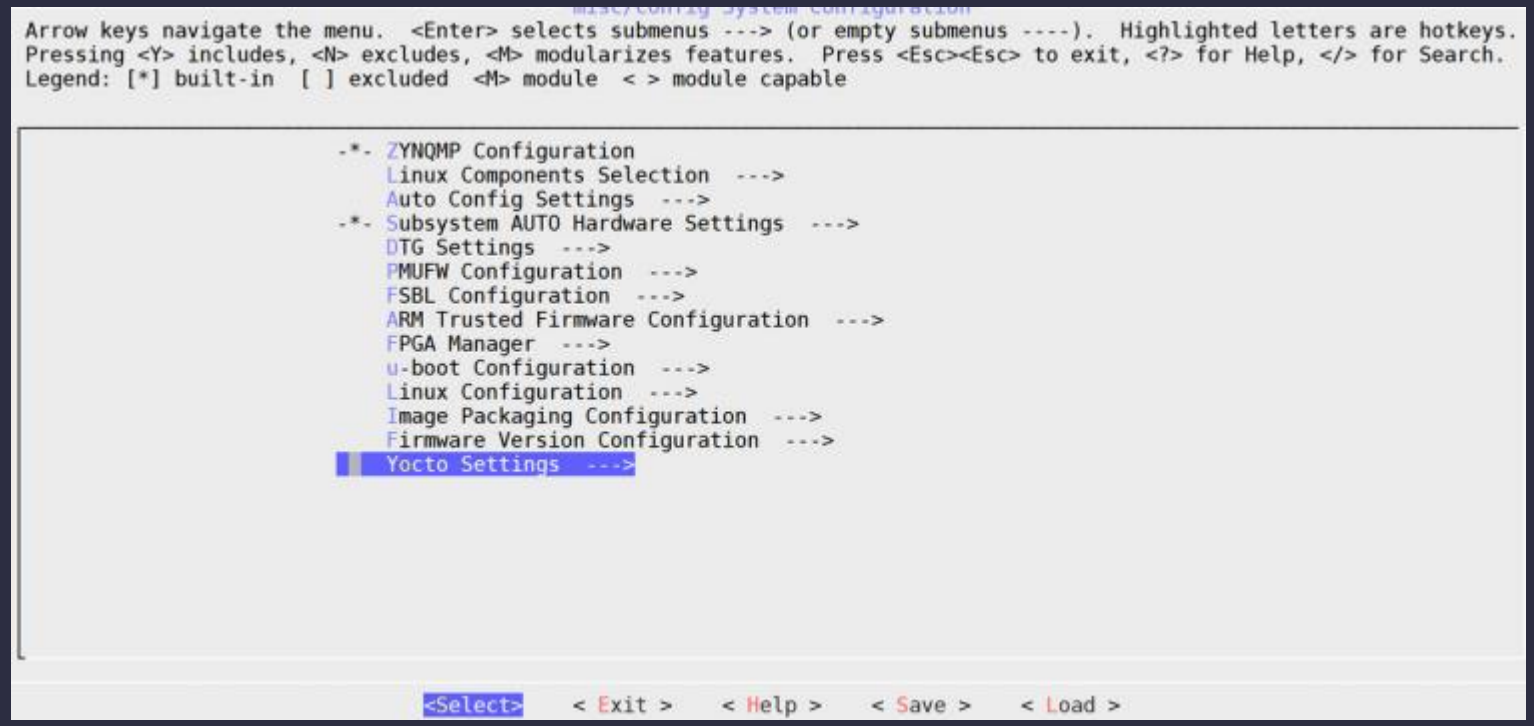
Petalinux ToolChain

Petalinux Configuration

Config tool will open a GUI

You may change general settings from this menu

After configuration finished, goto Exit



Petalinux ToolChain

Petalinux Configuration

After configuration, config tool will give these output logs

```
emre@emre-VirtualBox:~/Downloads/test$ petalinux-config --get-hw-description ../../project_11/
[INFO] Sourcing buildtools
INFO: Getting hardware description...
INFO: Renaming design_1_wrapper.xsa to system.xsa
[INFO] Generating Kconfig for project
[INFO] Menuconfig project
configuration written to /home/emre/Downloads/test/project-spec/configs/config

*** End of the configuration.
*** Execute 'make' to start the build or try 'make help'.

[INFO] Extracting yocto SDK to components/yocto. This may take time!
[INFO] Sourcing build environment
[INFO] Generating kconfig for Rootfs
[INFO] Silentconfig rootfs
[INFO] Generating plnxtool conf
[INFO] Adding user layers
[INFO] Generating workspace directory
```

Petalinux ToolChain

Petalinux Build

petalinux-build

```
emre@emre-VirtualBox:~/Downloads/test$  petalinux-build
[INFO] Sourcing buildtools
[INFO] Building project
[INFO] Sourcing build environment
[INFO] Generating workspace directory
INFO: bitbake petalinux-image-minimal
NOTE: Started PRServer with DBfile: /home/emre/Downloads/test/build/cache/prserv.sqlite3, IP: 127.0.0.1, POR
T: 34545, PID: 31914
Loading cache: 100% |                                                    | ETA:  --:--:--
Loaded 0 entries from dependency cache.
Parsing recipes:  30% |######################                             | ETA:  0:00:59
```

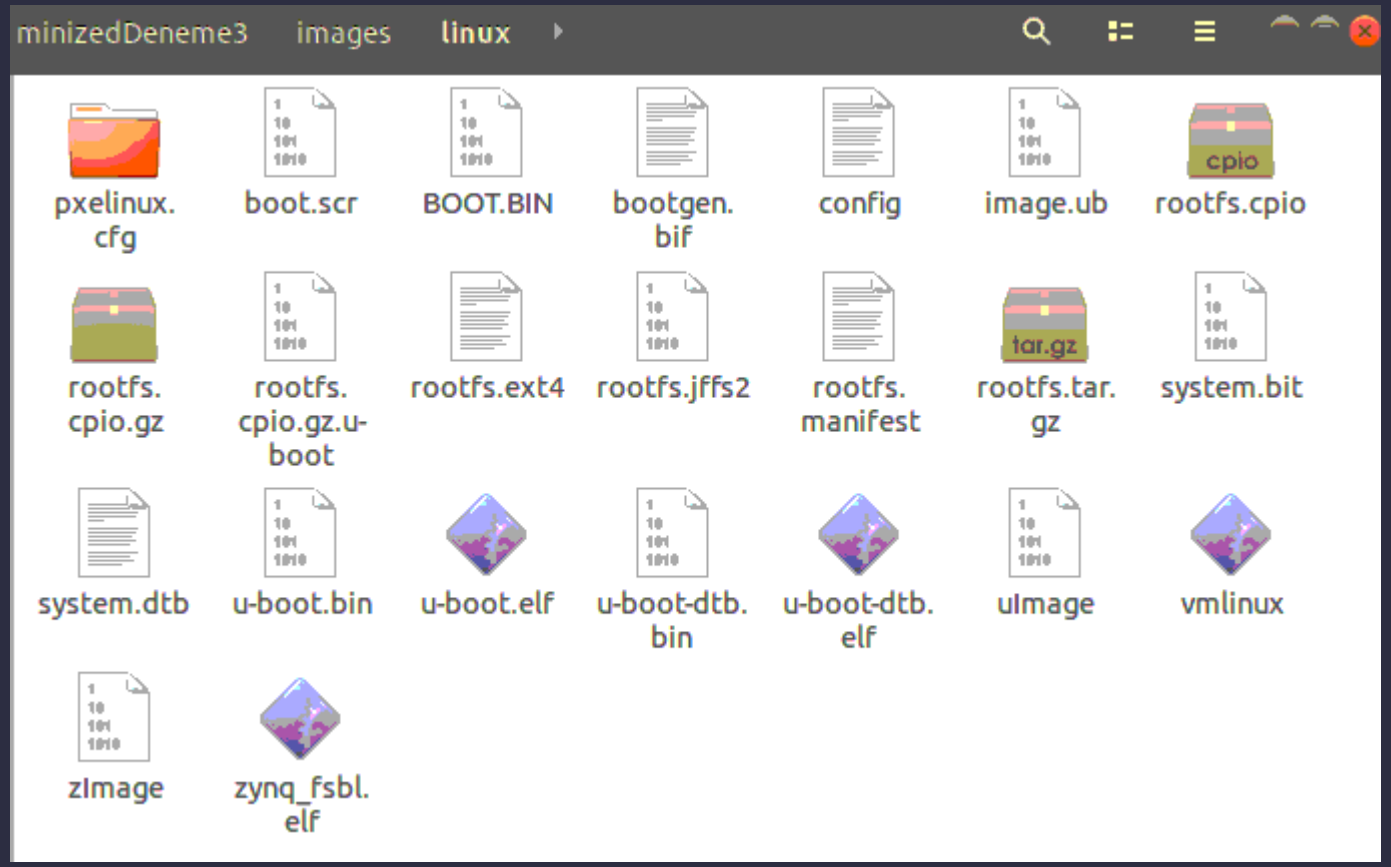
This command can take hours depends on internet connection speed and CPU power

Petalinux ToolChain

Petalinux Build

After build complation you can get builded images on

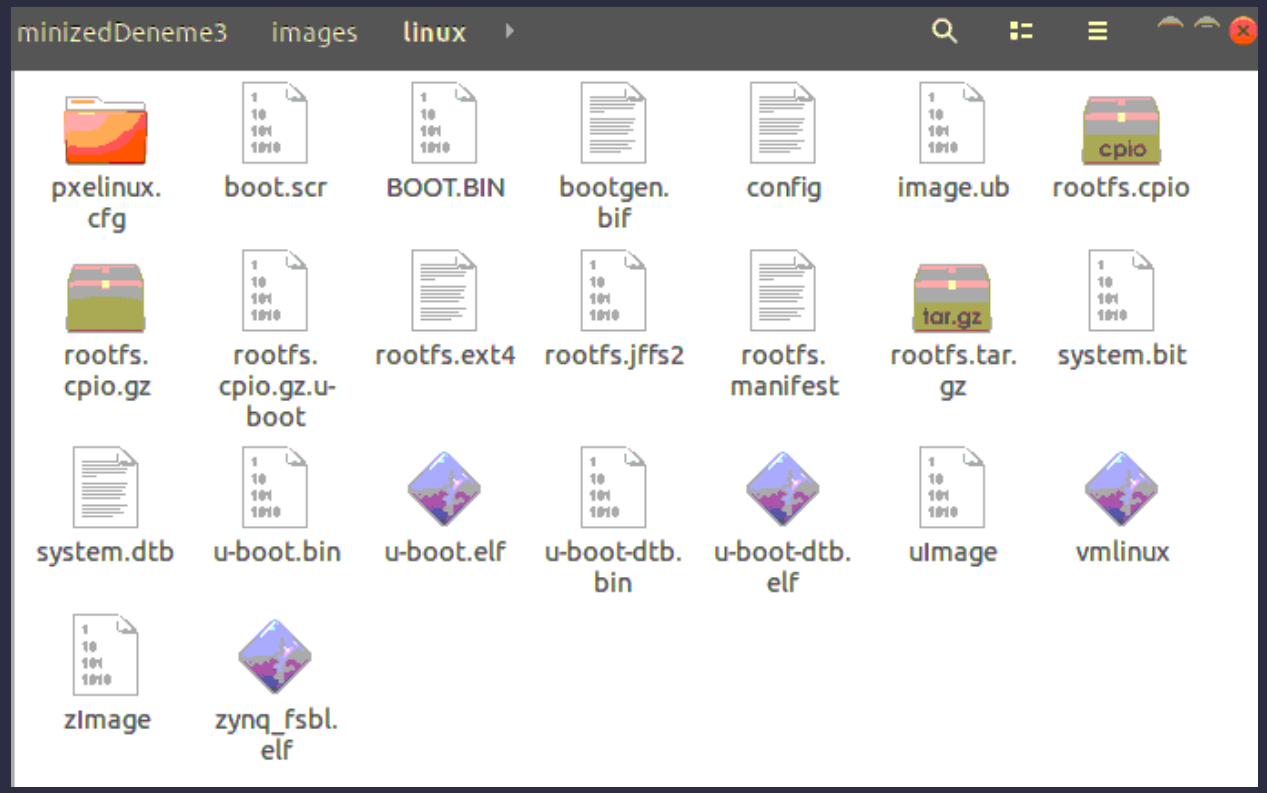
<plnx-proj-root>/images/linux



Petalinux ToolChain

Petalinux Build

- BOOT.BIN: Contains FSBL, system.bit, U-BOOT
- image.ub: Kernel image and device tree
- zimage: Kernel + RootFS (ZYNQ 7000)
- image: Kernel + RootFS (MPSOC & Versal)
- image.elf: Kernel + RootFS (Microblaze)
- ROOTFS.TAR.GZ: YOCTO Filesystem



Petalinux ToolChain

Device tree

- Introduced in kernel 2.6 as a way to describe non-discoverable hardware – Embedded systems (usually) don't have BIOS, ACPI and/or UEFI.
- The same information was previously hard-coded in the source code

Is a data structure, describing:

- The number and type of CPUs, size of RAM
- I/O memory mapping and resources
  - Base address, size, IRQs,
- Kernel Command Line Arguments
- The format allows to describe almost anything

The device tree source is described in a text files (.dts) and compiled by Device Tree Compiler (dtc) into a binary format (.dtb blob file)