Developing with PetaLinux for the Ultra96

SAN19-314

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Self Introduction

- Avnet – 12 years
- Global Products & Emerging Technologies Team
  - Technical training courses
  - Reference designs
  - PetaLinux BSPs
  - Dev board development
  - Embedded Linux & software development for Zynq, Zynq MPSoC, and MicroBlaze

Agenda

- **Intro to Ultra96-V2**
- Intro to Zynq MPSoC architecture
- Intro to PetaLinux
- Anatomy of a PetaLinux build
- Integrating a custom device driver
- Intro to Vivado and Petalinux build scripts
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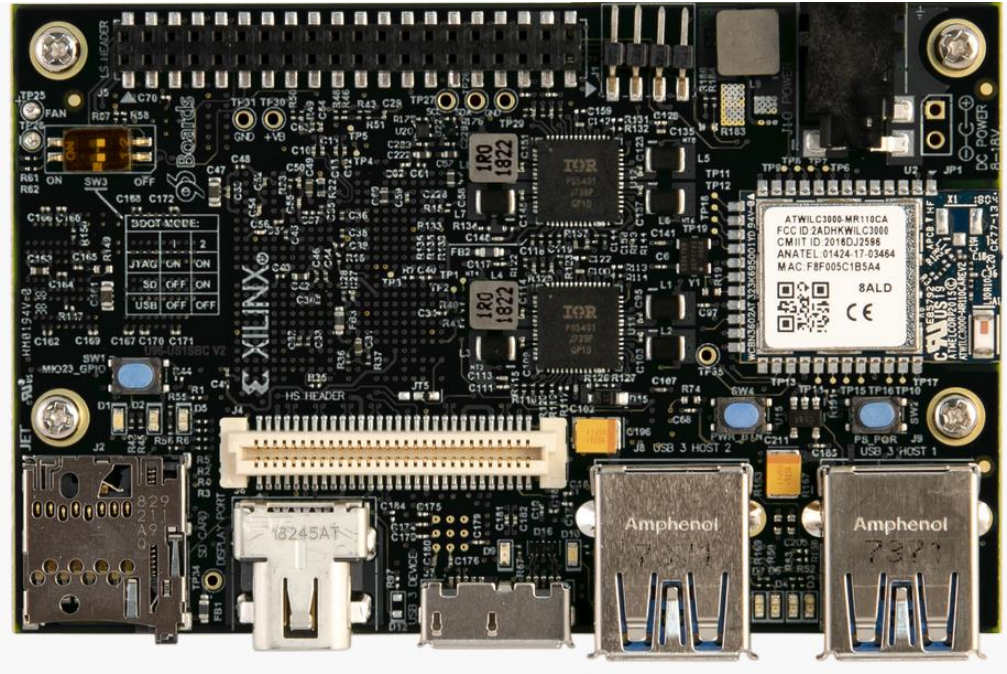
Ultra96-V2 Kit

- 96boards Consumer Edition
- What's in the box?
  - Ultra96-V2 featuring Zynq MPSoC ZU3EG
  - 16 GB MicroSD card + adapter
  - 1 Year SDSoC License Voucher
  - Quick Start Instructions
- Available online from Xilinx:
  - SDSoC, SDK, Vivado WebPACK (supports ZU3EG)
  - PetaLinux
- From Avnet: http://avnet.me/ultra96-v2
  - Schematics, BOM, UG, etc.
  - Tutorials and reference designs



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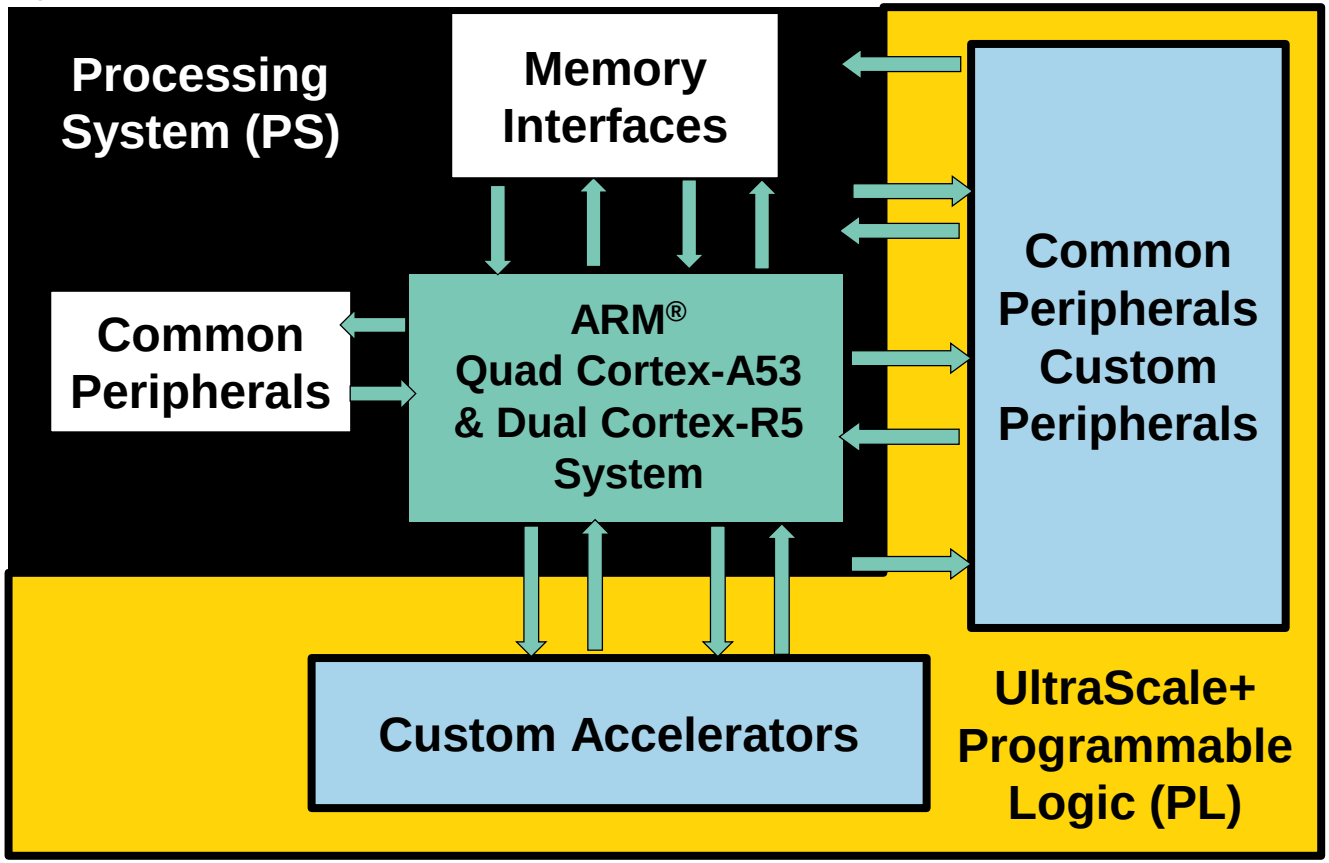
Zynq UltraScale+ MPSoC Architecture



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Intro to PetaLinux

- A build system:
  - A set of open-source cross-platform development command line and menu tools for use running under an x86 Linux Host OS
  - Tailors embedded Linux to run on many Xilinx platforms: Zynq MPSoC, Zynq and MicroBlaze.
  - PetaLinux tools now use the open-source community Yocto system since v2016.3
    - This is very useful for embedded Linux developers!
  - Also includes an emulator (QEMU) that can emulate PetaLinux under x86 Linux
    - Very useful for Kernel and some device driver development
- A productivity layer:
  - Just six PetaLinux commands (with many options):

    petalinux-create, petalinux-config, petalinux-build, petalinux-boot, petalinux-package, petalinux-util

PetaLinux vs Other Linux Dev Tools

- Ease of integration of customized hardware platforms
  - Zynq SoCs and FPGAs are endlessly configurable in ways that other ARM SoCs are not
  - Import PL bitstream and PS configuration
- Automatic devicetree generation based on Vivado import
- Automatic system peripheral detection
  - STDIO UART, etc.
- Other Linux providers will run on Zynq & Zynq MPSoC, but their build tools don't have a way to import the hardware definition from Vivado

What's Included

- Source code, libraries, applications and Yocto recipes
  - Mostly open-source based with a few exceptions for some hardware drivers
  - PetaLinux includes and manages the Linux kernel sources and libraries
  - Various hardware drivers and modules
  - Traditional Linux applications and utilities

- Through Yocto, PetaLinux can make use of additional embedded Linux applications beyond what Xilinx supplies.
  - More on that later!

PetaLinux Build Products

- Bootloaders and firmware
  - FSBL, ARM Trusted Firmware, PMU Firmware, u-boot
- A Linux OS image that runs on Xilinx Zynq MPSoC, Zynq, and MicroBlaze CPUs
  - 2018.x uses Linux kernel version 4.14
  - 2019.x uses Linux kernel version 4.19
  - For single or multiple CPUs
- Linux applications, device drivers and lots of logs and configuration files
- Detailed hardware and memory requirements can be found here: http://avnet.me/xilinx_ug1144

PetaLinux Tools Testing, Release, and Documentation

- u-boot, Linux kernel, Xen hypervisor
  - Sources:
    - Kernel.org + Xilinx patches & additions
  - Testing:
    - Xilinx silicon
    - Xilinx reference board features
  - Documentation:
    - Source code
    - Open source communities/forums
    - Answer Records for select interim issues
- Linux file system
  - Sources:
    - Yocto community code base
  - Testing:
    - Build verification
    - Testing of Xilinx-unique software and features
  - Release strategy:
    - Bug fixes with next Yocto release integration
  - Documentation:
    - Source code
    - Open source communities/forums

Linux Boot for Zynq MPSoC

Linux

U-Boot

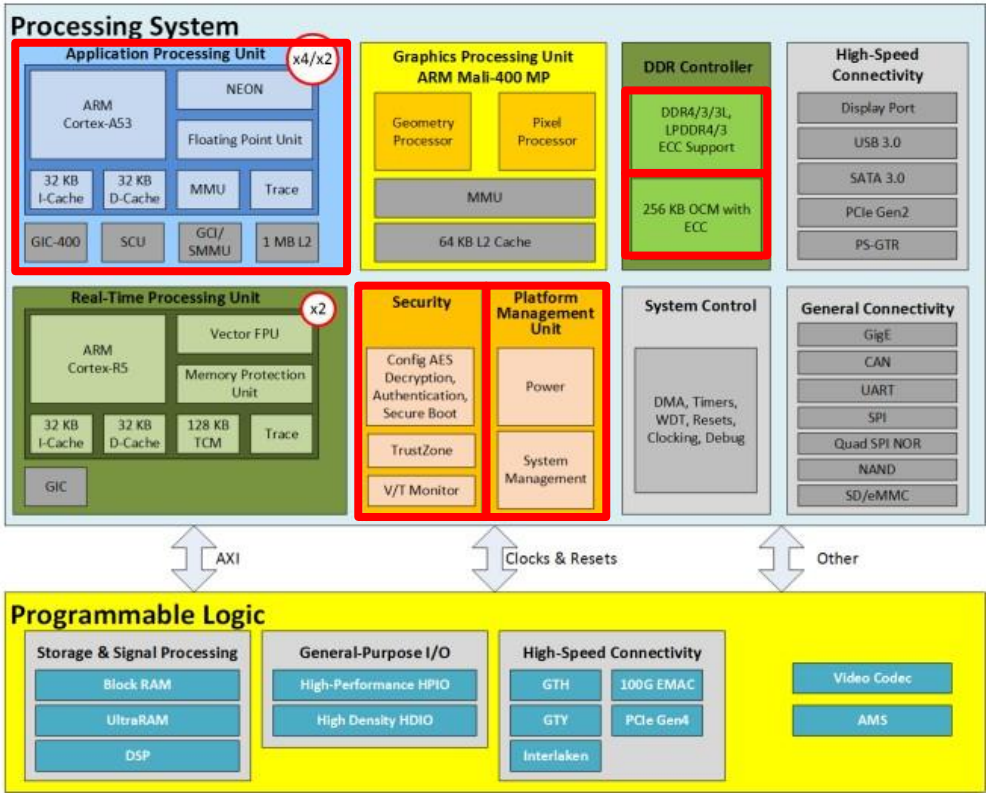
ARM Trusted Firmware

PMU Firmware

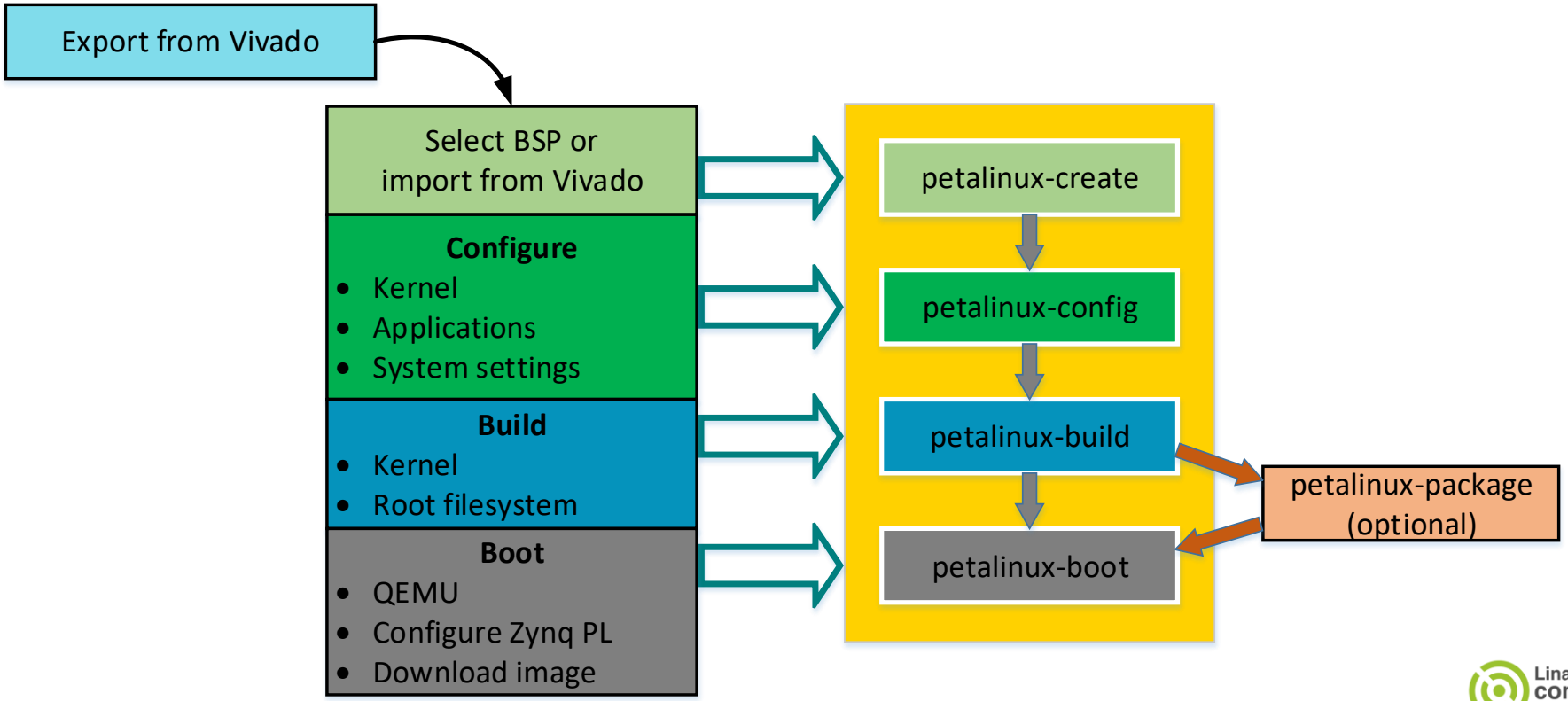
FSBL

Security | ARM Cortex-A53 | PMU

Programmable Logic | I/O | GPU | RPU

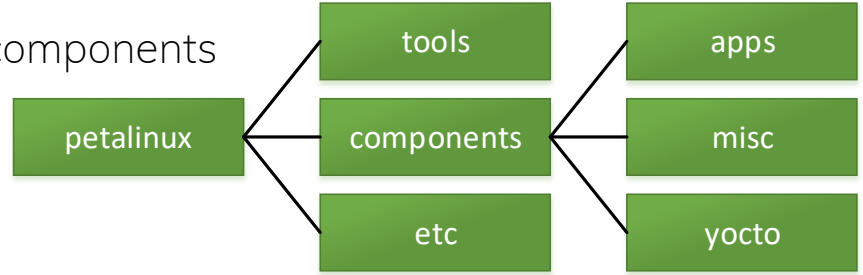


PetaLinux Tools Flow

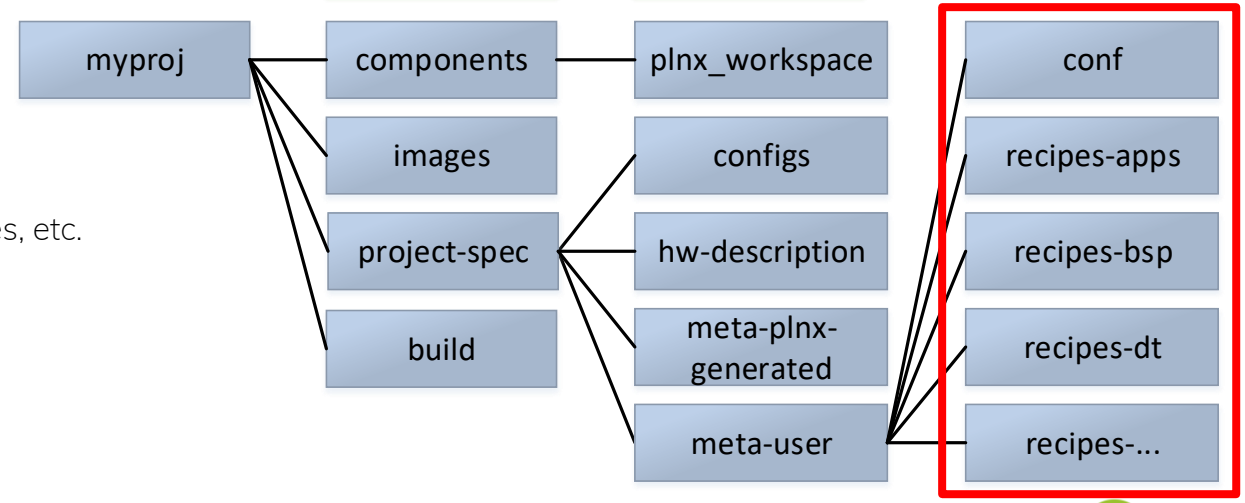


PetaLinux Install and Project Taxonomy

- Tools and default source components in install area



- Per-project directory
  - Configuration files
  - Custom recipes
    - Applications, scripts, libraries, etc.
  - Build products



PetaLinux and Yocto

- PetaLinux supports and is supported by the Yocto ecosystem
- PetaLinux tools have the ability to integrate Yocto-generated RPM feeds into the native configured Linux filesystem
  - Allows designs to fully leverage in-house and Yocto-community software
- Yocto build system can generate the complete PetaLinux filesystem
  - Ensures that all Yocto-built software is library-compatible with Xilinx-provided software
  - Allows comprehensive revision and source control
- Xilinx provides Yocto recipes for all PetaLinux components
  - ARM Trusted Firmware
  - PMU Firmware
  - u-boot
  - Kernel
  - Root filesystem

PetaLinux and Bitbake

- PetaLinux commands abstract the details of the bitbake commands
  - Creation of new software applications, kernel modules (drivers), scripts, etc.
  - Add new bitbake recipes
  - Additions to configuration menus
  - Build, clean, config
  - Installation onto the root file system

- Easy edits to makefile and recipe as application complexity grows
  - Add source files, etc.

- PetaLinux command to build the root file system becomes bitbake command…

```
$ petalinux-build -c rootfs
```

```
$ bitbake petalinux-user-image -c do_rootfs
```

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Create a PetaLinux Project

- **petalinux-create**
  - Creates a new PetaLinux project or component
  - Usage

```
petalinux-create [options] \
-t|--type <TYPE> \
-n|--name <COMPONENT_NAME>
```

Select BSP or import from Vivado

Required/Optional	Available Type
`-t, --type <TYPE>`	`project` - Create a PetaLinux project `apps` - Create an application `libs` - Create a library `modules` - Create a module
`-n, --name <COMPONENT_NAME>`	Specify name for the component/project Not required if BSP is specified

Configuring a PetaLinux Project

- **petalinux-config**
  - Configures the PetaLinux project or component
  - Usage

Configure
- Kernel
- Applications
- System settings

```
petalinux-config [options] {--component <COMPONENT> |\
--get-hw-description[=SRC] |\
--searchpath <--ACTION> [VALUE]}
```

Required/Optional	Available Type
`--get-hw-description[=SRC]`	Get hardware description Look in the location of Vivado SDK export
`-p, --project <PROJECT>`	Path to PetaLinux project

Customize the Ultra96-V2 Rootfs Config Menu

- Edit the bbappend file to add extra packages to rootfs config menu
  <>/project-spec/meta-user/recipes-core/images/petalinux-image-full.bbappend

- Add the desired packages and packagegroups (too many to show here)

```
IMAGE_INSTALL_append = " packagegroup-petalinux-ultra96-webapp"
IMAGE_INSTALL_append = " packagegroup-petalinux-v4lutils"
IMAGE_INSTALL_append = " packagegroup-petalinux-96boards-sensors"
IMAGE_INSTALL_append = " packagegroup-petalinux-x11"
IMAGE_INSTALL_append = " packagegroup-petalinux-matchbox"
```

Configure the Ultra96-V2 Rootfs

- **petalinux-config -c rootfs**

```
                                  user packages
  Arrow keys navigate the menu.  <Enter> selects submenus ---> (or empty submenus ----).  Highlighted letters are hotkeys.
  Pressing <Y> includes, <N> excludes, <M> modularizes features.  Press <Esc><Esc> to exit, <?> for Help, </> for Search.
  Legend: [*] built-in  [ ] excluded  <M> module  < > module capable

                                  ↑(-)
                                  [*] lmsensors-sensorsdetect
                                  [*] nano
                                  [*] packagegroup-base-extended
                                  [*] packagegroup-petalinux-96boards-sensors
                                  [*] packagegroup-petalinux-matchbox
                                  [*] packagegroup-petalinux-ultra96-webapp
                                  [*] packagegroup-petalinux-v4lutils
                                  [*] packagegroup-petalinux-x11
                                  [*] python-pyserial
                                  [*] python3-pip
                                  ↓(+)

                        <Select>    < Exit >    < Help >    < Save >    < Load >
```

Building a PetaLinux Project

- **`petalinux-build`**
  - Builds the PetaLinux project or component
  - Usage

    `petalinux-build [options]`

Build
- Kernel
- Root filesystem

Required/Optional	Available Type
`-p, --project <PROJECT>`	Path to PetaLinux project

`-c, --component <COMPONENT>`	Specify the component
	If specified, e.g.:
	`-c rootfs`
	`-c rootfs/myapp`

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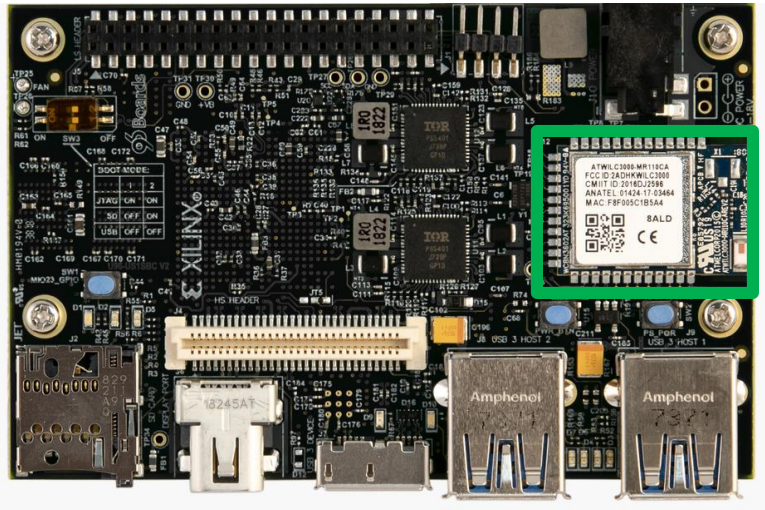
Microchip WiFi & Bluetooth LE for Ultra96-V2

- Replaces the TI WiLink™ 8 module on the Ultra96-V1
- Certified in 75 countries globally



- ***But…***
  - Only tested with Microchip ARM Cortex-M host CPUs and Microchip dev boards

Custom Integration of Microchip WiFi & Bluetooth LE

- Correct device driver not in mainline
- Driver under continuous development by Microchip, so need a custom recipe
- Edits and fixes needed to run on ARM A53 CPU inside Zynq UltraScale+ MPSoC
  - ARM v7 vs ARM v8 (Zynq MPSoC)
  - Turn off power management during DHCP IP address fetch & refresh
  - Disable driver manipulation of module enable and reset pins
- Avnet forked the driver sources into own github repository
  - Extensive email threads and collaborative conversations with Microchip
  - Working with Microchip to push changes upstream

Create Custom Kernel Module

- Add kernel module to PetaLinux project
  `petalinux-create –t modules –name wilc –enable`
- Create bitbake recipe file
  - Specify where to fetch source files:
    `SRC_URI = “git://github.com/avnet/u96v2-wilc-driver;protocol=http;branch=v15_2”`
  - Specify the git commit hash of the correct revision controlled sources
    `SRCREV = “01ab7484e0e6b2191c69d7ec7c6e89da5ca51f0f”`
  - Specify KCONFIG and MAKE options

```
EXTRA_OEMAKE = 'CONFIG_WILC=y \
     WLAN_VENDOR_MCHP=y \
     CONFIG_WILC_SDIO=m \
     CONFIG_WILC_SPI=n \
     CONFIG_WILC1000_HW_OOB_INTR=n \
     KERNEL_SRC="${STAGING_KERNEL_DIR}" \
     O=${STAGING_KERNEL_BUILDDIR}'
```

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Avnet Github Script Repositories

- Avnet git repositories
  - bdf
    https://github.com/Avnet/bdf
  - hdl
    https://github.com/Avnet/hdl
  - petalinux
    https://github.com/Avnet/petalinux
- Clone the repositories into the same parent folder
  - Scripts rely on relative paths
- Checkout the branch of the Vivado & PetaLinux tools you are using
  - 2018.2, 2018.3, etc.

Why Use Build Scripts to Build PetaLinux BSP?

- PetaLinux build scripts automate the steps to create and build the BSP
  - Provides consistency and avoids confusion
- Revision controlled so changes can be tracked
- Easily updated to new Vivado & PetaLinux tool versions
- Can build many BSPs at once (different SOM variants)
- Can build many boot binaries at once (SD card, QSPI, eMMC, etc.)
- Can create scripts for subsequent tasks
  - JTAG programming for booting via TFTP
  - QSPI & eMMC programming

Shell Script Variables

- Set boot method options
  - Many of Avnet's SOMs and dev boards can boot from more than one source
    BUILD_BOOT_SD_EXT4_OPTION=yes
- Specify location of where Vivado & PetaLinux tools are installed (defaults are shown)
  - Needed for setting PetaLinux and Vivado environment variables
    APP_PETALINUX_INSTALL_PATH=/opt/petalinux-v2018.3-final
    APP_VIVADO_INSTALL_PATH=/opt/Xilinx/Vivado/2018.3
- Project and board specific variables identify input and output files
  - Identify where to fetch input files
    HDL_HARDWARE_NAME=ultra96v2_oob_hw
    HDL_PROJECT_NAME=ultra96v2_oob
    HDL_BOARD_NAME=ULTRA96V2
    PETALINUX_ROOTFS_NAME=ultra96v2_oob
  - Specify output files and locations
    PLNX_VER=2018_3
    FSBL_PROJECT_NAME=zynqmp_fsbl
    PETALINUX_PROJECT_NAME=ultra96v2_oob_${PLNX_VER}

Scripted Prerequisites for BSP Build

- Run settings scripts to set tools environment variables
  `source_tools_settings ()`

- Build the Vivado hardware platform (if necessary)
  `build_hw_platform ()`

Scripted BSP Build

- Build the PetaLinux BSP
  `create_petalinux_bsp()`
  - Create the project
  - Import the hw platform from the Vivado project
  - Configure the project with the git revision controlled config file inputs
    - Project config
    - Devicetree
    - Rootfs
    - u-boot
    - Kernel
  - Build the OS image, rootfs, u-boot, etc.
  - Create the boot.bin for booting
    - Includes the FSBL, ATF, PMU firmware, and u-boot
  - Package the BSP for archiving & sharing

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Learn More

- Avnet Ultra96 Technical Training Courses
  https://www.avnet.me/ttc
  http://avnet.me/ttc_on_demand
- Download and install the BSP
  http://avnet.me/Ultra96-V2-2018.3-BSP
- Ultra96-V2 User Guide (and other documentation, etc.)
  http://avnet.me/ultra96-v2
- MicroZed Chronicle – Two Methods of Building PetaLinux for Ultra96
  http://avnet.me/two_methods_plnx_ultra96
- Xilinx Developer Forum 2018 – Linux Application Development with Ultra96
  http://avnet.me/linux_app_dev_ultra96

Helpful Resources

- Avnet git repositories
  - bdf
    https://github.com/Avnet/bdf
  - hdl
    https://github.com/Avnet/hdl
  - petalinux
    https://github.com/Avnet/petalinux
- Avnet VirtualBox VM setup instructions
  http://avnet.me/vbox-install-guide
- Xilinx UG1144 – PetaLinux Tools Documentation Reference Guide
  http://avnet.me/xilinx_ug1144
- Xilinx UG1157 – PetaLinux Command Line Reference Guide
  http://avnet.me/xilinx_ug1157

Thank you

Join Linaro to accelerate deployment of your Arm-based solutions through collaboration

contactus@linaro.org

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