Embedded Linux development with Buildroot training

On-line seminar

Title	**Embedded Linux development with Buildroot training**
Overview	Introduction to Buildroot Managing and building the configuration Buildroot source and build trees Toolchains in Buildroot Managing the Linux kernel configuration Root filesystem Download infrastructure GNU Make 101 Integrating new packages Advanced package aspects Analyzing the build Advanced topics Application development with Buildroot Understanding the Buildroot internals Buildroot community: support and contribution What's new in Buildroot?
Duration	**Four** half days - 16 hours (4 hours per half day). 80% of lectures, 20% of practical demos.
Trainer	**Thomas Petazzoni**. Thomas is a major Buildroot developer since 2009, with more than 2700 patches integrated and an active participation to the development process.
Language	Oral lectures: English Materials: English.
Audience	Companies already using or interested in using Buildroot to build their embedded Linux systems.

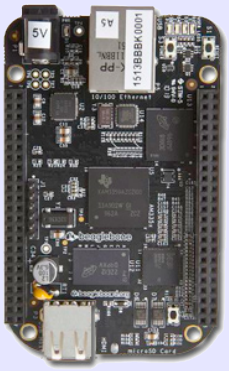
Prerequisites	**Familiarity with embedded Linux** as covered in our embedded Linux course:
	`https://bootlin.com/training/embedded-linux/`
	
	Knowledge and practice of Unix or GNU/Linux commands
	People lacking experience on this topic may get trained by themselves, for example with our freely available on-line slides:
	`https://bootlin.com/blog/command-line/`

Required equipment	• Computer with the operating system of your choice, provided it is supported by Zoom (`https://zoom.us` for videoconferencing • Webcam and microphone (preferably from an audio headset) • High speed access to the Internet
Materials	Electronic copies of presentations, demo instructions and data.

Hardware

The hardware platform used for the practical demos of this training session is the **BeagleBone Black**, which features:

- An ARM AM335x processor from Texas Instruments (Cortex-A8 based), 3D acceleration, etc.
- 512 MB of RAM
- 2 GB of on-board eMMC storage (4 GB in Rev C)
- USB host and device
- HDMI output
- 2 x 46 pins headers, to access UARTs, SPI buses, I2C buses and more.



Half day 1

Lecture - Embedded Linux and build system introduction

- The general architecture of an embedded Linux system
- Build systems vs. binary distributions
- Role of a build system
- Comparison of existing build systems

Lecture - Introduction to Buildroot

- Key facts about the project
- Getting Buildroot
- Basic configuration of Buildroot
- Doing a first build

Demo - Basic Buildroot usage

- Getting and setting up Buildroot
- Configuring and building a basic system with Buildroot for the BeagleBone Black
- Flash and test the generated system on the BeagleBone Black

Lecture - Managing the build and configuration

- Out of tree build
- Using and creating *defconfigs*
- Defconfig fragments
- Other building tips

Lecture - Buildroot source and build trees

- Details about the Buildroot source code organization
- Details about the Buildroot build tree

Half day 2

Lecture - Toolchains in Buildroot

- The different choices for using toolchains in Buildroot
- Overview of the toolchain options
- Using existing binary toolchains, such as Sourcery CodeBench toolchains, understanding *multilib* capabilities and integration of toolchains in Buildroot
- Generating custom toolchains with *Crosstool-NG*, and re-use them as external toolchains

Lecture - Managing the Linux kernel configuration

- Loading, changing and saving the kernel configuration

Lecture - Root filesystem construction in Buildroot

- Understand how Buildroot builds the root filesystem: *skeleton*, installation of packages, overlays, *post-build* and *post-image* scripts.
- Customization of the root filesystem contents
- System configuration: *console* selection, various `/dev` management methods, the different `init` implementations, etc.
- Understand how Buildroot generates filesystem images

Demo - Root filesystem customization

- Explore the build output
- Customize the root filesystem using a *rootfs overlay*
- Customize the kernel with patches and additional configuration options
- Add more packages
- Use *defconfig* files and *out of tree* build

Lecture - Download infrastructure in Buildroot

- Downloading logic
- Primary site and backup site, doing offline builds
- VCS download, integrity checking
- Download-related *make* targets

Half day 3

Lecture - GNU Make 101

- Basics of make rules
- Defining and referencing variables
- Conditions, functions
- Writing recipes

Lecture - Integrating new packages in Buildroot

- How to integrate new packages in the Buildroot configuration system
- Understand the different package infrastructures: for *generic*, *autotools*, *CMake*, *Python* packages and more.
- Writing a package `Config.in` file: how to express dependencies on other packages, on toolchain options, etc.
- Details on writing a package recipe: describing the package source code location, download method, configuration, build and installation steps, handling dependencies, etc.

Demo - New packages in Buildroot

- Create a new package for *nInvaders*
- Understand how to add dependencies
- Add patches to *nInvaders* for *Nunchuk* support

Lecture - Advanced package aspects

- Licensing report
- Patching support: patch ordering and format, global patch directory, etc.
- User, permission, device tables
- Init scripts and systemd unit files
- Config scripts
- Understanding *hooks*
- Overriding commands
- Legacy handling
- Virtual packages

Demo - Advanced packages

- Package an application with a mandatory dependency and an optional dependency
- Package a library, hosted on GitHub
- Use *hooks* to tweak packages
- Add a patch to a package

Half day 4

Lecture - Analyzing the build: licensing, dependencies, build time

- Usage of the legal information infrastructure
- Graphing dependencies of packages
- Collecting and graphing build time information

Lecture - Advanced topics

- `BR2_EXTERNAL` to store customizations outside of the Buildroot sources
- Package-specific targets
- Understanding rebuilds
- Tips for building faster

Demo - Advanced aspects

- Use build time graphing capabilities
- Use dependency graphing capabilities
- Use licensing report generation, and add licensing information to your own packages
- Use `BR2_EXTERNAL`

Lecture - Application development with Buildroot

- Using Buildroot during application development
- Usage of the Buildroot environment to build applications outside of Buildroot
- Generate an SDK for other developers
- Remote debugging with Buildroot

Demo - Application development with Buildroot

- Build and run your own application
- Remote debug your application
- Use `<pkg>_OVERRIDE_SRCDIR`

Lecture - Understanding Buildroot internals

- Detailed description of the Buildroot build process: toolchain, packages, root filesystem construction, stamp files, etc.
- Understanding virtual packages.

Lecture - Getting support and contributing, what's new in Buildroot

- Getting support: *Bugzilla*, *mailing list*, *IRC*
- Contributing: understanding the development process, how to submit patches
- What's new in Buildroot: summary of the major changes since the last two years

Questions and Answers

- Questions and answers with the audience about the course topics
- Extra presentations if time is left, according what most participants are interested in.