Buildroot: what’s new?

Thomas Petazzoni
thomas.petazzoni@bootlin.com
Thomas Petazzoni

- CTO/Embedded Linux engineer at Bootlin
  - Embedded Linux expertise
  - Development, consulting and training
  - Bootloader, Linux kernel, Yocto Project, Buildroot
  - Complete Linux BSP development
  - Hardware support in bootloader/Linux
  - Strong open-source focus: upstreaming and contributions
  - Freely available training materials

- Co-maintainer of Buildroot

- Living in Toulouse, France
Buildroot at a glance

- Is an **embedded Linux build system**, builds from source:
  - cross-compilation toolchain
  - root filesystem with many libraries/applications, cross-built
  - kernel and bootloader images
- **Fast**, simple root filesystem in minutes
- **Easy** to use and understand: kconfig and make
- **Small** root filesystem, default 2 MB
- More than **2500 packages** available
- Generates filesystem images, not a distribution
- Vendor neutral
- Active community, stable releases every 3 months
- Started in 2001, oldest still maintained build system
- [http://buildroot.org](http://buildroot.org)
Agenda

- See what’s new in Buildroot within the last two years
- Covering Buildroot 2018.05 to Buildroot 2020.05
  - Community activity
  - Release schedule
  - Architecture support
  - Toolchain support
  - Package infrastructure improvements
  - Download infrastructure improvements
  - Interesting package updates and additions
  - Reproducible builds
  - Top-level parallel build
  - Tooling improvements
Buildroot: an active project

Number of commits per release

- Kernel, drivers and embedded Linux - Development, consulting, training and support - https://bootlin.com
Number of contributors per release
Buildroot: an active project
Release schedule: long term support added

- What we already had
  - **Four releases** per year: YYYY.02, YYYY.05, YYYY.08, YYYY.11
  - **3-month cycles**: 2 months development 1 month stabilization

- What we also have now
  - **LTS**: Long Term Support release
  - Each YYYY.02 release is **supported during one year**
  - **Security** updates, bug fixes
  - YYYY.02.x maintenance branch, and regular (∼ monthly) point releases
  - 2017.02: to 2017.02.11, 860 commits
  - 2018.02: to 2018.02.12, 1075 commits
  - 2019.02: to 2019.02.11: 1301 commits
  - 2020.02: to 2020.02.3: 344 commits (so far)
Architecture support

- Support for new CPU architectures
  - **RISC-V**, 32-bit and 64-bit
  - NDS32
- Support for **new variants** of existing architectures:
  ARM Cortex cores, x86 cores, MIPS cores, ARC cores, C-SKY cores
- Removal of *Blackfin* architecture
- Overall, **support for**: ARC, ARM, AArch64, C-SKY, m68k, Microblaze, MIPS, NDS32, NIOS2, OpenRISC, PowerPC, RISC-V, SuperH, SPARC, x86, Xtensa

[Bootlin.com](https://bootlin.com)
Internal toolchain: Buildroot builds your toolchain from source

- No significant change, just regular updates
- gcc 8.x and 9.x added (gcc 10.x coming soon), gcc 4.9, 5.x, 6.x removed
- binutils updated, 2.33.1
- uClibc-ng updated, 1.0.34
- musl updated, 1.2.0
- glibc updated, 2.30
- Useful testing done by Romain Naour using the toolchains-builder project
Toolchain support: external toolchain

**External toolchain**: Buildroot uses an existing pre-built toolchain

- ARM toolchains added
- AArch64 big-endian toolchains from ARM and Linaro added
- Andes NDS32 toolchain added
- Updates to numerous existing toolchains
- Declaring external toolchains from `BR2_EXTERNAL` trees
Package infrastructures **factorize the common logic** to configure, build and install packages that use a standardized build system

**Three new** package infrastructures:
- **golang-package** for Go-based packages
- **meson-package** for Meson-based packages
- **qmake-package** for QMake-based packages (Qt world)

**Already** had support for: Autotools, CMake, Kconfig, LuaRocks, Perl, Python, Erlang, Waf and kernel modules
Go package example: docker-cli

package/docker-cli/docker-cli.mk

# docker-cli
#
# DOCKER_CLI_VERSION = 18.09.9
DOCKER_CLI_SITE = $(call github,docker,cli,v$(DOCKER_CLI_VERSION))
DOCKER_CLI_WORKSPACE = gopath

DOCKER_CLI_LICENSE = Apache-2.0
DOCKER_CLI_LICENSE_FILES = LICENSE

DOCKER_CLI_DEPENDENCIES = host-pkgconf

DOCKER_CLI_TAGS = autogen
DOCKER_CLI_BUILD_TARGETS = cmd/docker

DOCKER_CLI_LDFLAGS = \n  -X github.com/docker/cli/cli.GitCommit=$(DOCKER_CLI_VERSION) \n  -X github.com/docker/cli/cli.Version=$(DOCKER_CLI_VERSION)

DOCKER_CLI_INSTALL_BINS = $(notdir $(DOCKER_CLI_BUILD_TARGETS))

$(eval $(golang-package))
Meson package example: libmpdclient

package/libmpdclient/libmpdclient.mk

```
# libmpdclient

LIBMPDCLIENT_VERSION_MAJOR = 2
LIBMPDCLIENT_VERSION = $(LIBMPDCLIENT_VERSION_MAJOR).16
LIBMPDCLIENT_SOURCE = libmpdclient-$(LIBMPDCLIENT_VERSION).tar.xz
LIBMPDCLIENT_SITE = http://www.musicpd.org/download/libmpdclient/$(LIBMPDCLIENT_VERSION_MAJOR)
LIBMPDCLIENT_INSTALL_STAGING = YES
LIBMPDCLIENT_LICENSE = BSD-3-Clause
LIBMPDCLIENT_LICENSE_FILES = COPYING

$(eval $(meson-package))
```
Download infrastructure improvements

- **Main improvement**: **Git caching**, for Git-fetched packages
  - **Before**: complete clone of the Git repository, checkout the requested version, create a tarball with the source code, throw away the Git repository
  - **Drawback**: another full clone next time the package version is changed
  - **Now**: keep a clone of the git repository in `$DL_DIR/<package>/git/`, much faster download when a Git-fetched package is updated

- Tarballs are now stored in per-package sub-directories in `$DL_DIR`

- Major rewrite of the internals of the download infrastructure, `package/pkg-download.mk`, support/download/
Package updates and additions

- Between 2018.05 and 2020.05:
  - 435 packages have been added
  - A few packages have been removed: individual X.org proto packages, Qt4, GStreamer 0.10
- Addition of: Rust (compiler, cargo), LLVM/Clang (not as a compiler), Mender, OpenJDK, OpenRC init system, OP-TEE OS, GObject-Introspection, AppArmor, zillions of Perl/Python modules
- Update of all major software stacks: Qt 5.15, X.org 1.20, GStreamer 1.16, Wayland 1.18, Weston 8.0, Kodi 18.7.

$ git log --format=oneline 2018.05..2020.05 package/ \ 
  | grep -i bump | wc -l
4016
Hardening options

- Addition of support for building the entire code base with a number of security hardening mechanisms
- Improvement of Stack Protection options:
  - BR2_SSP_REGULAR, BR2_SSP_STRONG, BR2_SSP_ALL
- Addition of RELRO protection options:
  - BR2_RELRO_NONE, BR2_RELRO_PARTIAL, BR2_RELRO_FULL
- Addition of buffer-overflow detection (*FORTIFY SOURCE*) options: BR2_FORTIFY_SOURCE_NONE, BR2_FORTIFY_SOURCE_1, BR2_FORTIFY_SOURCE_2
- Mostly contributed by Collins Aerospace
New target: make show-info

- New top-level target:
  make show-info
- Outputs a JSON blurb that provides lost of metadata about the packages enabled in the current configuration
- JSON makes it easily usable in scripts and tools
- Allows to analyze the contents of a system, validate the choice of packages, get their download URL, and more.
- Other analysis tool already present:
  - legal-info
  - graph-build, graph-size

```json
{
  "busybox": {
    "type": "target",
    "virtual": false,
    "version": "1.31.0",
    "licenses": "GPL-2.0",
    "dl_dir": "busybox",
    "install_target": true,
    "install_staging": false,
    "install_images": false,
    "downloads": [
      {
        "source": "busybox-1.31.0.tar.bz2",
        "uris": [
          "http+http://www.busybox.net/downloads",
          "http|urlencode+http://sources.buildroot.net/busybox",
          "http|urlencode+http://sources.buildroot.net"
        ]
      }
    ],
    "dependencies": [
      "host-skeleton",
      "host-tar",
      "skeleton",
      "toolchain"
    ],
    "reverse_dependencies": []
  }
}
Reproducible builds

- Goal: given a Buildroot configuration/version, two builds will give two exactly identical results
- Google Summer of Code in summer 2019, with Atharva Lele working on Reproducible Builds
- Mentored by Arnout Vandecappelle and Yann E. Morin
- Automated testing on autobuild.buildroot.org
  - Some builds are done twice, with `BR2_REPRODUCIBLE=y`, and then tested for equality
  - If not equal, comparison done with `diffoscope` to facilitate the analysis
  - Differences between builds: build time and location
  - Ultimately between environments
- Fixes in tar, gzip and cpio handling to avoid timestamp issues
- More work is needed: improving the `diffoscope` reporting (in progress), fix the reproducibility issues
Reproducible build result

--- /home/naourr/work/instance-1/output-1/images/rootfs.tar
+++ /home/naourr/work/instance-1/output-2/images/rootfs.tar
./usr/lib/asterisk/modules/app_agent_pool.so
/home/naourr/work/instance-1/output-1/host/bin/m68k-linux-readelf --wide --decompress --hex-dump=.rodata {}
@@ -112,15 +112,15 @@
     0x0000a332 742e0a00 4e4f545f 434f444e 4545554e  %s: Failed to
     0x0000a342 44002f68 6f6d652f 6e616f72742f73 16.6.1/instance-1/output-1/build/asterisk/strings.h
     0x0000a352 75747075 742d31 362e312f696e terisk-16.6.1/in
- 0x0000a362 75747075 742d312f6275666c6567732e68 416374696f6e49443a2025730d0a
+ 0x0000a362 75747075 742d322f6275666c6567732e68 416374696f6e49443a2025730d0a
     0x0000a372 74657269736b2d31362e312f696e ActionID: %s...Name: %s...
- Kernel, drivers and embedded Linux - Development, consulting, training and support - https://bootlin.com
+ 0x0000a372 74657269736b2d31362e312f696e ActionID: %s...Name: %s...
Top-level parallel build

- **Goal:** build several packages in parallel
- Experimental support **merged** in 2020.02
- **BR2_PER_PACKAGE_DIRECTORIES=y** option
  - Enables *per-package build*
  - Each package has its own `HOST_DIR` (including the compiler sysroot) and `TARGET_DIR`
  - Guarantees that the dependencies seen by the package are always consistent
- When enabled, **make** `-jX` at the top-level works!
- Still some limitations: Qt5 has issues, the `-rebuild`, `-reconfigure`, `-reinstall` targets are not working yet
Without top-level parallel build
With top-level parallel build
A runtime test infrastructure was introduced in 2017.02.

Each test case:
- Builds a well-defined configuration
- Boots it under Qemu
- Runs some tests to verify that a given feature is working

Complementary to autobuilder testing, which tests the build of random configurations.

```
./support/testing/run-tests -h
```

Since 2017.11, many new test cases added
- ATF, Python modules, Perl modules, Lua modules, OpenJDK, X.org/Mesa3D, Docker/Docker-Compose, hardening flags
Tooling improvements

- Internship of Victor Huesca at Bootlin in summer 2019, mentored by Thomas Petazzoni
- Topic: improve the Buildroot maintenance tooling
  - Use of release-monitoring.org for tracking upstream releases
  - Improved Buildroot developer notifications
  - Improved autobuilder search capabilities
Tooling: use of release-monitoring.org

- release-monitoring.org is a service from the Fedora community that tracks upstream releases of open-source projects
- Currently tracks 27000+ projects
- Buildroot has 2500+ packages, difficult to make sure they are all kept up-to-date
- Buildroot `pkg-stats` script produces a table of statistics about Buildroot packages, especially current version vs. upstream version
- Improvements:
  - Lots of mappings between Buildroot packages and release-monitoring.org packages added
  - Fixes to Buildroot packages for the package version to match better
  - JSON output in addition to HTML output (useful for tooling, next slide)
  - Speed improvement
### Project: busybox

<table>
<thead>
<tr>
<th>busybox</th>
<th>Flag</th>
<th>Edit</th>
</tr>
</thead>
</table>

**Latest version**

1.31.0

**Homepage:**

http://www.busybox.net

**Backend:**

custom

**Version scheme:**

RPM

**Version check url:**

http://www.busybox.net/downloads/

### Status

<table>
<thead>
<tr>
<th>Status</th>
<th>Updated</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OK</td>
<td>2019-10-18 08:55:56 (UTC)</td>
<td>No new version found</td>
</tr>
</tbody>
</table>

### Versions

<table>
<thead>
<tr>
<th>Version</th>
<th>Retrieved on (UTC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.31.0</td>
<td>2019-06-10 11:03</td>
</tr>
<tr>
<td>1.30.1</td>
<td>2019-02-14 15:02</td>
</tr>
<tr>
<td>1.30.0</td>
<td>2019-01-07 12:11</td>
</tr>
<tr>
<td>1.29.3</td>
<td>Date information unavailable</td>
</tr>
<tr>
<td>1.29.2</td>
<td>Date information unavailable</td>
</tr>
<tr>
<td>1.29.1</td>
<td>Date information unavailable</td>
</tr>
<tr>
<td>1.29.0</td>
<td>Date information unavailable</td>
</tr>
<tr>
<td>1.28.4</td>
<td>Date information unavailable</td>
</tr>
<tr>
<td>1.28.3</td>
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<tr>
<td>1.28.2</td>
<td>Date information unavailable</td>
</tr>
<tr>
<td>1.28.1</td>
<td>Date information unavailable</td>
</tr>
<tr>
<td>1.28.0</td>
<td>Date information unavailable</td>
</tr>
<tr>
<td>1.27.2</td>
<td>Date information unavailable</td>
</tr>
<tr>
<td>1.27.1</td>
<td>Date information unavailable</td>
</tr>
<tr>
<td>1.27.0</td>
<td>Date information unavailable</td>
</tr>
<tr>
<td>1.26.2</td>
<td>Date information unavailable</td>
</tr>
<tr>
<td>1.26.1</td>
<td>Date information unavailable</td>
</tr>
<tr>
<td>1.26.0</td>
<td>Date information unavailable</td>
</tr>
</tbody>
</table>

### Mappings

<table>
<thead>
<tr>
<th>Distribution</th>
<th>Package name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fedora</td>
<td>busybox</td>
</tr>
<tr>
<td>Alpine</td>
<td>busybox</td>
</tr>
<tr>
<td>NixOS</td>
<td>busybox</td>
</tr>
<tr>
<td>Arch Linux</td>
<td>busybox</td>
</tr>
<tr>
<td>Arch Linux</td>
<td>mknitoio-busybox</td>
</tr>
<tr>
<td>Cygwin</td>
<td>busybox</td>
</tr>
<tr>
<td>Buildroot</td>
<td>busybox</td>
</tr>
</tbody>
</table>
CVE checking

- Goal: ensure Buildroot has fixes for the CVEs reported on all its packages
- The NIST provides the National Vulnerability Database (NVD) containing all known CVEs
- Buildroot pkg-stats has been improved to report CVE associated to each package, depending on the package version.
- New variable `<pkg>_IGNORE_CVES` that allows to ignore CVEs if they are fixed locally by a patch.

```bash
# debian/patches/length-check.patch
LIBMAD_IGNORE_CVES += CVE-2017-8374
```

- Allows package maintainers to know when they have CVEs to look at and update the package accordingly
<table>
<thead>
<tr>
<th>Package</th>
<th>Status</th>
<th>Kernel</th>
<th>Drivers</th>
<th>Embedded Linux</th>
<th>Version</th>
<th>Vulnerabilities</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>package/ccache/ccache.mk</td>
<td>0</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>3.7.9</td>
<td>3.7.9 found by distro</td>
<td>Link</td>
</tr>
<tr>
<td>package/ccid/ccid.mk</td>
<td>0</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>1.4.31</td>
<td>1.4.32 found by distro</td>
<td>Link</td>
</tr>
<tr>
<td>package/crypt/crypt.mk</td>
<td>0</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>1.11</td>
<td>1.11 found by distro</td>
<td>Link</td>
</tr>
<tr>
<td>package/cctz/cctz.mk</td>
<td>0</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>2.3</td>
<td>2.3 found by distro</td>
<td>invalid 429</td>
</tr>
<tr>
<td>package/cdkt/cdkt.mk</td>
<td>2</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>1.1.11</td>
<td>1.1.11 found by distro</td>
<td>Link</td>
</tr>
<tr>
<td>package/cgui/cgui.mk</td>
<td>2</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>0-8-7</td>
<td>0-8-7 found by distro</td>
<td>Link</td>
</tr>
<tr>
<td>package/cereal/cereal.mk</td>
<td>0</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>1.3.0</td>
<td>1.3.0 found by distro</td>
<td>invalid 429 CVE-2020-11104 CVE-2020-11105</td>
</tr>
<tr>
<td>package/cgic/cgic.mk</td>
<td>3</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>2.07</td>
<td>2.07 found by distro</td>
<td>Link</td>
</tr>
<tr>
<td>package/cgilua/cgilua.mk</td>
<td>0</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>5.2.1-1</td>
<td>5.2.1-1 found by distro</td>
<td>Link</td>
</tr>
</tbody>
</table>
Tooling: improved developer notifications

- Buildroot has a **DEVELOPERS** file, associating developers with packages, defconfigs, architectures, tests they maintain.
- Already used to send notifications of build failures reported by the Buildroot autobuilders.
- Notification e-mail has been improved with:
  - Notification about packages that are not up-to-date, according to release-monitoring.org.
  - Notification about packages that have unfixed CVEs according to the NVD database.
  - Failures in the build of defconfigs in Gitlab CI.
  - Failures in the execution of runtime tests in Gitlab CI.

- Kernel, drivers and embedded Linux - Development, consulting, training and support - https://bootlin.com
# Tooling: improved developer notifications

## Packages having a newer version

<table>
<thead>
<tr>
<th>name</th>
<th>found by</th>
<th>link to release-monitoring.org</th>
<th>version</th>
<th>upstream</th>
<th>orph?</th>
</tr>
</thead>
<tbody>
<tr>
<td>acpica</td>
<td>DISTRO</td>
<td><a href="https://release-monitoring.org/project/00018">https://release-monitoring.org/project/00018</a></td>
<td>20190703</td>
<td>20190816</td>
<td></td>
</tr>
<tr>
<td>acscd</td>
<td>DISTRO</td>
<td><a href="https://release-monitoring.org/project/15661">https://release-monitoring.org/project/15661</a></td>
<td>1.1.4</td>
<td>1.1.7</td>
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</tr>
<tr>
<td>adwaita-icon-theme</td>
<td>DISTRO</td>
<td><a href="https://release-monitoring.org/project/13117">https://release-monitoring.org/project/13117</a></td>
<td>3.22.0</td>
<td>3.34.0</td>
<td></td>
</tr>
<tr>
<td>aesspipe</td>
<td>DISTRO</td>
<td><a href="https://release-monitoring.org/project/21320">https://release-monitoring.org/project/21320</a></td>
<td>2.4e</td>
<td>2.4f</td>
<td>ORPH</td>
</tr>
<tr>
<td>alljoyn</td>
<td>DISTRO</td>
<td><a href="https://release-monitoring.org/project/21665">https://release-monitoring.org/project/21665</a></td>
<td>16.04.00a</td>
<td>16.10.02</td>
<td></td>
</tr>
<tr>
<td>alljoyn-tcl</td>
<td>DISTRO</td>
<td><a href="https://release-monitoring.org/project/21666">https://release-monitoring.org/project/21666</a></td>
<td>16.04.00a</td>
<td>16.10.02</td>
<td></td>
</tr>
<tr>
<td>android-tools</td>
<td>GUESS</td>
<td><a href="https://release-monitoring.org/project/13989">https://release-monitoring.org/project/13989</a></td>
<td>4.2.2+git...</td>
<td>10.0.0-r5</td>
<td></td>
</tr>
<tr>
<td>armadillo</td>
<td>DISTRO</td>
<td><a href="https://release-monitoring.org/project/07066">https://release-monitoring.org/project/07066</a></td>
<td>7.900.1</td>
<td>9.800.1</td>
<td></td>
</tr>
<tr>
<td>assimp</td>
<td>DISTRO</td>
<td><a href="https://release-monitoring.org/project/06988">https://release-monitoring.org/project/06988</a></td>
<td>4.1.0</td>
<td>5.0.0</td>
<td></td>
</tr>
<tr>
<td>asterisk</td>
<td>DISTRO</td>
<td><a href="https://release-monitoring.org/project/09838">https://release-monitoring.org/project/09838</a></td>
<td>16.5.1</td>
<td>16.6.0</td>
<td></td>
</tr>
<tr>
<td>at-spi2-atk</td>
<td>DISTRO</td>
<td><a href="https://release-monitoring.org/project/07840">https://release-monitoring.org/project/07840</a></td>
<td>2.26.2</td>
<td>2.34.1</td>
<td></td>
</tr>
<tr>
<td>at-spi2-core</td>
<td>DISTRO</td>
<td><a href="https://release-monitoring.org/project/07841">https://release-monitoring.org/project/07841</a></td>
<td>2.28.0</td>
<td>2.34.0</td>
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</tr>
<tr>
<td>atk</td>
<td>DISTRO</td>
<td><a href="https://release-monitoring.org/project/00130">https://release-monitoring.org/project/00130</a></td>
<td>2.33.3</td>
<td>2.35.1</td>
<td>ORPH</td>
</tr>
<tr>
<td>atkmik</td>
<td>DISTRO</td>
<td><a href="https://release-monitoring.org/project/07962">https://release-monitoring.org/project/07962</a></td>
<td>2.24.2</td>
<td>2.29.1</td>
<td></td>
</tr>
</tbody>
</table>

## Packages having CVEs

<table>
<thead>
<tr>
<th>name</th>
<th>CVE</th>
<th>link</th>
</tr>
</thead>
</table>
Tooling: improved developer notifications

Detail of defconfig failures

<table>
<thead>
<tr>
<th>defconfig</th>
<th>link to the job</th>
<th>orph?</th>
</tr>
</thead>
<tbody>
<tr>
<td>beaglebone_qt5</td>
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Detail of runtime-test failures

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<th>runtime-test</th>
<th>link to the job</th>
<th>orph?</th>
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<td>TestGlxinfo</td>
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</tbody>
</table>
Tooling: improved autobuilder search capabilities

- `autobuild.buildroot.org` collects results from random builds executed by our autobuilders.
- Testing random configurations 24/7, allows to detect numerous dependency problems, version compatibility issues, toolchain problems, and more.
- Running this testing effort for many years.
- Improvement:
  - Can now search through build results by config symbol.
  - Ex: what are the successful builds that had `BR2_PACKAGE_BUSYBOX=y` on ARM, with `uClibc`?
  - Very useful tool when analyzing build issues, and trying to understand in which situations it happens / since when.
Other smaller improvements

- Addition of a `make <pkg>-diff-config` target for `kconfig` based packages: Linux, U-Boot, Busybox, etc.
  - Shows the difference between the current package configuration and the one that is stored in the Buildroot configuration
- Support for generating rootfs images in F2FS, BTRFS and EROFS formats
- Support for `gettext-tiny` as an alternative to full blown `GNU Gettext`
  - Smaller footprint, smaller build time, for cases where native language support is not needed
Conclusion

- Very active project
- LTS release, 1 year maintenance for security/bug fixes
- New CPU architectures
- Package infrastructures for new build systems
- Git caching
- Packages kept up-to-date, many new packages
- Top-level parallel build in good progress
- Reproducible builds effort in progress
- Maintenance tooling improvements

Questions? Suggestions? Comments?

Thomas Petazzoni
thomas.petazzoni@bootlin.com

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