# Buildroot

## BASC2020 seminar

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# BuildRoot

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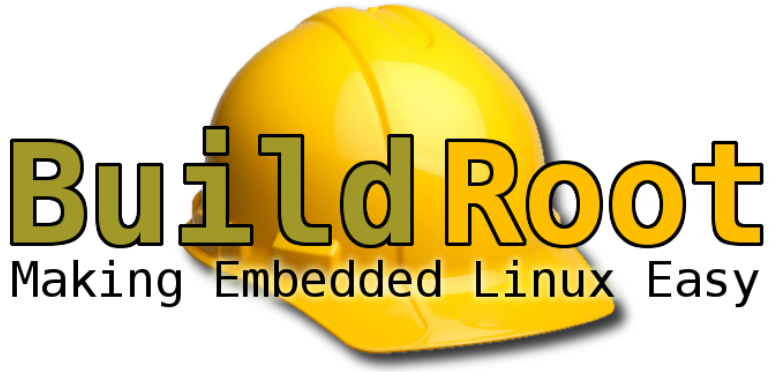
## What's BuildRoot

# BuildRoot




Official website: https://buildroot.org

- Born in 2005

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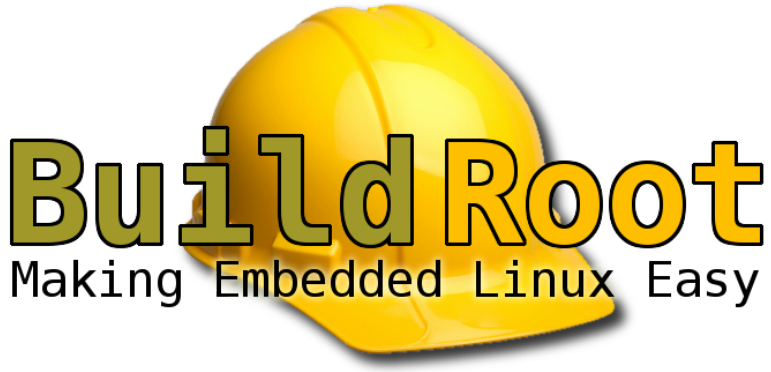


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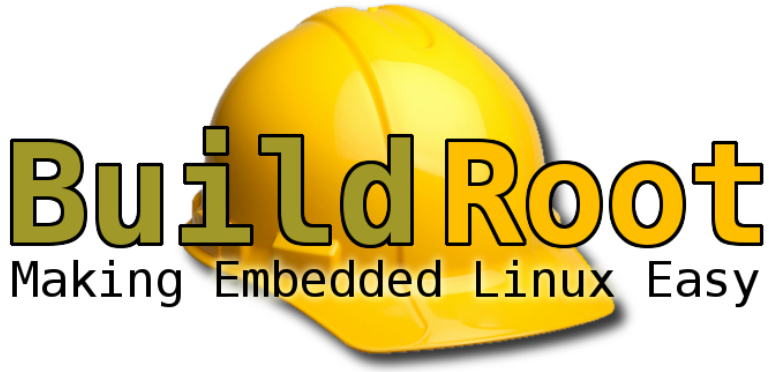


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- Born in 2005
- Entirely based on makefiles and kconfig
- Only one goal: *producing root file system images* for *100% custom Linux systems*

# BuildRoot users

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- IoT devices

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- Automated factory controllers
- Point of sale devices
- Car multimedia units
- High end Hi-Fi amplifiers

# BuildRoot

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- Complete customization of target architecture and build flags
- Multiple compiler / libc / system layout choices
- Updated every 3 months current version is 2020.11-rc3
- Easily extendable

# Why BuildRoot: architecture support

$\approx$ 20 architectures supported

- ARC LE & BE
- **ARM** LE & BE
- AArch64 LE & BE
- csky
- **i386**
- Microblaze AXI & Non-AXI
- MIPS LE & BE
- MIPS64 LE & BE
- nds32
- Nios II
- PowerPC
- PowerPC64 LE & BE
- RISCV
- SuperH
- SPARC
- **x86_64**
- Xtensa

# BuildRoot

## BuildRoot process

# The BuildRoot process

**What the user sees**

1. Create a configuration file

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1. Build a cross compiler on our machine
2. Resolve the configuration dependencies
3. Compile from source the requested packages
4. Assemble an image

# The BuildRoot process

**What the user sees**

1. Create a configuration file
2. Start the build
3. Flash the image on the device

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# Creating some BuildRoots

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## Prerequisites

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## Packages for an ARM BuildRoot

### Ubuntu 20.04

```
sudo apt-get update
sudo apt-get install -y \
  curl tar \
  make \
  gcc g++ \
  libncurses-dev libssl-dev \
  qemu-user-static \
  qemu-system-arm
```

### Others

Binaries needed

Downloaders curl & wget

Extractor tar

Compilers gcc & g++

Libraries ncurses & openssl

Execution QEMU system for ARM & QEMU static

# Preparing our BuildRoot working directory

1. Clone the repository at
   `https://github.com/gabibbo97/basc-buildroot`
2. Enter the directory
3. Run `sh ./seminar-scripts/get-buildroot.sh`

## Please use the provided script

The script downloads BuildRoot 2020.11-rc3 but also applies two required patches that we need for today's seminar

# Creating some BuildRoots

## Creating an ARM cross compiler

# Creating some BuildRoots

## Creating an ARM root filesystem

# Creating some BuildRoots

## Creating a bootable ARM root filesystem

# Using our BuildRoot

# Using our BuildRoot

## Producing binaries for the target

# Using the cross-compiler

1. Extract the cross-compiler
2. Run `relocate-sdk.sh`
3. Edit your `$PATH` variable: `export PATH="$PATH:$PWD/bin"`
4. You can invoke your cross compiler with commands like `arm-buildroot-linux-gnueabihf-<COMMAND NAME>`
   **Notable entries**
   - `arm-buildroot-linux-gnueabihf-gcc`
   - `arm-buildroot-linux-gnueabihf-gdb`
   - `arm-buildroot-linux-gnueabihf-nm`

## Improving gdb with library simbols

See the section ▸ Using gdb

# Using our BuildRoot

## Running dynamic executables

# Running dynamic executables in Docker

```
sudo docker import rootfs.tar basc-buildroot
sudo docker run --rm -it \
  --volume "$(which qemu-arm-static):/bin/qemu-arm-static" \
  --volume "${PWD}/:/host" \
  --entrypoint /bin/qemu-arm-static \
  --workdir "/host" \
  basc-buildroot \
  /bin/sh
```

# Running dynamic executables with systemd-nspawn

```
mkdir -p basc-rootfs
tar -xf rootfs.tar -C basc-rootfs
cp -f "$(which qemu-arm-static)" \
  basc-rootfs/bin/qemu-arm-static
sudo systemd-nspawn \
  --register=no \
  -D basc-rootfs \
  /bin/qemu-arm-static /bin/sh
```

## Package needed

You might need to install the package `systemd-container`

# Using our BuildRoot

## Performing dynamic analysis

# Booting the rootfs

```
#!/bin/sh
#
# Boots the built rootfs
#
exec qemu-system-arm \
  -machine virt \
  -cpu cortex-a7 \
  -smp 2 -m 2000 \
  -kernel bootable-rootfs/zImage \
  -device virtio-blk-device,drive=rootfs \
  -drive file=bootable-rootfs/rootfs.ext2,if=none,format=raw,id=rootfs \
  -append "console=ttyAMA0,115200 rootwait root=/dev/vda" \
  -netdev user,id=user0,hostfwd=tcp::2222-:22,hostfwd=tcp::1234-:1234 \
  -device virtio-net-device,netdev=user0 \
  -serial stdio \
  -display none
```

## Opening an SSH session

```
exec ssh \
  -o UserKnownHostsFile=/dev/null -o StrictHostKeyChecking=no \
  -p 2222 \
  root@localhost
```

## Sharing a folder

```
mkdir -p guest-os-ssh
exec sshfs root@localhost:/ ./guest-os-ssh \
  -f \
  -o port=2222 \
  -o reconnect \
  -o UserKnownHostsFile=/dev/null -o StrictHostKeyChecking=no
```

# Using {l,s,uf}trace

## What did you expect?

- {l,s,uf}trace do work as expected
- Can only be performed on QEMU **system** emulation

### ltrace is buggy on ARM

*ltrace* has a bug with unwinding DWARF tables on ARM and will show limited information.

# Using gdb

**On the guest**

`gdbserver :1234` *command to debug*

**On the host** (*From the cross-compiler extracted folder*)[1]

```
bin/arm-buildroot-linux-gnueabihf-gdb \
  -x arm-buildroot-linux-gnueabihf/sysroot/usr/share/buildroot/gdbinit \
  executable name
```

**On the host gdb shell** attach with `target remote localhost:1234`

[1] or use `run-cross-gdb.sh` from my release package

# Customizing our images

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## Build time overlay

- Create a directory
- Add `BR2_ROOTFS_OVERLAY=my-overlay` to `.config`
- Rebuild using `make`
- The structure of `my-overlay` will be copied to the rootfs

### How to specify multiple overlays

Multiple overlays can be specified by separating them with spaces in the `BR2_ROOTFS_OVERLAY` directive

# Customizing our images

## Build time script

Add `BR2_ROOTFS_POST_BUILD_SCRIPT=my-script.sh` to `.config`
Available environment variables inside:

| | |
|---|---|
| `BR2_CONFIG` | path of `.config` |
| `HOST_DIR` | path of `output/host` |
| `STAGING_DIR` | path of `output/staging` |
| `TARGET_DIR` | path of `output/target` |
| `BUILD_DIR` | path of `output/build` |
| `BINARIES_DIR` | path of `output/images` |
| `BASE_DIR` | path of `output` |

### How to specify multiple scripts

Multiple scripts can be specified by separating them with spaces in the `BR2_ROOTFS_POST_BUILD_SCRIPT` directive

# Customizing our images

## Editing the target directory

1. Add your files to the `output/target` directory
2. Rebuild using `make`

### Warning

Your files might be rewritten / deleted by buildroot

# Customizing our images

## D.I.Y. approach

1. Unpack your rootfs (with `tar -xzf` for instance)
2. Perform your modifications
3. Repack your rootfs (with `tar -cf` for instance)