Comparing embedded Linux build systems and distros

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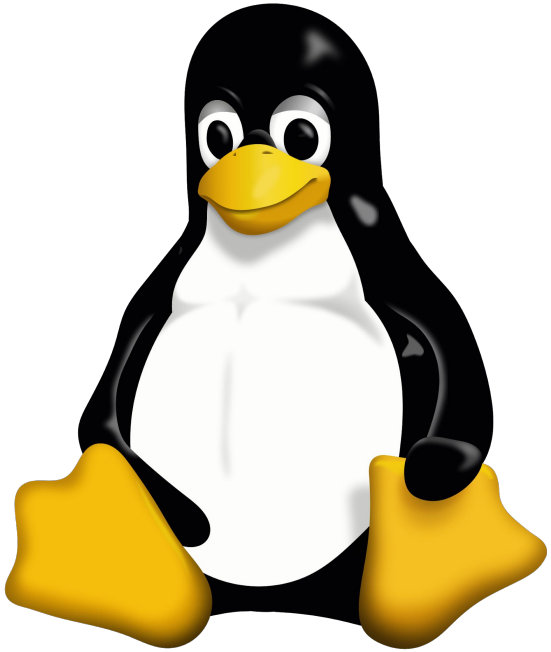
Session overview

- Review of embedded Linux development challenges.
- Define build system and criteria.
- Discuss a few popular options.
- Give me an opportunity to learn about some of the other tools.



Goal: Help new embedded Linux developers get started

About me

Drew Moseley

- 10 years in Embedded Linux/Yocto development.
- Longer than that in general Embedded Software.
- Project Lead and Solutions Architect.

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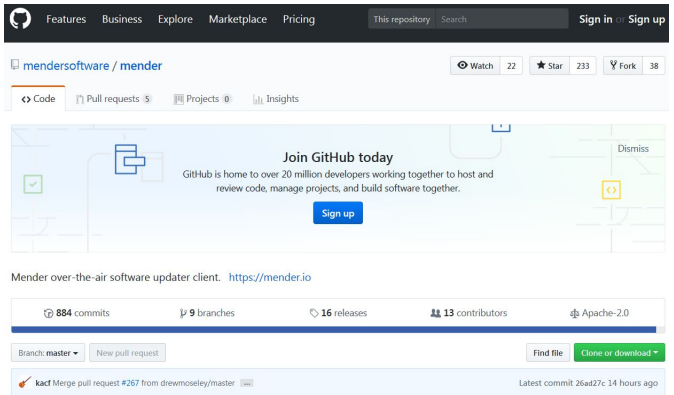
Mender.io

- Over-the-air updater for Embedded Linux
- Open source (Apache License, v2)
- Dual A/B rootfs layout (client)
- Remote deployment management (server)
- Under active development



Challenges for Embedded Linux Developers

Hardware variety

Storage Media

Software may be maintained in forks

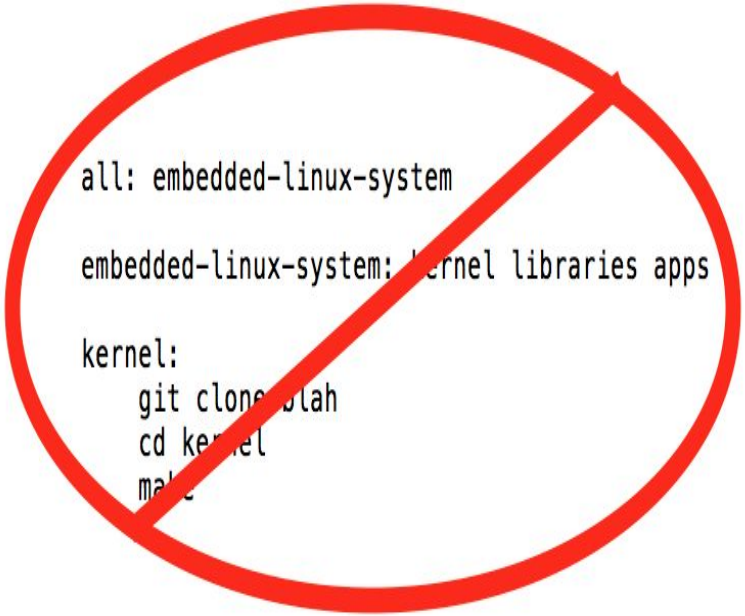
Cross development

Initial device provisioning

Simple Makefiles don't cut it (anymore)

Facts:

- These systems are huge
- Dependency Hell is a thing
- Builds take a long time
- Builds take a lot of resources
- Embedded applications require significant customization
- Developers need to modify from defaults



Build System Defined

*_Is_*

- Mechanism to specify and build
  - Define hardware/BSP components
  - Integrate user-space applications; including custom code
- Need reproducibility
- Must support multiple developers
- Allow for parallel processing
- (Cross) Toolchains
- License Management

*_Is Not_*

- An IDE
- A Distribution
- A deployment and provisioning tool
- An out-of-the-box solution

Yocto Project - Overview

"It's not an embedded Linux distribution -- it creates a custom one for you"[1]

- Recipes, metadata, dependencies and configuration
- Primary output: package feed
- Secondary output: boot images
- Builds all components from source
- Mechanism, not policy

Products:

- Root filesystem image
- Kernel, Bootloader, Toolchain
- Package Feed

[1]See more at https://www.yoctoproject.org

Yocto Project - Details

Organized into independent layers:

- Separation of functionality
- Allows different release schedules
- Expandability
  - Recipes developed in python and bash

SDK mechanism

- Separation of system and application devs
- Easily allows multiple developers to contribute

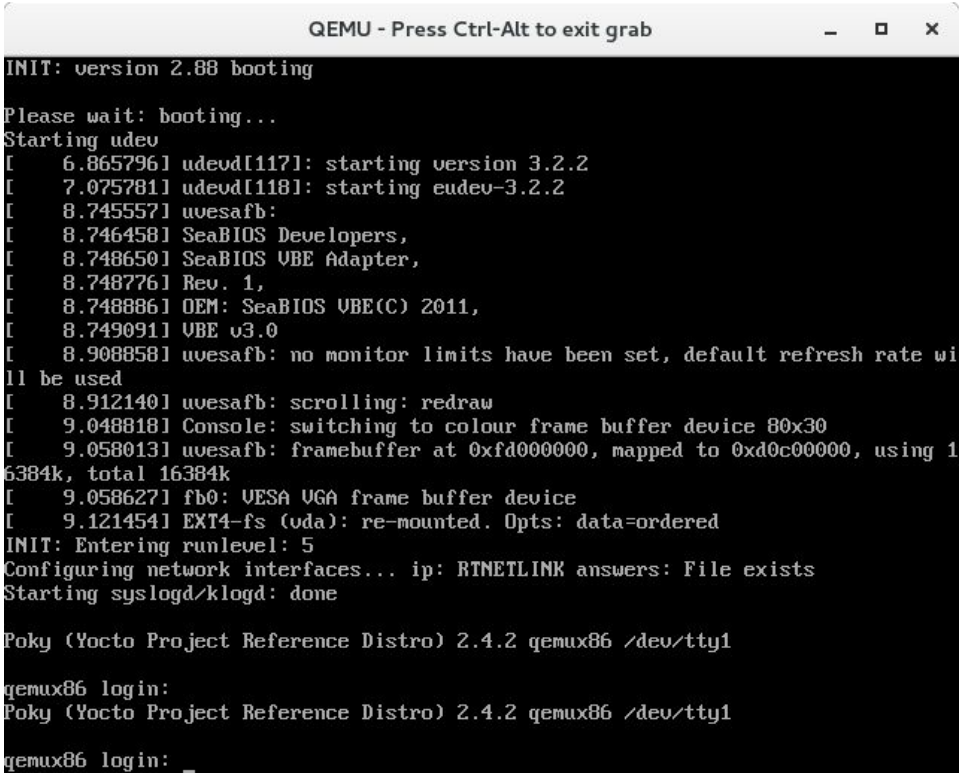
Optimizations:

- Faster build time reusing prebuilt binaries
- Parallel builds

Previous ELC talk estimated ~ 8400 software packages available

Yocto Project - Getting Started

```
$ git clone -b rocko \
    git://git.yoctoproject.org/poky.git
$ source poky/oe-init-build-env
$ MACHINE=qemux86 bitbake \
    core-image-minimal
$ runqemu qemux86
```



Yocto Project - Summary

Pros:

- Widely supported by board and semiconductor vendors
- Active developer community
- Wide functionality and board support enabled by layer mechanism
- Customizable and expandable
- Minimal native tooling required

Cons:

- Steep learning curve
- Unfamiliar environment to non-embedded developers
- Resource-intensive
  - Long initial build times
  - Disk space

Buildroot - Overview

"Buildroot is a simple, efficient and easy-to-use tool to generate embedded Linux systems through cross-compilation."[1]

- Primary output: boot images
- Does not support rpm-style package mgmt
- "Firmware Generator"
- Builds all components from source
- Focus on simplicity

Products:

- Root filesystem image
- Kernel, Bootloader, Toolchain

[1]See more at https://buildroot.org/

Buildroot - Details

Uses Makefiles and Kconfig

- Widely support and well-known

Relatively small images and quick builds

BR2_EXTERNAL mechanism

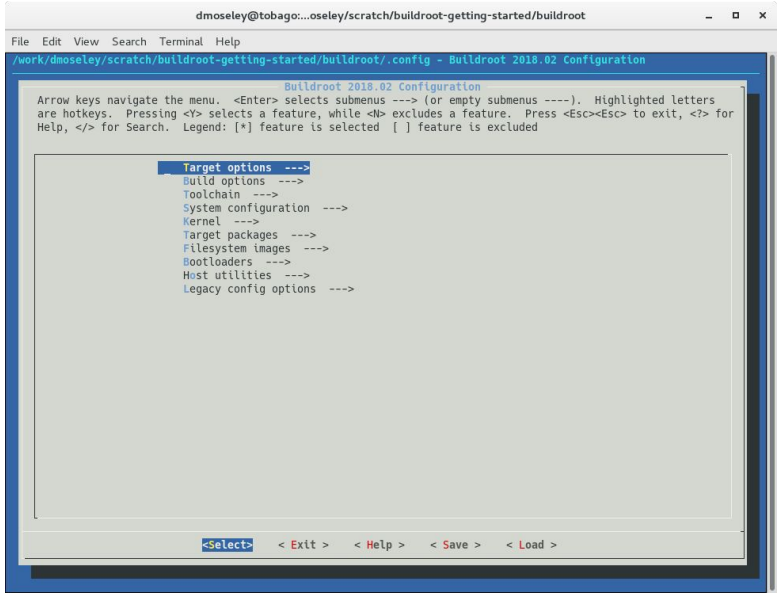
- Local additions stored outside the Buildroot source tree
- Package recipes, defconfigs, etc.

Recipes developed in kconfig and make

SDK mechanism

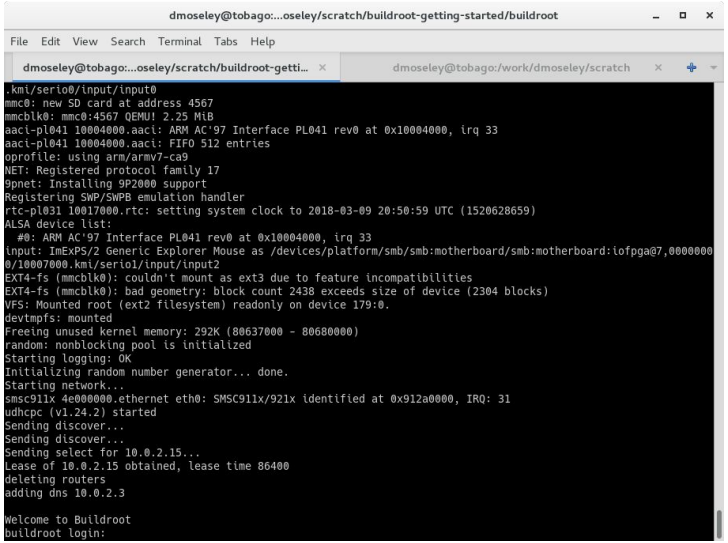
- Separation of system and application devs
- Easily allows multiple developers to contribute

Previous ELC talk estimated ~ 1800 software packages available



Buildroot - Getting Started

```
$ git clone -b 2018.02 https://git.buildroot.net/buildroot
$ cd buildroot
$ make qemu_arm_vexpress_defconfig
$ make
$ eval $(grep qemu-system-arm board/qemu/arm-vexpress/readme.txt)
```



Buildroot - Summary

Pros:

- Little corporate involvement
- Quick to get started
- Easy to understand
- Active developer community
- Broad architecture and board support

Cons:

- Little corporate involvement
- Configuration changes require full rebuild
- No reusable shared state by default

OpenWRT - Overview

"OpenWrt provides a fully writable filesystem with package management."[1]

Primary focus is networking

- Replacement firmware for consumer devices
- Primarily a binary distribution
- On-device package management

Products:

- Firmware image in device-specific format
- Network available package repositories

[1]See more at https://openwrt.org/

OpenWRT - Build System

- Consists of Makefiles and patches
- Generates a cross-toolchain and root filesystem image
- Uses kconfig
- More details here:
  - https://openwrt.org/docs/guide-developer/build-system

OpenWRT - Summary

Pros:

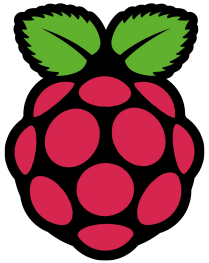
- Great choice as replacement firmware
- Good choice for:
  - Router/networking device
  - If your application needs package-based updates

Cons:

- Less flexible for general Embedded applications
- Policy imposed by OpenWRT design
- Package based updates can make fleet management difficult

Desktop Distros - Overview

(or why can’t I just use <favorite-distro>?)



You can.

Sometimes.

Desktop Distros - Details

Use installer from favorite distro

Increased usage (Raspberry Pi)

Slim down to meet your needs

Generally uses prebuilt binaries

Imposes (significant?) policy

Dependent on distro vendor decisions

Likely not targeted at embedded applications

May not be cross-development friendly

Desktop Distros - Summary

Pros:

- Lots of choices to start with
- Developer familiarity
- Large selection of prebuilt packages
- Quick getting started
- Simplicity
- On-target builds are possible

Cons:

- Policy imposed by vendor
- Difficulty in removing packages due to dependencies
- Reproducibility is complicated
- On-target builds may be slow
- Off-target builds may be difficult or impossible

Other Criteria

- Hardware vendor provided material
- Training and documentation
- Vendor for support
- Developer experience

Related Tools

uClinux (http://www.uclinux.org/)

- Port of Linux to systems without a Memory Management Unit
- Kernel 2.6, user applications, libraries and tool chains.

crosstool-NG (https://crosstool-ng.github.io/)

- Cross-toolchain generator
- Uses kConfig

Other Build Options

ELBE (https://github.com/linutronix/elbe)
ISAR (https://github.com/ilbers/isar/)
Android (https://source.android.com/)

...

To Be Continued...

Summary - Use Cases

- Beginner/hobbyist/maker:
  - Commercial dev board/easy getting started
  - Desktop distro or OpenWRT
- Commercial use, single configuration
  - Fast build time/easy getting started
  - Buildroot
- Commercial use, multiple configurations
  - Modular/HW vendor support
  - Yocto Project

Summary

	Yocto Project	Buildroot	OpenWRT	Desktop Distro
Expandability				
Configurability				
Ease of Getting Started				
Package Availability				
Industry Support				

Thank You!

Q & A

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