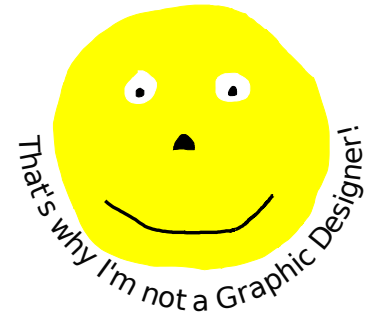


Build your own (embedded) Linux distribution with Yocto

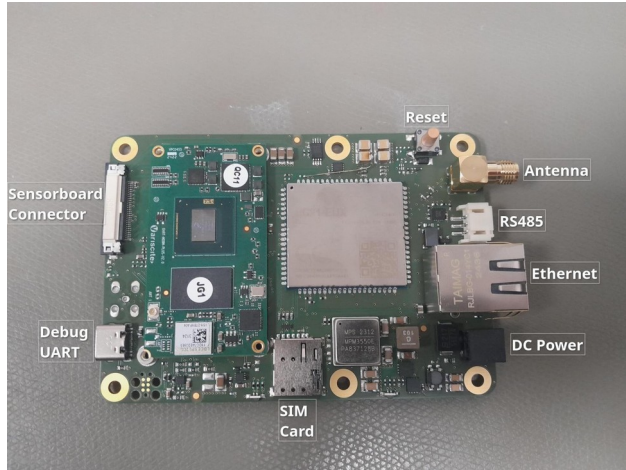
First steps for creating your own embedded Linux distribution.
by Thomas Marangoni (DasChaos)

About me

- Embedded Linux Engineer since 2021
- Smart Displays and now Vision Devices
- Areas of expertise:
 - bootloader
 - Linux kernel
 - user-space
 - Yocto



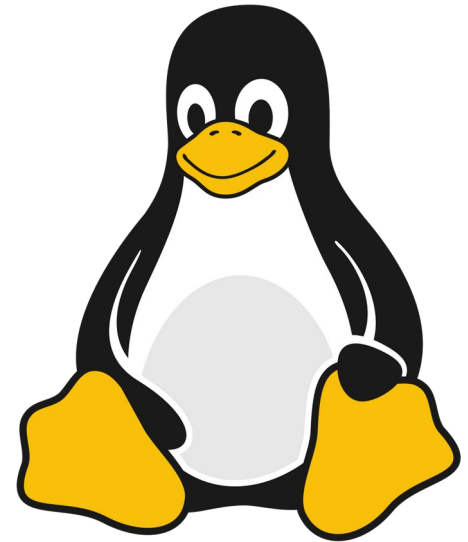
What is embedded?



- embedded != small and low power
- designed for a specific use-case
- RAM: 32MB to 16GB
- CPU: 1C@533MHz to 8C@2GHz
- Storage: 64MB NAND to 128GB NVME
- Architectures: arm64, riscv, x86_64

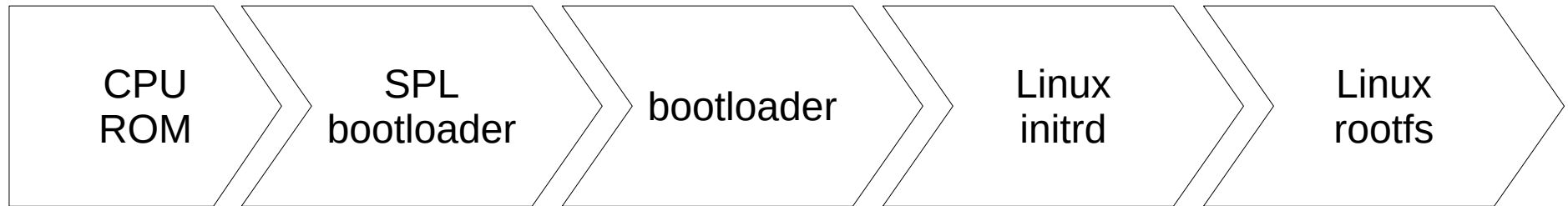
Why embedded Linux?

- wide support of hardware components
- large set of excellent tools
- solid OS infrastructure is provided
- Linux and Posix APIs available on different hardware
- similarity to desktop and server Linux
- a lot of documentation exists already

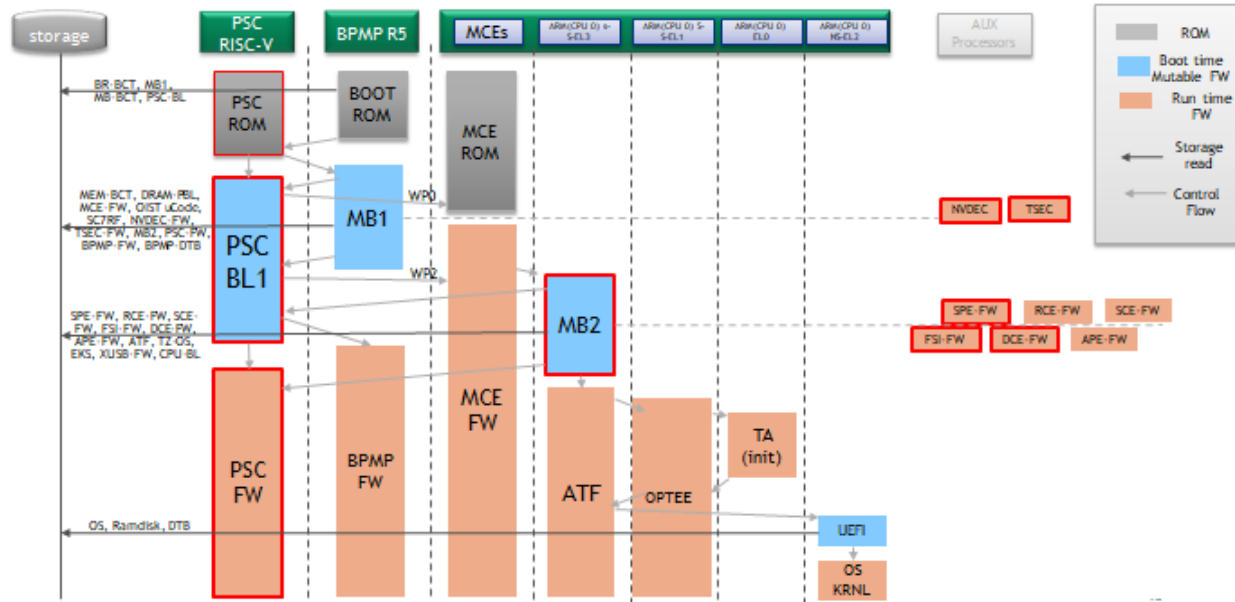


<https://commons.wikimedia.org/wiki/File:TuxFlat.svg>

Linux Boot Process



Linux Boot Process



<https://docs.nvidia.com/jetson/archives/r36.4.4/DeveloperGuide/AR/BootArchitecture/JetsonOrinSeriesBootFlow.html>

Available Tooling



debian

<https://www.debian.org/>



<https://fedoraproject.org/iot/>



<https://buildroot.org/>



<https://www.yoctoproject.org/>

- custom scripts
- Debootstrap
- generic distributions
- embedded distributions
- Buildroot
- Yocto

Yocto and OpenEmbedded

- Tool-chain/set for building embedded Linux distributions
- Based on python3 and Bash
- Very small dependency set is needed on host
- Everything gets compiled and cross compiled for your host and hardware



<https://www.yoctoproject.org/development/technical-overview/>

Yocto

- Requirements
 - 8 CPU-Threads
 - 16GB Memory
 - 100GB storage (SSD)
- License Management
- Multiple hardware and distros in one project
- Recipes are defined for everything
 - compiler, bootloader, kernel, applications
- predefined features and systems
- Large amount of recipes available
- Very good documentation

Bitbake

- It's the build engine and maintained by OpenEmbedded
- Provided by openembedded/poky
- “source layers/poky/oe-init-build-env build”
 - MACHINE=qemu-x64
 - DISTRO=poky
- “bitbake -c TASK RECIPE_NAME” or “bitbake RECIPE_NAME”
 - “bitbake world” – will build every recipe

Layers

- Set of recipes, classes and configurations
- Always have meta- prefix in name, eg meta-foo
- Naming should be descriptive, but no limits:
 - meta-oe
 - meta-tegra
 - meta-python
- Search index for layers and recipes:
<https://layers.openembedded.org/layerindex/branch/master/layers/>

Variables & Syntax

- predefined variables exist
 - see Variables Glossary in docs
- custom variables can be defined in recipes, classes and includes
- use `${VARIABLE_NAME}` to expand variables

```
A = "foo"  
B ?= "foo"  
C ??= "foo"  
D := "foo"
```

```
E =+ "foo"  
F =. "foo"  
G:append = "foo"
```

```
H += "foo"  
I .= "foo "  
J:prepend = "foo "
```

```
K:remove = "foo"
```

```
unset L
```

Tasks

- types
 - automatic tasks
 - manual tasks
- can be triggered manually with `bitbake -c clean RECIPE_NAME`
- can be manipulated in other recipes with `:append` and `:prepend`

```
do_compile() {  
    ${CC} ${LDFLAGS} helloworld.c -o helloworld  
}  
  
do_install() {  
    install -d ${D}${bindir}  
    install -m 0755 helloworld ${D}${bindir}  
}  
  
do_compile:prepend() {  
    rm -rf helloworld  
}  
  
do_install:append() {  
    install -m 0755 helloworld.finished ${D}${bindir}  
}
```

Tasks

- automatic
 - do_fetch
 - do_patch
 - do_configure
 - do_compile
 - do_deploy
 - do_package
 - do_install
- manually:
 - do_populate_sdk
 - do_clean
 - do_cleanall

Recipes

- file extension:
 - .bb
 - .bbappend
 - .inc
- naming (eg btop_1.4.5.bb)
 - software name
 - version
- bbappend hierarchy
 - btop_1.4.%.bbappend
 - btop_1.%.bbappend
 - btop_%.bbappend
- include files
 - import with “include filename”

Recipes

- local files and patches
 - stored in directory next to bb or bbappend file
 - naming
 - files
 - RECIPE_NAME
 - RECIPE_NAME-VERSION
- inside of a subdir in a layer
- required variables
 - SUMMARY
 - LICENSE
 - LIC_FILES_CHKSUM
 - SRC_URI

Recipes - Example

- btop 1.4.5 as a simple example
 - source code is hosted on git
 - license is Apache2
 - has a complete CMake file
 - it's basically a minimal recipe
- part of meta-oe

Recipes – btop 1.45

SUMMARY = "Resource monitor that shows usage and stats for processor, memory, disks, network and proces



HOMEPAGE = "https://github.com/aristocratos/btop"

LICENSE = "Apache-2.0"

LIC_FILES_CHKSUM = "file://LICENSE;md5=3b83ef96387f14655fc854ddc3c6bd57"

SECTION = "console/utils"

SRC_URI = "git://github.com/aristocratos/btop.git;protocol=https;branch=main;tag=v\${PV} \

SRCREV = "a1099d075fa914452366b28c67ff171e21a1f02e"

inherit cmake

```
FILES:${PN} += " \
    ${datadir}/icons \
    ${datadir}/icons/hicolor \
    ${datadir}/icons/hicolor/48x48 \
    ${datadir}/icons/hicolor/scalable \
    ${datadir}/icons/hicolor/48x48/apps \
    ${datadir}/icons/hicolor/48x48/apps/btop.png \
    ${datadir}/icons/hicolor/scalable/apps \
    ${datadir}/icons/hicolor/scalable/apps/btop.svg \
"
```

The short summary of the
binary package for
packaging systems.

Recipes – btop 1.45

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- `${datadir}/icons/hicolor/scalable \`
- `${datadir}/icons/hicolor/48x48/apps \`
- `${datadir}/icons/hicolor/48x48/apps/btop.png \`
- `${datadir}/icons/hicolor/scalable/apps \`
- `${datadir}/icons/hicolor/scalable/apps/btop.svg \`

"

Website where more information about the software the recipe is building can be found.

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 \${datadir}/icons/hicolor/scalable/apps/btop.svg \
"

The list of source licenses
for the recipe.

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    ${datadir}/icons/hicolor/scalable/apps \
    ${datadir}/icons/hicolor/scalable/apps/btop.svg \
"
```

Checksums of the license
text in the recipe source
code.

Recipes – btop 1.45

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 \${datadir}/icons/hicolor/scalable/apps \
 \${datadir}/icons/hicolor/scalable/apps/btop.svg \
"

The list of source files - local or remote.

PV – variable of recipe version.

Recipes – btop 1.45

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- \${datadir}/icons/hicolor/scalable/apps \
- \${datadir}/icons/hicolor/scalable/apps/btop.svg \

"

The revision of the source code used to build the package.

Recipes – btop 1.45

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    ${datadir}/icons/hicolor/scalable/apps \
    ${datadir}/icons/hicolor/scalable/apps/btop.svg \
"
```

Use cmake class for this recipe.

Recipes – btop 1.45

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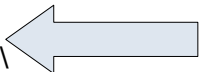
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SRC_URI = "git://github.com/aristocratos/btop.git;protocol=https;branch=main;tag=v\${PV} \n"

SRCREV = "a1099d075fa914452366b28c67ff171e21a1f02e"

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 \${datadir}/icons/hicolor/scalable/apps \n
 \${datadir}/icons/hicolor/scalable/apps/btop.svg \n
"



Files that get added to the rootfs by the recipe.

PN – variable of recipe name.

Images

- naming
 - contains “image”
 - PROJECT-image-USAGE
- it's a special recipe
 - IMAGE_INSTALL
 - IMAGE_LINGUAS
 - IMAGE_FSTYPES
 - FEATURE_PACKAGES
- defines the root filesystem
- images included in poky
 - core-image-base
 - core-image-minimal
 - core-image-minimal-dev
 - core-image-sato
 - core-image-weston

Classes

- file extension:
 - .bbclass
- naming (eg ccmake.bb)
 - toolset name
- usage
 - image formats
 - security scans
 - build systems
 - source formats

Configurations

- file extension:
 - .conf
- naming (eg ccmake.bb)
 - software name
- location
 - meta-foo/conf/
- important conf files
 - layer.conf
 - machine/name.conf
 - distro/name.conf
- special conf files
 - local.conf
 - bblayers.conf

Machine Configuration

- defines a hardware
 - soc family
 - default tune
 - machine overrides
 - kernel image type
 - provider for kernel, dtb, bootloader
- recipes can be limited
 - COMPATIBLE_MACHINE
- variables can be appended
 - VARIABLE:tegra = “foo”
 - VARIABLE:append:tegra

Distro Configuration

- defines the os environment
 - name
 - default features
 - preferred kernel version
 - package system
 - init system
- SDK
 - name
 - default path
- Host system
 - tested distros
 - requirements
- sanity checking

Additional Tools

- devtool – advanced development utils
- toaster – web UI for a build machine
- kas – configuration management
- distrobox – container cli utility
- Search index for layers and recipes:
<https://layers.openembedded.org/layerindex/branch/master/layers/>

Contact

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Icons by <https://tabler.io>

