Embedded Linux Conference Europe 2020

OpenEmbedded and Yocto Project best practices

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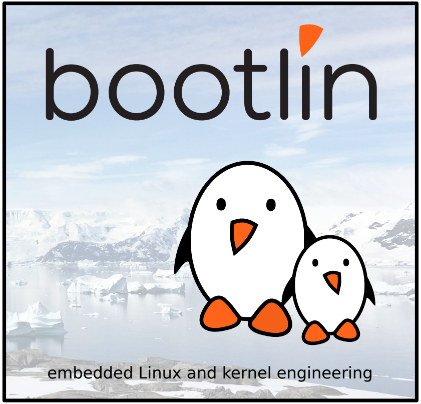
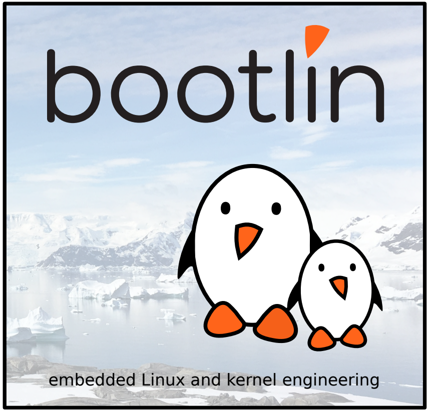


embedded Linux and kernel engineering

Alexandre Belloni

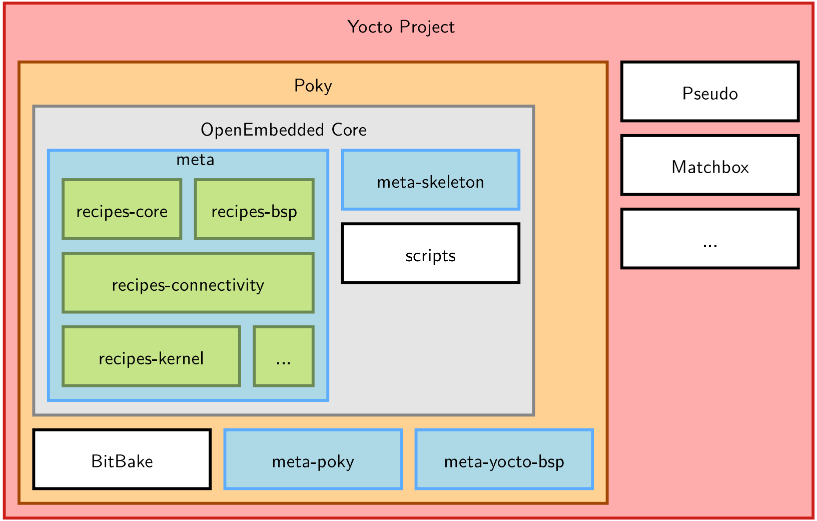
- Embedded Linux engineer at Bootlin
  - Embedded Linux **expertise**
  - **Development**, consulting and training
  - Bootloader, Linux kernel, Yocto Project, Buildroot
  - Complete Linux BSP development
  - Hardware support in bootloader/Linux
  - Strong open-source focus: upstreaming and contributions
  - Freely available training materials
- Open-source contributor
  - Maintainer for the Linux kernel **RTC subsystem**
  - Co-Maintainer of **kernel support for Microchip (ARM and MIPS) processors**



embedded Linux and kernel engineering

Distributions

Poky


Yocto Project
Poky
OpenEmbedded Core
meta
recipes-core
recipes-bsp
recipes-connectivity
recipes-kernel
...
meta-skeleton
scripts
BitBake
meta-poky
meta-yocto-bsp
Pseudo
Matchbox
...

Poky

- Yocto Project is an entity, not something you can use.
- Poky is the reference distribution, the code that is downladed and used.
- As a reference distribution, it is not tailored to your system (e.g. it always includes opengl)
- It can generate demo images but is not meant to be used as-is on production systems.
- The included features are not stable (e.g. it switched from xorg to wayland)
- Poky bundles Openembedded-core, bitbake and two very small layers:
  - `meta-yocto-bsp` is a **BSP** layer for reference boards from the Yocto Project members
  - `meta-poky` is a **distro** layer with four distributions: `poky`, `poky-tiny`, `poky-bleeding`, `poky-altcfg`

Poky

- For your project, not using Poky has some advantages:
  - when reporting bugs, it is necessary to reproduce with a `nodistro` build
  - it is easier to start from `nodistro` and create a distribution than tuning a distribution including `poky.conf`
  - it is easier to work with the oe-core repository when sending patches upstream
  - Confidentiality, Poky defines `PREMIRRORS` that point to `http://downloads.yoctoproject.org/mirror/sources/`, it will leak the name of everything that is fetched using version control.
- The main drawback is having to match the oe-core and bitbake branches manually.

Creating your own distribution

- Not that difficult, simply have `conf/distro/<distro_name>.conf`
- Used to define the distribution wide policies:
  - Toolchain (including libc) selection
  - init selection
  - `DISTRO_FEATURES`
  - `PREFERRED_PROVIDERS`
  - `PACKAGE_CLASSES`
  - QA checks with `WARN_QA` and `ERROR_QA`

local.conf

local.conf

- `local.conf` is really for local configuration (CPU number, disk space).
- Avoid the numerous tutorials saying otherwise
- The main reason is distribution of the changes and reproducibility of the build.
- Also huge drawback, a change in `local.conf` makes bitbake parse all the recipes again.
- It is fine to carry changes in `local.conf` for development/testing.

local.conf - site.conf

- `site.conf` is for site wide configuration (proxies, mirrors, shared sstate-cache location).
- Unfortunately, it suffers from the same `local.conf` distribution drawback.

local.conf - image recipes

- The most abused variable in `local.conf` is `IMAGE_INSTALL_append` (seen in tutorials from SoM vendors).
- This is not even easy for beginners due to parse order.
- The solution is simply to create your own image recipe as soon as the `core-image-*.bb` recipes are not enough anymore.

local.conf - machine configuration

All the machine related varibales should go in the machine configuration:

- PREFERRED_PROVIDER_virtual/kernel
- PREFERRED_PROVIDER_virtual/bootloader
- PREFERRED_VERSION_linux-*
- IMAGE_FSTYPES
- In a few cases, IMAGE_INSTALL_append, for example, to actually install the kernel in the root filesystem.

local.conf - distro configuration

The other variables should go in the distro configuration:

- PREFERRED_PROVIDER_*
- PREFERRED_VERSION_*
- PACKAGECONFIG_pn-*
- INCOMPATIBLE_LICENSE
- LICENSE_FLAGS_WHITELIST

Release management

Release management

There are multiple tasks that OE/bitbake based projects let you do on your own to ensure build reproducibility:

- Code distribution and project setup.
- Release tagging

A separate tool is needed for that, usual solutions are:

- combo-layer, as done by Poky: `https://wiki.yoctoproject.org/wiki/Combo-layer`
- git submodules + setup script. Great example in YOE: `https://github.com/YoeDistro/yoe-distro`
- repo and `templateconf` or setup script
- kas

repo

- `repo` is used in Android to distribute its source code, which is split into many `git` repositories. It's a wrapper to handle several `git` repositories at once.
- The `repo` configuration is stored in `manifest` file, usually available in its own `git` repository.
- It could also be in a specific branch of your custom layer.
- It only handles fetching code, handling `local.conf` and `bblayers.conf` is done separately

Manifest example

```xml
<?xml version="1.0" encoding="UTF-8"?>
<manifest>
  <default sync-j="4" revision="dunfell"/>

  <remote fetch="https://github.com/openembedded" name="oe"/>
  <remote fetch="https://github.com/Freescale" name="freescale"/>
  <remote fetch="ssh://git@server.com" name="private"/>

  <project remote="freescale" name="meta-freescale" path="sources/meta-freescale"/>
  <project remote="oe" name="openembedded-core" path="sources/openembedded-core"/>
  <project remote="oe" name="bitbake" path="sources/openembedded-core/bitbake"
           revision="1.46" />
  <project remote="oe" name="meta-openembedded" path="sources/meta-openembedded"/>

  <project remote="private" name="meta-custom" path="sources/meta-custom">
    <copyfile dest="setup-environment" src="buildconf/setup-environment"/>
  </project>
</manifest>
```

repo: release

To tag a release, a few steps have to be taken:

- Optionally tag the custom layers
- For each project entry in the manifest, set the revision parameter to either a tag or a commit hash.
- Commit and tag this version of the manifest.

kas

- Specific tool developed by Siemens for OpenEmbedded: `https://github.com/siemens/kas`
- Will fetch layers and build the image in a single command
- Uses a single JSON or YAML configuration file part of the custom layer
- Can generate and run inside a Docker container
- Can setup `local.conf` and `bblayers.conf`

kas configuration

```yaml
header:
  version: 8
machine: mymachine
distro: mydistro
target:
  - myimage

repos:
  meta-custom:

  bitbake:
    url: "https://git.openembedded.org/bitbake"
    refspec: "1.46"

  openembedded-core:
    url: "https://git.openembedded.org/openembedded-core"
    refspec: dunfell
    layers:
      meta:
```

kas configuration

```
meta-freescale:
  url: "https://github.com/Freescale/meta-freescale"
  refspec: dunfell

meta-openembedded:
 url: http://git.openembedded.org/meta-openembedded
 refspec: dunfell
 layers:
   meta-oe:
   meta-python:
   meta-networking:
```

Network access

Another task when creating a release is to ensure all the code is available internally, either on the local build machine or on local mirrors.

- Ensure there is no `SRCREV = "${AUTOREV}"` in any recipe.
- Set `BB_GENERATE_MIRROR_TARBALLS = "1"` to generate tarballs of the git repositories in `DL_DIR`.
- Fetch all the source (e.g using `bitbake -c fetchall <target>`).
- Archive `DL_DIR`, make the tarballs available internally.
- Optionally build once with `BB_NO_NETWORK = "1"` to check for missing tarballs or remaining `AUTOREV`.
- Point bitbake to your internal mirrors, using `PREMIRRORS` or `INHERIT += "own-mirrors"` with `SOURCE_MIRROR_URL`
- Build the release, from scratch using `BB_FETCH_PREMIRRORONLY = "1"`.

Build optimization

Sharing the sstate-cache

It is possible to share the shared state cache across multiple build machines:

- Set up CI or nightly builds.
- Use the `DL_DIR` to populate the `PREMIRRORS`.
- Share the sstate-cache (`SSTATE_DIR`) over NFS or HTTP.
- Setup `SSTATE_MIRRORS` to point to that share

This works well if all the hosts are similar as this influence checksums. Containers will help.

Cleaning the sstate-cache

The sstate-cache is growing over time. It is possible to clean old data with:

```
$ ./scripts/sstate-cache-management.sh --remove-duplicated -d \
  --cache-dir=<SSTATE_DIR>
```

License compliance

Listing licenses

OpenEmbbedded will generate a manifest of all the licenses of the software present on the target image in `LICENSE_DIRECTORY/IMAGE_NAME/license.manifest`

```
PACKAGE NAME: busybox
PACKAGE VERSION: 1.31.1
RECIPE NAME: busybox
LICENSE: GPLv2 & bzip2-1.0.6

PACKAGE NAME: dropbear
PACKAGE VERSION: 2019.78
RECIPE NAME: dropbear
LICENSE: MIT & BSD-3-Clause & BSD-2-Clause & PD
```

Providing license text

To include the license text in the root filesystem either:

- Use `COPY_LIC_DIRS = "1"` and `COPY_LIC_MANIFEST = "1"`
- or use `LICENSE_CREATE_PACKAGE = "1"` to generate packages including the license and install the required license packages.

Providing sources

OpenEmbbedded provides the `archiver` class to generate tarballs of the source code:

- Use `INHERIT += "archiver"`
- Set the `ARCHIVER_MODE` variable, the default is to provide patched sources. To provide configured sources:

```
ARCHIVER_MODE[src] = "configured"
```

Questions? Suggestions? Comments?

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`http://bootlin.com/pub/conferences/2020/elce/belloni-yocto-best-practices/`