Building Custom Linux Systems with the Yocto Project

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Yocto Project

- It's not an embedded Linux distribution, it creates one for you
- Automates downloading sources, cross-compiling, and assembling images
- Uses tools and metadata co-developed with OpenEmbedded
- Includes a reference distribution called Poky

Yocto Project

- Robust framework for customization
- Auditing
  - Build entire toolchain and final image from source
  - Licensing
  - CVE analysis
- Easier hardware porting
- Community

First Steps

```
$ git clone -b zeus git://git.yoctoproject.org/poky
$ cd poky
$ . oe-init-build-env
$ bitbake core-image-minimal
$ runqemu
```

Shared State Cache

Downloading and compiling an entire Linux system can take a long time. Bitbake caches build artifacts to help ease the pain.

- Source code is saved to a common directory: DL_DIR
- Build artifacts are saved to sstate cache directory: SSTATE_DIR
- Can be shared between developers
  - NFS
  - HTTP/HTTPS

Customize

Simple changes can be done in local.conf

local.conf

```
IMAGE_INSTALL_append = " vim"
```

Run the build

```
$ bitbake core-image-minimal
$ runqemu
```

Customize More

local.conf

```
IMAGE_INSTALL_append = " vim htop"
```

Run the build

```
$ bitbake core-image-minimal
```

Customize More

local.conf

```
IMAGE_INSTALL_append = " vim htop"
```

Run the build

```
$ bitbake core-image-minimal
```

:-(

```
ERROR: Nothing RPROVIDES 'htop' (but /home/robert/yocto/seagl2019/poky/
meta/recipes-core/images/core-image-minimal.bb RDEPENDS on or otherwise
requires it)
```

Bitbake Layers

- Layers are software repositories
- Make reuse easier
- Allow placing recipes into logical groups
- A layer can modify recipes from another layer

OpenEmbedded Layer Index

OpenEmbedded Layer In

https://layers.openembedded.org/layerindex/recipe/108561/

OpenEmbedded Layer Index

Submit layer | Log in

zeus → meta-oe → htop

htop 2.2.0

Name	htop
Version	2.2.0
Summary	Interactive process viewer
Description	
Section	console/utils
License	GPLv2
Homepage	http://hisham.hm/htop
Recipe file	recipes-support/htop/htop_2.2.0.bb
Layer	meta-oe (zeus branch)

Use the Community

Clone another layer

```
$ git clone -b zeus git://git.openembedded.org/meta-openembedded
```

bblayers.conf

```
BBLAYERS += "/home/robert/yocto/seagl2019/poky/meta-openembedded/meta-oe"
```

Run the build

```
$ bitbake core-image-minimal
$ runqemu
```

How it Works

- bitbake parses layers for configuration and recipes, then performs the build
- Layers contain recipes
- Recipes build packages
  - Download and patch source code
  - Set configure options
  - Cross-compile
  - rpm, ipk, or deb
- Packages are assembled into images

Recipe Ingredients

robert@bucephalus:~/yocto/seagl2019/poky

```
SUMMARY = "Interactive process viewer"
HOMEPAGE = "http://hisham.hm/htop"
SECTION = "console/utils"
LICENSE = "GPLv2"
LIC_FILES_CHKSUM = "file://COPYING;md5=c312653532e8e669f30e5ec8bdc23be3"

DEPENDS = "ncurses"

SRC_URI = "http://hisham.hm/htop/releases/${PV}/${BP}.tar.gz \
           file://0001-Use-pkg-config.patch"
SRC_URI[md5sum] = "0d816b6beed31edc75babcfbf863ffa8"
SRC_URI[sha256sum] = "d9d6826f10ce3887950d709b53ee1d8c1849a70fa38e91d5896ad8cbc6ba3c57"

inherit autotools pkgconfig

PACKAGECONFIG ??= "proc \
                   cgroup \
                   taskstats \
                   unicode \
                   linux-affinity \
                   delayacct"
PACKAGECONFIG[proc] = "--enable-proc,--disable-proc"
PACKAGECONFIG[openvz] = "--enable-openvz,--disable-openvz"
PACKAGECONFIG[cgroup] = "--enable-cgroup,--disable-cgroup"
PACKAGECONFIG[vserver] = "--enable-vserver,--disable-vserver"
PACKAGECONFIG[taskstats] = "--enable-taskstats,--disable-taskstats"
PACKAGECONFIG[unicode] = "--enable-unicode,--disable-unicode"
PACKAGECONFIG[linux-affinity] = "--enable-linux-affinity,--disable-linux-affinity"
PACKAGECONFIG[hwloc] = "--enable-hwloc,--disable-hwloc,hwloc"
PACKAGECONFIG[setuid] = "--enable-setuid,--disable-setuid"
PACKAGECONFIG[delayacct] = "--enable-delayacct,--disable-delayacct,libnl"

do_configure_prepend () {
    rm -rf ${S}/config.h
}
"meta-openembedded/meta-oe/recipes-support/htop/htop_2.2.0.bb" 35L, 1367C 1,1          All
```

Modify a Recipe from Another Layer

Don't fork upstream layers. Modify recipes from your own layer.

```
$ bitbake-layers create-layer ../meta-seagl
$ bitbake-layers add-layer ../meta-seagl
```

Create a .bbappend file.

```
mkdir -p ../meta-seagl/recipes-support/htop
vi ../meta-seagl/recipes-support/htop/htop_%.bbappend
```

Modify a Recipe from Another Layer

meta-seagl/recipes-support/htop/htop_%.bbappend

```
PACKAGECONFIG = "proc"
```

meta-seagl/recipes-support/htop/htop_%.bbappend

```
PACKAGECONFIG_append = " hwloc"
```

meta-seagl/recipes-support/htop/htop_%.bbappend

```
PACKAGECONFIG_remove = "delayacct"
```

Recipe WORKDIR

robert@bucephalus:~/yocto/seagl2019/poky/build

```
robert@bucephalus ~/yocto/seagl2019/poky/build $ ls tmp/work/aarch64-poky-linux/
htop/2.2.0-r0/
0001-Use-pkg-config.patch  pkgdata-sysroot
build                      pseudo
configure.sstate           recipe-sysroot
debugsources.list          recipe-sysroot-native
deploy-rpms                sstate-install-package
htop-2.2.0                 sstate-install-packagedata
htop.spec                  sstate-install-package_qa
image                      sstate-install-package_write_rpm
license-destdir            sstate-install-populate_lic
package                    sstate-install-populate_sysroot
packages-split             sysroot-destdir
pkgdata                    temp
pkgdata-pdata-input
robert@bucephalus ~/yocto/seagl2019/poky/build $
```

Package Content

robert@bucephalus:~/yocto/seagl2019/poky/build

```
robert@bucephalus ~/yocto/seagl2019/poky/build $ tree tmp/work/aarch64-poky-linu
x/htop/2.2.0-r0/packages-split/htop
tmp/work/aarch64-poky-linux/htop/2.2.0-r0/packages-split/htop
└── usr
    ├── bin
    │   └── htop
    └── share
        ├── applications
        │   └── htop.desktop
        └── pixmaps
            └── htop.png

5 directories, 3 files
robert@bucephalus ~/yocto/seagl2019/poky/build $
```

Modify Package Content

Remove files from package

meta-seagl/recipes-support/htop/htop_%.bbappend

```
do_install_append() {
    rm -r ${D}${datadir}
}
```

Modify Package Content

robert@bucephalus:~/yocto/seagl2019/poky/build

```
robert@bucephalus ~/yocto/seagl2019/poky/build $ tree tmp/work/aarch64-poky-linu
x/htop/2.2.0-r0/packages-split/htop
tmp/work/aarch64-poky-linux/htop/2.2.0-r0/packages-split/htop
└── usr
    └── bin
        └── htop

2 directories, 1 file
robert@bucephalus ~/yocto/seagl2019/poky/build $
```

Larger Changes

- MACHINE
  - Select hardware platform
  - Impacts compile options, kernel options, and potentially anything that is hardware specific
- DISTRO
  - Sets distro-wide policy
  - Should applications build GUIs?
  - sysvinit or systemd?
  - Recipes can inspect DISTRO_FEATURES to enable or disable features
- IMAGE_FEATURES
  - Should debug, source, or dev packages be installed?
  - Debug or release build?

Booting Real Hardware

local.conf

```
MACHINE = "genericx86-64"
IMAGE_FSTYPES_append = " wic"
WKS_FILE = "mkefidisk.wks"
```

More wks examples are in `poky/scripts/lib/wic/canned-wks/`

Write to disk

```
$ dd if=tmp/deploy/images/genericx86-64/core-image-minimal.wic \
     of=/dev/sdb bs=1M
```

Changing init

Generally the DISTRO selects the init manager. Poky defaults to sysvinit, but this can be overridden.

local.conf

```
DISTRO_FEATURES_append = " systemd"
VIRTUAL-RUNTIME_init_manager = "systemd"
# Remove initscripts entirely from the image
DISTRO_FEATURES_BACKFILL_CONSIDERED = "sysvinit"
VIRTUAL-RUNTIME_initscripts = ""
```

Tracking Changes

The buildhistory class captures metadata for build and can commit to a git repository. This helps see how changes impact the image as a whole.

- Files in images and packages
- File sizes and permissions
- Package dependencies

local.conf

```
INHERIT += "buildhistory"
BUILDHISTORY_COMMIT = "1"
```

Resources

Yocto has extensive documentation

- https://yoctoproject.org
- https://yoctoproject.org/docs/latest/mega-manual/mega-manual.html
- https://yoctoproject.org/community/mailing-lists/
- https://layers.openembedded.org/layerindex/branch/zeus/recipes/

LaTeX source code for this presentation is available on my website:

- https://git.robertjoslyn.com/seagl2019/
- robert.joslyn@redrectangle.org