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Manual Notes

- This version of the ***Yocto Project Board Support Package (BSP) Developer's Guide*** is for the 2.6 release of the Yocto Project. To be sure you have the latest version of the manual for this release, go to the Yocto Project documentation page and select the manual from that site. Manuals from the site are more up-to-date than manuals derived from the Yocto Project released TAR files.
- If you located this manual through a web search, the version of the manual might not be the one you want (e.g. the search might have returned a manual much older than the Yocto Project version with which you are working). You can see all Yocto Project major releases by visiting the Releases page. If you need a version of this manual for a different Yocto Project release, visit the Yocto Project documentation page and select the manual set by using the "ACTIVE RELEASES DOCUMENTATION" or "DOCUMENTS ARCHIVE" pull-down menus.
- To report any inaccuracies or problems with this manual, send an email to the Yocto Project discussion group at `yocto@yoctoproject.com` or log into the freenode `#yocto` channel.

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Chapter 1. Board Support Packages (BSP) - Developer's Guide¶

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A Board Support Package (BSP) is a collection of information that defines how to support a particular hardware device, set of devices, or hardware platform. The BSP includes information about the hardware features present on the device and kernel configuration information along with any additional hardware drivers required. The BSP also lists any additional software components required in addition to a generic Linux software stack for both essential and optional platform features.

This guide presents information about BSP Layers, defines a structure for components so that BSPs follow a commonly understood layout, discusses how to customize a recipe for a BSP, addresses BSP licensing, and provides information that shows you how to create a BSP Layer using the `bitbake-layers` tool.

1.1. BSP Layers¶

A BSP consists of a file structure inside a base directory. Collectively, you can think of the base directory, its file structure, and the contents as a BSP Layer. Although not a strict requirement, BSP layers in the Yocto Project use the following well-established naming convention:

```
meta-bsp_root_name
```

The string "meta-" is prepended to the machine or platform name, which is *bsp_root_name* in the above form.

Tip

Because the BSP layer naming convention is well-established, it is advisable to follow it when creating layers. Technically speaking, a BSP layer name does not need to start with `meta-`. However, various scripts and tools in the Yocto Project development environment assume this convention.

To help understand the BSP layer concept, consider the BSPs that the Yocto Project supports and provides with each release. You can see the layers in the Yocto Project Source Repositories through a web interface at http://git.yoctoproject.org. If you go to that interface, you will find a list of repositories under "Yocto Metadata Layers".

Note

Layers that are no longer actively supported as part of the Yocto Project appear under the heading "Yocto Metadata Layer Archive."

Each repository is a BSP layer supported by the Yocto Project (e.g. `meta-raspberrypi` and `meta-intel`). Each of these layers is a repository unto itself and clicking on a layer reveals information that includes two links from which you can choose to set up a clone of the layer's repository on your local host system. Here is an example that clones the Raspberry Pi BSP layer:

```
$ git clone git://git.yoctoproject.org/meta-raspberrypi
```

In addition to BSP layers, the `meta-yocto-bsp` layer is part of the shipped `poky` repository. The `meta-yocto-bsp` layer maintains several BSPs such as the Beaglebone, EdgeRouter, and generic versions of both 32-bit and 64-bit IA machines.

For information on the BSP development workflow, see the "Developing a Board Support Package (BSP)" section. For more information on how to set up a local copy of source files from a Git repository, see the "Locating Yocto Project Source Files" section in the Yocto Project Development Tasks Manual.

The layer's base directory (`meta-`*`bsp_root_name`*) is the root directory of the BSP Layer. This directory is what you add to the `BBLAYERS` variable in the `conf/bblayers.conf` file found in the Build Directory, which is established after you run the OpenEmbedded build environment setup script (i.e. `oe-init-build-env`). Adding the root directory allows the OpenEmbedded build system to recognize the BSP layer and from it build an image. Here is an example:

```
BBLAYERS ?= " \
  /usr/local/src/yocto/meta \
  /usr/local/src/yocto/meta-poky \
  /usr/local/src/yocto/meta-yocto-bsp \
  /usr/local/src/yocto/meta-mylayer \
  "
```

Tip

Ordering and `BBFILE_PRIORITY` for the layers listed in `BBLAYERS` matter. For example, if multiple layers define a machine configuration, the OpenEmbedded build system uses the last layer searched given similar layer priorities. The build system works from the top-down through the layers listed in `BBLAYERS`.

Some BSPs require or depend on additional layers beyond the BSP's root layer in order to be functional. In this case, you need to specify these layers in the `README` "Dependencies" section of the BSP's root layer. Additionally, if any build instructions exist for the BSP, you must add them to the "Dependencies" section.

Some layers function as a layer to hold other BSP layers. These layers are knows as "container layers". An example of this type of layer is the `meta-intel` layer. This layer contains BSP layers for the Intel-core2-32 Intel® Common Core (Intel-core2-32) and the Intel-corei7-64 Intel® Common Core (Intel-corei7-64). the `meta-intel` layer also contains the `common/` directory, which contains common content across those layers.

For more information on layers, see the "Understanding and Creating Layers" section of the Yocto Project Development Tasks Manual.

1.2. Preparing Your Build Host to Work With BSP Layers¶

This section describes how to get your build host ready to work with BSP layers. Once you have the host set up, you can create the layer as described in the "Creating a new BSP Layer Using the `bitbake-layers` Script" section.

Note

For structural information on BSPs, see the Example Filesystem Layout section.

1. ***Set Up the Build Environment:*** Be sure you are set up to use BitBake in a shell. See the "Preparing the Build Host" section in the Yocto Project Development Tasks Manual for information on how to get a build host ready that is either a native Linux machine or a machine that uses CROPS.
2. ***Clone the `poky` Repository:*** You need to have a local copy of the Yocto Project Source Directory (i.e. a local `poky` repository). See the "Cloning the `poky` Repository" and possibly the "Checking Out by Branch in Poky" or "Checking Out by Tag in Poky" sections all in the Yocto Project Development Tasks Manual for information on how to clone the `poky` repository and check out the appropriate branch for your work.
3. ***Determine the BSP Layer You Want:*** The Yocto Project supports many BSPs, which are maintained in their own layers or in layers designed to contain several BSPs. To get an idea of machine support through BSP layers, you can look at the index of machines for the release.
4. ***Optionally Clone the `meta-intel` BSP Layer:*** If your hardware is based on current Intel CPUs and devices, you can leverage this BSP layer. For details on the `meta-intel` BSP layer, see the layer's `README` file.
    a. ***Navigate to Your Source Directory:*** Typically, you set up the `meta-intel` Git repository inside the Source Directory (e.g. `poky`).

    ```
    $ cd /home/you/poky
    ```

    b. ***Clone the Layer:***

    ```
    $ git clone git://git.yoctoproject.org/meta-intel.git
    Cloning into 'meta-intel'...
    remote: Counting objects: 15585, done.
    remote: Compressing objects: 100% (5056/5056), done.
    remote: Total 15585 (delta 9123), reused 15329 (delta 8867)
    Receiving objects: 100% (15585/15585), 4.51 MiB | 3.19 MiB/s, done.
    Resolving deltas: 100% (9123/9123), done.
    Checking connectivity... done.
    ```

    c. ***Check Out the Proper Branch:*** The branch you check out for `meta-intel` must match the same branch you are using for the Yocto Project release (e.g. thud):

    ```
    $ cd meta-intel
    $ git checkout -b thud remotes/origin/thud
    Branch thud set up to track remote branch thud from origin.
    Switched to a new branch 'thud'
    ```

    ### Note

    To see the available branch names in a cloned repository, use the `git branch -al` command. See the "Checking Out By Branch in Poky" section in the Yocto Project Development Tasks Manual for more information.

5. ***Optionally Set Up an Alternative BSP Layer:*** If your hardware can be more closely leveraged to an existing BSP not within the `meta-intel` BSP layer, you can clone that BSP layer.

    The process is identical to the process used for the `meta-intel` layer except for the layer's name. For example, if you determine that your hardware most closely matches the `meta-raspberrypi`, clone that layer:

```
$ git clone git://git.yoctoproject.org/meta-raspberrypi
Cloning into 'meta-raspberrypi'...
remote: Counting objects: 4743, done.
remote: Compressing objects: 100% (2185/2185), done.
remote: Total 4743 (delta 2447), reused 4496 (delta 2258)
Receiving objects: 100% (4743/4743), 1.18 MiB | 0 bytes/s, done.
Resolving deltas: 100% (2447/2447), done.
Checking connectivity... done.
```

6. ***Initialize the Build Environment:*** While in the root directory of the Source Directory (i.e. `poky`), run the `oe-init-build-env` environment setup script to define the OpenEmbedded build environment on your build host.

   ```
   $ source oe-init-build-env
   ```

   Among other things, the script creates the Build Directory, which is `build` in this case and is located in the Source Directory. After the script runs, your current working directory is set to the `build` directory.

1.3. Example Filesystem Layout¶

Defining a common BSP directory structure allows end-users to understand and become familiar with that standard. A common format also encourages standardization of software support for hardware.

The proposed form described in this section does have elements that are specific to the OpenEmbedded build system. It is intended that developers can use this structure with other build systems besides the OpenEmbedded build system. It is also intended that it will be be simple to extract information and convert it to other formats if required. The OpenEmbedded build system, through its standard layers mechanism, can directly accept the format described as a layer. The BSP layer captures all the hardware-specific details in one place using a standard format, which is useful for any person wishing to use the hardware platform regardless of the build system they are using.

The BSP specification does not include a build system or other tools - the specification is concerned with the hardware-specific components only. At the end-distribution point, you can ship the BSP layer combined with a build system and other tools. Realize that it is important to maintain the distinction that the BSP layer, a build system, and tools are separate components that could to be combined in certain end products.

Before looking at the common form for the file structure inside a BSP Layer, you should be aware that some requirements do exist in order for a BSP layer to be considered compliant with the Yocto Project. For that list of requirements, see the "Released BSP Requirements" section.

Below is the common form for the file structure inside a BSP Layer. While this basic form represents the standard, realize that the actual file structures for specific BSPs could differ.

```
meta-bsp_root_name/
meta-bsp_root_name/bsp_license_file
meta-bsp_root_name/README
meta-bsp_root_name/README.sources
meta-bsp_root_name/binary/bootable_images
meta-bsp_root_name/conf/layer.conf
meta-bsp_root_name/conf/machine/*.conf
meta-bsp_root_name/recipes-bsp/*
meta-bsp_root_name/recipes-core/*
meta-bsp_root_name/recipes-graphics/*
meta-bsp_root_name/recipes-kernel/linux/linux-yocto_kernel_rev.bbappend
```

Below is an example of the Raspberry Pi BSP layer that is available from the Source Respositories:

```
meta-raspberrypi/COPYING.MIT
meta-raspberrypi/README.md
meta-raspberrypi/classes
meta-raspberrypi/classes/sdcard_image-rpi.bbclass
meta-raspberrypi/conf/
meta-raspberrypi/conf/layer.conf
meta-raspberrypi/conf/machine/
meta-raspberrypi/conf/machine/raspberrypi-cm.conf
meta-raspberrypi/conf/machine/raspberrypi-cm3.conf
meta-raspberrypi/conf/machine/raspberrypi.conf
meta-raspberrypi/conf/machine/raspberrypi0-wifi.conf
meta-raspberrypi/conf/machine/raspberrypi0.conf
meta-raspberrypi/conf/machine/raspberrypi2.conf
meta-raspberrypi/conf/machine/raspberrypi3-64.conf
meta-raspberrypi/conf/machine/raspberrypi3.conf
meta-raspberrypi/conf/machine/include
meta-raspberrypi/conf/machine/include/rpi-base.inc
meta-raspberrypi/conf/machine/include/rpi-default-providers.inc
meta-raspberrypi/conf/machine/include/rpi-default-settings.inc
meta-raspberrypi/conf/machine/include/rpi-default-versions.inc
meta-raspberrypi/conf/machine/include/tune-arm1176jzf-s.inc
meta-raspberrypi/docs
meta-raspberrypi/docs/Makefile
meta-raspberrypi/docs/conf.py
meta-raspberrypi/docs/contributing.md
meta-raspberrypi/docs/extra-apps.md
meta-raspberrypi/docs/extra-build-config.md
meta-raspberrypi/docs/index.rst
meta-raspberrypi/docs/layer-contents.md
```

```
meta-raspberrypi/docs/readme.md
meta-raspberrypi/files
meta-raspberrypi/files/custom-licenses
meta-raspberrypi/files/custom-licenses/Broadcom
meta-raspberrypi/recipes-bsp
meta-raspberrypi/recipes-bsp/bootfiles
meta-raspberrypi/recipes-bsp/bootfiles/bcm2835-bootfiles.bb
meta-raspberrypi/recipes-bsp/bootfiles/rpi-config_git.bb
meta-raspberrypi/recipes-bsp/common
meta-raspberrypi/recipes-bsp/common/firmware.inc
meta-raspberrypi/recipes-bsp/formfactor
meta-raspberrypi/recipes-bsp/formfactor/formfactor
meta-raspberrypi/recipes-bsp/formfactor/formfactor/raspberrypi
meta-raspberrypi/recipes-bsp/formfactor/formfactor/raspberrypi/machconfig
meta-raspberrypi/recipes-bsp/formfactor/formfactor_0.0.bbappend
meta-raspberrypi/recipes-bsp/rpi-u-boot-src
meta-raspberrypi/recipes-bsp/rpi-u-boot-src/files
meta-raspberrypi/recipes-bsp/rpi-u-boot-src/files/boot.cmd.in
meta-raspberrypi/recipes-bsp/rpi-u-boot-src/rpi-u-boot-scr.bb
meta-raspberrypi/recipes-bsp/u-boot
meta-raspberrypi/recipes-bsp/u-boot/u-boot
meta-raspberrypi/recipes-bsp/u-boot/u-boot/*.patch
meta-raspberrypi/recipes-bsp/u-boot/u-boot_%.bbappend
meta-raspberrypi/recipes-connectivity
meta-raspberrypi/recipes-connectivity/bluez5
meta-raspberrypi/recipes-connectivity/bluez5/bluez5
meta-raspberrypi/recipes-connectivity/bluez5/bluez5/*.patch
meta-raspberrypi/recipes-connectivity/bluez5/bluez5/BCM43430A1.hcd
meta-raspberrypi/recipes-connectivity/bluez5/bluez5brcm43438.service
meta-raspberrypi/recipes-connectivity/bluez5/bluez5_%.bbappend
meta-raspberrypi/recipes-core
meta-raspberrypi/recipes-core/images
meta-raspberrypi/recipes-core/images/rpi-basic-image.bb
meta-raspberrypi/recipes-core/images/rpi-hwup-image.bb
meta-raspberrypi/recipes-core/images/rpi-test-image.bb
meta-raspberrypi/recipes-core/packagegroups
meta-raspberrypi/recipes-core/packagegroups/packagegroup-rpi-test.bb
meta-raspberrypi/recipes-core/psplash
meta-raspberrypi/recipes-core/psplash/files
meta-raspberrypi/recipes-core/psplash/files/psplash-raspberrypi-img.h
meta-raspberrypi/recipes-core/psplash/psplash_git.bbappend
meta-raspberrypi/recipes-core/udev
meta-raspberrypi/recipes-core/udev/udev-rules-rpi
meta-raspberrypi/recipes-core/udev/udev-rules-rpi/99-com.rules
meta-raspberrypi/recipes-core/udev/udev-rules-rpi.bb
meta-raspberrypi/recipes-devtools
meta-raspberrypi/recipes-devtools/bcm2835
meta-raspberrypi/recipes-devtools/bcm2835/bcm2835_1.52.bb
meta-raspberrypi/recipes-devtools/pi-blaster
meta-raspberrypi/recipes-devtools/pi-blaster/files
meta-raspberrypi/recipes-devtools/pi-blaster/files/*.patch
meta-raspberrypi/recipes-devtools/pi-blaster/pi-blaster_git.bb
meta-raspberrypi/recipes-devtools/python
meta-raspberrypi/recipes-devtools/python/python-rtimu
meta-raspberrypi/recipes-devtools/python/python-rtimu/*.patch
meta-raspberrypi/recipes-devtools/python/python-rtimu_git.bb
meta-raspberrypi/recipes-devtools/python/python-sense-hat_2.2.0.bb
meta-raspberrypi/recipes-devtools/python/rpi-gpio
meta-raspberrypi/recipes-devtools/python/rpi-gpio/*.patch
meta-raspberrypi/recipes-devtools/python/rpi-gpio_0.6.3.bb
meta-raspberrypi/recipes-devtools/python/rpio
meta-raspberrypi/recipes-devtools/python/rpio/*.patch
meta-raspberrypi/recipes-devtools/python/rpio_0.10.0.bb
meta-raspberrypi/recipes-devtools/wiringPi
meta-raspberrypi/recipes-devtools/wiringPi/files
meta-raspberrypi/recipes-devtools/wiringPi/files/*.patch
meta-raspberrypi/recipes-devtools/wiringPi/wiringpi_git.bb
meta-raspberrypi/recipes-graphics
meta-raspberrypi/recipes-graphics/eglinfo
meta-raspberrypi/recipes-graphics/eglinfo/eglinfo-fb_%.bbappend
meta-raspberrypi/recipes-graphics/eglinfo/eglinfo-x11_%.bbappend
meta-raspberrypi/recipes-graphics/mesa
meta-raspberrypi/recipes-graphics/mesa/mesa-gl_%.bbappend
meta-raspberrypi/recipes-graphics/mesa/mesa_%.bbappend
meta-raspberrypi/recipes-graphics/userland
meta-raspberrypi/recipes-graphics/userland/userland
meta-raspberrypi/recipes-graphics/userland/userland/*.patch
meta-raspberrypi/recipes-graphics/userland/userland_git.bb
meta-raspberrypi/recipes-graphics/vc-graphics
meta-raspberrypi/recipes-graphics/vc-graphics/files
meta-raspberrypi/recipes-graphics/vc-graphics/files/egl.pc
meta-raspberrypi/recipes-graphics/vc-graphics/files/vchiq.sh
meta-raspberrypi/recipes-graphics/vc-graphics/vc-graphics-hardfp.bb
meta-raspberrypi/recipes-graphics/vc-graphics/vc-graphics.bb
meta-raspberrypi/recipes-graphics/vc-graphics/vc-graphics.inc
meta-raspberrypi/recipes-graphics/wayland
meta-raspberrypi/recipes-graphics/wayland/weston_%.bbappend
meta-raspberrypi/recipes-graphics/xorg-xserver
meta-raspberrypi/recipes-graphics/xorg-xserver/xserver-xf86-config
meta-raspberrypi/recipes-graphics/xorg-xserver/xserver-xf86-config/rpi
meta-raspberrypi/recipes-graphics/xorg-xserver/xserver-xf86-config/rpi/xorg.conf
meta-raspberrypi/recipes-graphics/xorg-xserver/xserver-xf86-config/rpi/xorg.conf.d
meta-raspberrypi/recipes-graphics/xorg-xserver/xserver-xf86-config/rpi/xorg.conf.d/10-evdev.conf
meta-raspberrypi/recipes-graphics/xorg-xserver/xserver-xf86-config/rpi/xorg.conf.d/98-pitft.conf
```

```
meta-raspberrypi/recipes-graphics/xorg-xserver/xserver-xf86-config/rpi/xorg.conf.d/99-calibration.co
meta-raspberrypi/recipes-graphics/xorg-xserver/xserver-xf86-config_0.1.bbappend
meta-raspberrypi/recipes-graphics/xorg-xserver/xserver-xorg_%.bbappend
meta-raspberrypi/recipes-kernel
meta-raspberrypi/recipes-kernel/linux-firmware
meta-raspberrypi/recipes-kernel/linux-firmware/files
meta-raspberrypi/recipes-kernel/linux-firmware/files/brcmfmac43430-sdio.bin
meta-raspberrypi/recipes-kernel/linux-firmware/files/brcfmac43430-sdio.txt
meta-raspberrypi/recipes-kernel/linux-firmware/linux-firmware_%.bbappend
meta-raspberrypi/recipes-kernel/linux
meta-raspberrypi/recipes-kernel/linux/linux-raspberrypi-dev.bb
meta-raspberrypi/recipes-kernel/linux/linux-raspberrypi.inc
meta-raspberrypi/recipes-kernel/linux/linux-raspberrypi_4.14.bb
meta-raspberrypi/recipes-kernel/linux/linux-raspberrypi_4.9.bb
meta-raspberrypi/recipes-multimedia
meta-raspberrypi/recipes-multimedia/gstreamer
meta-raspberrypi/recipes-multimedia/gstreamer/gstreamer1.0-omx
meta-raspberrypi/recipes-multimedia/gstreamer/gstreamer1.0-omx/*.patch
meta-raspberrypi/recipes-multimedia/gstreamer/gstreamer1.0-omx_%.bbappend
meta-raspberrypi/recipes-multimedia/gstreamer/gstreamer1.0-plugins-bad_%.bbappend
meta-raspberrypi/recipes-multimedia/gstreamer/gstreamer1.0-omx-1.12
meta-raspberrypi/recipes-multimedia/gstreamer/gstreamer1.0-omx-1.12/*.patch
meta-raspberrypi/recipes-multimedia/omxplayer
meta-raspberrypi/recipes-multimedia/omxplayer/omxplayer
meta-raspberrypi/recipes-multimedia/omxplayer/omxplayer/*.patch
meta-raspberrypi/recipes-multimedia/omxplayer/omxplayer_git.bb
meta-raspberrypi/recipes-multimedia/x264
meta-raspberrypi/recipes-multimedia/x264/x264_git.bbappend
meta-raspberrypi/wic
meta-raspberrypi/wic/sdimage-raspberrypi.wks
```

The following sections describe each part of the proposed BSP format.

1.3.1. License Files¶

You can find these files in the BSP Layer at:

```
meta-bsp_root_name/bsp_license_file
```

These optional files satisfy licensing requirements for the BSP. The type or types of files here can vary depending on the licensing requirements. For example, in the Raspberry Pi BSP all licensing requirements are handled with the `COPYING.MIT` file.

Licensing files can be MIT, BSD, GPLv*, and so forth. These files are recommended for the BSP but are optional and totally up to the BSP developer. For information on how to maintain license compliance, see the "Maintaining Open Source License Compliance During Your Product's Lifecycle" section in the Yocto Project Development Tasks Manual.

1.3.2. README File¶

You can find this file in the BSP Layer at:

```
meta-bsp_root_name/README
```

This file provides information on how to boot the live images that are optionally included in the `binary/` directory. The `README` file also provides information needed for building the image.

At a minimum, the `README` file must contain a list of dependencies, such as the names of any other layers on which the BSP depends and the name of the BSP maintainer with his or her contact information.

1.3.3. README.sources File¶

You can find this file in the BSP Layer at:

```
meta-bsp_root_name/README.sources
```

This file provides information on where to locate the BSP source files used to build the images (if any) that reside in `meta-`*`bsp_root_name`*`/binary`. Images in the `binary` would be images released with the BSP. The information in the `README.sources` file also helps you find the Metadata used to generate the images that ship with the BSP.

> **Note**
> If the BSP's `binary` directory is missing or the directory has no images, an existing `README.sources` file is meaningless and usually does not exist.

1.3.4. Pre-built User Binaries¶

You can find these files in the BSP Layer at:

```
meta-bsp_root_name/binary/bootable_images
```

This optional area contains useful pre-built kernels and user-space filesystem images released with the BSP that are appropriate to the target system. This directory typically contains graphical (e.g. Sato) and minimal live images when the BSP tarball has been created and made available in the Yocto Project website. You can use these kernels and images to get a system running and quickly get started on development tasks.

The exact types of binaries present are highly hardware-dependent. The `README` file should be present in the BSP Layer and it explains how to use the images with the target hardware. Additionally, the `README.sources` file should be present to locate the sources used to build the images and provide information on the Metadata.

1.3.5. Layer Configuration File¶

You can find this file in the BSP Layer at:

```
meta-bsp_root_name/conf/layer.conf
```

The `conf/layer.conf` file identifies the file structure as a layer, identifies the contents of the layer, and contains information about how the build system should use it. Generally, a standard boilerplate file such as the following works. In the following example, you would replace *bsp* with the actual name of the BSP (i.e. *bsp_root_name* from the example template).

```
# We have a conf and classes directory, add to BBPATH
BBPATH .= ":${LAYERDIR}"

# We have a recipes directory, add to BBFILES
BBFILES += "${LAYERDIR}/recipes-*/*/*.bb \
            ${LAYERDIR}/recipes-*/*/*.bbappend"

BBFILE_COLLECTIONS += "bsp"
BBFILE_PATTERN_bsp = "^${LAYERDIR}/"
BBFILE_PRIORITY_bsp = "6"

LAYERDEPENDS_bsp = "intel"
```

To illustrate the string substitutions, here are the corresponding statements from the Raspberry Pi `conf/layer.conf` file:

```
# We have a conf and classes directory, append to BBPATH
BBPATH .= ":${LAYERDIR}"

# We have a recipes directory containing .bb and .bbappend files, add to BBFILES
BBFILES += "${LAYERDIR}/recipes*/*/*.bb \
            ${LAYERDIR}/recipes*/*/*.bbappend"

BBFILE_COLLECTIONS += "raspberrypi"
BBFILE_PATTERN_raspberrypi := "^${LAYERDIR}/"
BBFILE_PRIORITY_raspberrypi = "9"

# Additional license directories.
LICENSE_PATH += "${LAYERDIR}/files/custom-licenses"
     .
     .
     .
```

This file simply makes BitBake aware of the recipes and configuration directories. The file must exist so that the OpenEmbedded build system can recognize the BSP.

1.3.6. Hardware Configuration Options¶

You can find these files in the BSP Layer at:

```
meta-bsp_root_name/conf/machine/*.conf
```

The machine files bind together all the information contained elsewhere in the BSP into a format that the build system can understand. Each BSP Layer requires at least one machine file. If the BSP supports multiple machines, multiple machine configuration files can exist. These filenames correspond to the values to which users have set the `MACHINE` variable.

These files define things such as the kernel package to use (`PREFERRED_PROVIDER` of virtual/kernel), the hardware drivers to include in different types of images, any special software components that are needed, any bootloader information, and also any special image format requirements.

This configuration file could also include a hardware "tuning" file that is commonly used to define the package architecture and specify optimization flags, which are carefully chosen to give best performance on a given processor.

Tuning files are found in the `meta/conf/machine/include` directory within the Source Directory. For example, many `tune-*` files (e.g. `tune-arm1136jf-s.inc`, `tun-1586-nlp.inc`, and so forth) reside in the `poky/meta/conf/machine/include` directory.

To use an include file, you simply include them in the machine configuration file. For example, the Raspberry Pi BSP `raspberrypi3.conf` contains the following statement:

```
include conf/machine/include/rpi-base.inc
```

1.3.7. Miscellaneous BSP-Specific Recipe Files¶

You can find these files in the BSP Layer at:

```
meta-bsp_root_name/recipes-bsp/*
```

This optional directory contains miscellaneous recipe files for the BSP. Most notably would be the formfactor files. For example, in the Raspberry Pi BSP there is the `formfactor_0.0.bbappend` file, which is an append file used to augment the recipe that starts the build. Furthermore, there are machine-specific settings used during the build that are defined by the `machconfig` file further down in the directory. Here is the `machconfig` file for the Raspberry Pi BSP:

```
HAVE_TOUCHSCREEN=0
HAVE_KEYBOARD=1

DISPLAY_CAN_ROTATE=0
DISPLAY_ORIENTATION=0
DISPLAY_DPI=133
```

Note

If a BSP does not have a formfactor entry, defaults are established according to the formfactor configuration file that is installed by the main formfactor recipe `meta/recipes-bsp/formfactor/formfactor_0.0.bb`, which is found in the Source Directory.

1.3.8. Display Support Files¶

You can find these files in the BSP Layer at:

```
meta-bsp_root_name/recipes-graphics/*
```

This optional directory contains recipes for the BSP if it has special requirements for graphics support. All files that are needed for the BSP to support a display are kept here.

1.3.9. Linux Kernel Configuration¶

You can find these files in the BSP Layer at:

```
meta-bsp_root_name/recipes-kernel/linux/linux*.bbappend
meta-bsp_root_name/recipes-kernel/linux/*.bb
```

Append files (`*.bbappend`) modify the main kernel recipe being used to build the image. The `*.bb` files would be a developer-supplied kernel recipe. This area of the BSP hierarchy can contain both these types of files, although in practice, it is likely that you would have one or the other.

For your BSP, you typically want to use an existing Yocto Project kernel recipe found in the Source Directory at `meta/recipes-kernel/linux`. You can append machine-specific changes to the kernel recipe by using a similarly named append file, which is located in the BSP Layer for your target device (e.g. the `meta-bsp_root_name/recipes-kernel/linux` directory).

Suppose you are using the `linux-yocto_4.4.bb` recipe to build the kernel. In other words, you have selected the kernel in your `bsp_root_name.conf` file by adding `PREFERRED_PROVIDER` and `PREFERRED_VERSION` statements as follows:

```
PREFERRED_PROVIDER_virtual/kernel ?= "linux-yocto"
PREFERRED_VERSION_linux-yocto ?= "4.4%"
```

Note

When the preferred provider is assumed by default, the `PREFERRED_PROVIDER` statement does not appear in the `bsp_root_name.conf` file.

You would use the `linux-yocto_4.4.bbappend` file to append specific BSP settings to the kernel, thus configuring the kernel for your particular BSP.

You can find more information on what your append file should contain in the "Creating the Append File" section in the Yocto Project Linux Kernel Development Manual.

An alternate scenario is when you create your own kernel recipe for the BSP. A good example of this is the Raspberry Pi BSP. If you examine the `recipes-kernel/linux` directory you see the following:

```
linux-raspberrypi-dev.bb
linux-raspberrypi.inc
linux-raspberrypi_4.14.bb
linux-raspberrypi_4.9.bb
```

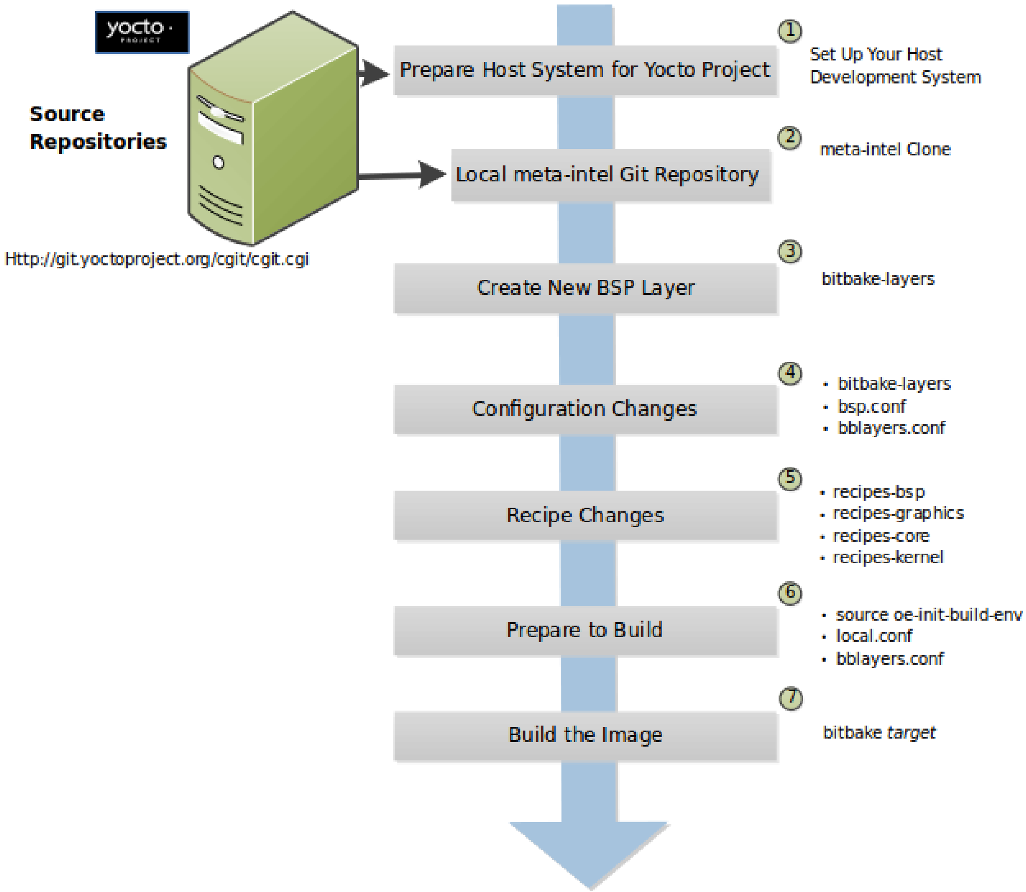
The directory contains three kernel recipes and a common include file.

1.4. Developing a Board Support Package (BSP)¶

This section contains the high-level procedure you can follow to create a BSP. Although not required for BSP creation, the `meta-intel` repository, which contains many BSPs supported by the Yocto Project, is part of the example.

For an example that shows how to create a new layer using the tools, see the "Creating a New BSP Layer Using the `bitbake-layers` Script" section.

The following illustration and list summarize the BSP creation general workflow.



1. ***Set up Your Host Development System to Support Development Using the Yocto Project***: See the "Preparing the Build Host" section in the Yocto Project Development Tasks Manual for options on how to get a system ready to use the Yocto Project.

2. ***Establish the `meta-intel` Repository on Your System:*** Having local copies of these supported BSP layers on your system gives you access to layers you might be able to leverage when creating your BSP. For information on how to get these files, see the "Preparing Your Build Host to Work with BSP Layers" section.

3. ***Create Your Own BSP Layer Using the `bitbake-layers` Script:*** Layers are ideal for isolating and storing work for a given piece of hardware. A layer is really just a location or area in which you place the recipes and configurations for your BSP. In fact, a BSP is, in itself, a special type of layer. The simplest way to create a new BSP layer that is compliant with the Yocto Project is to use the `bitbake-layers` script. For information about that script, see the "Creating a New BSP Layer Using the `bitbake-layers` Script" section.

   Another example that illustrates a layer is an application. Suppose you are creating an application that has library or other dependencies in order for it to compile and run. The layer, in this case, would be where all the recipes that define those dependencies are kept. The key point for a layer is that it is an isolated area that contains all the relevant information for the project that the OpenEmbedded build system knows about. For more information on layers, see the "The Yocto Project Layer Model" section in the Yocto Project Overview and Concepts Manual. You can also reference the "Understanding and Creating Layers" section in the Yocto Project Development Tasks Manual. For more information on BSP layers, see the "BSP Layers" section.

Notes

- Five hardware reference BSPs exist that are part of the Yocto Project release and are located in the `poky/meta-yocto-bsp` BSP layer:
  - Texas Instruments Beaglebone (`beaglebone-yocto`)
  - Freescale MPC8315E-RDB (`mpc8315e-rdb`)
  - Ubiquiti Networks EdgeRouter Lite (`edgerouter`)
  - Two general IA platforms (`genericx86` and `genericx86-64`)
- Three core Intel BSPs exist as part of the Yocto Project release in the `meta-intel` layer:
  - `intel-core2-32`, which is a BSP optimized for the Core2 family of CPUs as well as all CPUs prior to the Silvermont core.
  - `intel-corei7-64`, which is a BSP optimized for Nehalem and later Core and Xeon CPUs as well as Silvermont and later Atom CPUs, such as the Baytrail SoCs.
  - `intel-quark`, which is a BSP optimized for the Intel Galileo gen1 & gen2 development boards.

When you set up a layer for a new BSP, you should follow a standard layout. This layout is described in the "Example Filesystem Layout" section. In the standard layout, notice the suggested structure for recipes and configuration information. You can see the standard layout for a BSP by examining any supported BSP found in the `meta-intel` layer inside the Source Directory.

4. ***Make Configuration Changes to Your New BSP Layer:*** The standard BSP layer structure organizes the files you need to edit in `conf` and several `recipes-*` directories within the BSP layer. Configuration changes identify where your new layer is on the local system and identifies the kernel you are going to use. When you run the `bitbake-layers` script, you are able to interactively configure many things for the BSP (e.g. keyboard, touchscreen, and so forth).

5. ***Make Recipe Changes to Your New BSP Layer:*** Recipe changes include altering recipes (`*.bb` files), removing recipes you do not use, and adding new recipes or append files (`.bbappend`) that support your hardware.

6. ***Prepare for the Build:*** Once you have made all the changes to your BSP layer, there remains a few things you need to do for the OpenEmbedded build system in order for it to create your image. You need to get the build environment ready by sourcing an environment setup script (i.e. `oe-init-build-env`) and you need to be sure two key configuration files are configured appropriately: the `conf/local.conf` and the `conf/bblayers.conf` file. You must make the OpenEmbedded build system aware of your new layer. See the "Enabling Your Layer" section in the Yocto Project Development Tasks Manual for information on how to let the build system know about your new layer.

7. ***Build the Image:*** The OpenEmbedded build system uses the BitBake tool to build images based on the type of image you want to create. You can find more information about BitBake in the BitBake User Manual.

   The build process supports several types of images to satisfy different needs. See the "Images" chapter in the Yocto Project Reference Manual for information on supported images.

1.5. Requirements and Recommendations for Released BSPs¶

Certain requirements exist for a released BSP to be considered compliant with the Yocto Project. Additionally, recommendations also exist. This section describes the requirements and recommendations for released BSPs.

1.5.1. Released BSP Requirements¶

Before looking at BSP requirements, you should consider the following:

- The requirements here assume the BSP layer is a well-formed, "legal" layer that can be added to the Yocto Project. For guidelines on creating a layer that meets these base requirements, see the "BSP Layers" section in this manual and the "Understanding and Creating Layers"" section in the Yocto Project Development Tasks Manual.
- The requirements in this section apply regardless of how you package a BSP. You should consult the packaging and distribution guidelines for your specific release process. For an example of packaging and distribution requirements, see the "Third Party BSP Release Process" wiki page.
- The requirements for the BSP as it is made available to a developer are completely independent of the released form of the BSP. For example, the BSP Metadata can be contained within a Git repository and could have a directory structure completely different from what appears in the officially released BSP layer.
- It is not required that specific packages or package modifications exist in the BSP layer, beyond the requirements for general compliance with the Yocto Project. For example, no requirement exists dictating that a specific kernel or kernel version be used in a given BSP.

Following are the requirements for a released BSP that conform to the Yocto Project:

- ***Layer Name:*** The BSP must have a layer name that follows the Yocto Project standards. For information on BSP layer names, see the "BSP Layers" section.
- ***File System Layout:*** When possible, use the same directory names in your BSP layer as listed in the `recipes.txt` file, which is found in `poky/meta` directory of the Source Directory or in the OpenEmbedded-Core Layer (`openembedded-core`) at http://git.openembedded.org/openembedded-core/tree/meta.

  You should place recipes (`*.bb` files) and recipe modifications (`*.bbappend` files) into `recipes-*` subdirectories by functional area as outlined in `recipes.txt`. If you cannot find a category in `recipes.txt` to fit a particular recipe, you can make up your own `recipes-*` subdirectory.

  Within any particular `recipes-*` category, the layout should match what is found in the OpenEmbedded-Core Git repository (`openembedded-core`) or the Source Directory (`poky`). In other words, make sure you place related files in appropriately related `recipes-*` subdirectories specific to the recipe's function, or within a subdirectory containing a set of closely-related recipes. The recipes themselves should follow the general guidelines for recipes used in the Yocto Project found in the "OpenEmbedded Style Guide".
- ***License File:*** You must include a license file in the `meta-`*`bsp_root_name`* directory. This license covers the BSP Metadata as a whole. You must specify which license to use since no default license exists when one not specified. See the `COPYING.MIT` file for the Raspberry Pi BSP in the `meta-raspberrypi` BSP layer as an example.
- ***README File:*** You must include a `README` file in the `meta-`*`bsp_root_name`* directory. See the `README.md` file for the Raspberry Pi BSP in the `meta-raspberrypi` BSP layer as an example.

  At a minimum, the `README` file should contain the following:

  - A brief description about the hardware the BSP targets.
  - A list of all the dependencies on which a BSP layer depends. These dependencies are typically a list of required layers needed to build the BSP. However, the dependencies should also contain information regarding any other dependencies the BSP might have.
  - Any required special licensing information. For example, this information includes information on special variables needed to satisfy a EULA, or instructions on information needed to build or distribute binaries built from the BSP Metadata.
  - The name and contact information for the BSP layer maintainer. This is the person to whom patches and questions should be sent. For information on how to find the right person, see the "Submitting a Change to the Yocto Project" section in the Yocto Project Development Tasks Manual.
  - Instructions on how to build the BSP using the BSP layer.
  - Instructions on how to boot the BSP build from the BSP layer.
  - Instructions on how to boot the binary images contained in the `binary` directory, if present.
  - Information on any known bugs or issues that users should know about when either building or booting the BSP binaries.
- ***README.sources File:*** If you BSP contains binary images in the `binary` directory, you must include a `README.sources` file in the `meta-`*`bsp_root_name`* directory. This file specifies exactly where you can find the sources used to generate the binary images.
- ***Layer Configuration File:*** You must include a `conf/layer.conf` file in the `meta-`*`bsp_root_name`* directory. This file identifies the `meta-`*`bsp_root_name`* BSP layer as a layer to the build system.
- ***Machine Configuration File:*** You must include one or more `conf/machine/`*`bsp_root_name`*`.conf` files in the `meta-`*`bsp_root_name`* directory. These configuration files define machine targets that can be built using the BSP layer. Multiple machine configuration files define variations of machine configurations that the BSP supports. If a BSP supports multiple machine variations, you need to adequately describe each variation in the BSP `README` file. Do not use multiple machine configuration files to describe disparate hardware. If you do have very different targets, you should create separate BSP layers for each target.

> **Note**
>
> It is completely possible for a developer to structure the working repository as a conglomeration of unrelated BSP files, and to possibly generate BSPs targeted for release from that directory using scripts or some other mechanism (e.g. `meta-yocto-bsp` layer). Such considerations are outside the scope of this document.

1.5.2. Released BSP Recommendations¶

Following are recommendations for released BSPs that conform to the Yocto Project:

- ***Bootable Images:*** Released BSPs can contain one or more bootable images. Including bootable images allows users to easily try out the BSP using their own hardware.

  In some cases, it might not be convenient to include a bootable image. If so, you might want to make two versions of the BSP available: one that contains binary images, and one that does not. The version that does not contain bootable images avoids unnecessary download times for users not interested in the images.

If you need to distribute a BSP and include bootable images or build kernel and filesystems meant to allow users to boot the BSP for evaluation purposes, you should put the images and artifacts within a `binary/` subdirectory located in the `meta-`*`bsp_root_name`* directory.

> **Note**
> If you do include a bootable image as part of the BSP and the image was built by software covered by the GPL or other open source licenses, it is your responsibility to understand and meet all licensing requirements, which could include distribution of source files.

- ***Use a Yocto Linux Kernel:*** Kernel recipes in the BSP should be based on a Yocto Linux kernel. Basing your recipes on these kernels reduces the costs for maintaining the BSP and increases its scalability. See the `Yocto Linux Kernel` category in the Source Repositories for these kernels.

1.6. Customizing a Recipe for a BSP¶

If you plan on customizing a recipe for a particular BSP, you need to do the following:

- Create a `*.bbappend` file for the modified recipe. For information on using append files, see the "Using .bbappend Files in Your Layer" section in the Yocto Project Development Tasks Manual.
- Ensure your directory structure in the BSP layer that supports your machine is such that the OpenEmbedded build system can find it. See the example later in this section for more information.
- Put the append file in a directory whose name matches the machine's name and is located in an appropriate sub-directory inside the BSP layer (i.e. `recipes-bsp`, `recipes-graphics`, `recipes-core`, and so forth).
- Place the BSP-specific files in the proper directory inside the BSP layer. How expansive the layer is affects where you must place these files. For example, if your layer supports several different machine types, you need to be sure your layer's directory structure includes hierarchy that separates the files according to machine. If your layer does not support multiple machines, the layer would not have that additional hierarchy and the files would obviously not be able to reside in a machine-specific directory.

Following is a specific example to help you better understand the process. This example customizes customizes a recipe by adding a BSP-specific configuration file named `interfaces` to the `init-ifupdown_1.0.bb` recipe for machine "xyz" where the BSP layer also supports several other machines:

1. Edit the `init-ifupdown_1.0.bbappend` file so that it contains the following:

   ```
   FILESEXTRAPATHS_prepend := "${THISDIR}/files:"
   ```

   The append file needs to be in the `meta-xyz/recipes-core/init-ifupdown` directory.

2. Create and place the new `interfaces` configuration file in the BSP's layer here:

   ```
   meta-xyz/recipes-core/init-ifupdown/files/xyz-machine-one/interfaces
   ```

   > **Note**
   > If the `meta-xyz` layer did not support multiple machines, you would place the `interfaces` configuration file in the layer here:
   >
   > ```
   > meta-xyz/recipes-core/init-ifupdown/files/interfaces
   > ```

   The `FILESEXTRAPATHS` variable in the append files extends the search path the build system uses to find files during the build. Consequently, for this example you need to have the `files` directory in the same location as your append file.

1.7. BSP Licensing Considerations¶

In some cases, a BSP contains separately licensed Intellectual Property (IP) for a component or components. For these cases, you are required to accept the terms of a commercial or other type of license that requires some kind of explicit End User License Agreement (EULA). Once you accept the license, the OpenEmbedded build system can then build and include the corresponding component in the final BSP image. If the BSP is available as a pre-built image, you can download the image after agreeing to the license or EULA.

You could find that some separately licensed components that are essential for normal operation of the system might not have an unencumbered (or free) substitute. Without these essential components, the system would be non-functional. Then again, you might find that other licensed components that are simply 'good-to-have' or purely elective do have an unencumbered, free replacement component that you can use rather than agreeing to the separately licensed component. Even for components essential to the system, you might find an unencumbered component that is not identical but will work as a less-capable version of the licensed version in the BSP recipe.

For cases where you can substitute a free component and still maintain the system's functionality, the "DOWNLOADS" selection from the "SOFTWARE" tab on the Yocto Project website makes available de-featured BSPs that are completely free of any IP encumbrances. For these cases, you can use the substitution directly and without any further licensing requirements. If present, these fully de-featured BSPs are named appropriately different as compared to the names of their respective encumbered BSPs. If available, these substitutions are your simplest and most preferred options. Obviously, use of these substitutions assumes the resulting functionality meets system requirements.

Note

If however, a non-encumbered version is unavailable or it provides unsuitable functionality or quality, you can use an encumbered version.

A couple different methods exist within the OpenEmbedded build system to satisfy the licensing requirements for an encumbered BSP. The following list describes them in order of preference:

1. ***Use the `LICENSE_FLAGS` Variable to Define the Recipes that Have Commercial or Other Types of Specially-Licensed Packages:*** For each of those recipes, you can specify a matching license string in a `local.conf` variable named `LICENSE_FLAGS_WHITELIST`. Specifying the matching license string signifies that you agree to the license. Thus, the build system can build the corresponding recipe and include the component in the image. See the "Enabling Commercially Licensed Recipes" section in the Yocto Project Development Tasks Manual for details on how to use these variables.

   If you build as you normally would, without specifying any recipes in the `LICENSE_FLAGS_WHITELIST`, the build stops and provides you with the list of recipes that you have tried to include in the image that need entries in the `LICENSE_FLAGS_WHITELIST`. Once you enter the appropriate license flags into the whitelist, restart the build to continue where it left off. During the build, the prompt will not appear again since you have satisfied the requirement.

   Once the appropriate license flags are on the white list in the `LICENSE_FLAGS_WHITELIST` variable, you can build the encumbered image with no change at all to the normal build process.

2. ***Get a Pre-Built Version of the BSP:*** You can get this type of BSP by selecting the "DOWNLOADS" item from the "SOFTWARE" tab on the Yocto Project website. You can download BSP tarballs that contain proprietary components after agreeing to the licensing requirements of each of the individually encumbered packages as part of the download process. Obtaining the BSP this way allows you to access an encumbered image immediately after agreeing to the click-through license agreements presented by the website. If you want to build the image yourself using the recipes contained within the BSP tarball, you will still need to create an appropriate `LICENSE_FLAGS_WHITELIST` to match the encumbered recipes in the BSP.

Note

Pre-compiled images are bundled with a time-limited kernel that runs for a predetermined amount of time (10 days) before it forces the system to reboot. This limitation is meant to discourage direct redistribution of the image. You must eventually rebuild the image if you want to remove this restriction.

1.8. Creating a new BSP Layer Using the `bitbake-layers` Script¶

The `bitbake-layers create-layer` script automates creating a BSP layer. What makes a layer a "BSP layer", is the presence of a machine configuration file. Additionally, a BSP layer usually has a kernel recipe or an append file that leverages off an existing kernel recipe. The primary requirement, however, is the machine configuration.

Use these steps to create a BSP layer:

- ***Create a General Layer:*** Use the `bitbake-layers` script with the `create-layer` subcommand to create a new general layer. For instructions on how to create a general layer using the `bitbake-layers` script, see the "Creating a General Layer Using the `bitbake-layers` Script" section in the Yocto Project Development Tasks Manual.
- ***Create a Layer Configuration File:*** Every layer needs a layer configuration file. This configuration file establishes locations for the layer's recipes, priorities for the layer, and so forth. You can find examples of `layer.conf` files in the Yocto Project Source Repositories. To get examples of what you need in your configuration file, locate a layer (e.g. "meta-ti") and examine the http://git.yoctoproject.org/cgit/cgit.cgi/meta-ti/tree/conf/layer.conf file.
- ***Create a Machine Configuration File:*** Create a `conf/machine/`*`bsp_root_name`*`.conf` file. See `meta-yocto-bsp/conf/machine` for sample *`bsp_root_name`*`.conf` files. Other samples such as `meta-ti` and `meta-freescale` exist from other vendors that have more specific machine and tuning examples.

- ***Create a Kernel Recipe:*** Create a kernel recipe in `recipes-kernel/linux` by either using a kernel append file or a new custom kernel recipe file (e.g. `yocto-linux_4.12.bb`). The BSP layers mentioned in the previous step also contain different kernel examples. See the "Modifying an Existing Recipe" section in the Yocto Project Linux Kernel Development Manual for information on how to create a custom kernel.

The remainder of this section provides a description of the Yocto Project reference BSP for Beaglebone, which resides in the Container Layer (i.e. `meta-yocto-bsp`).

1.8.1. BSP Layer Configuration Example¶

The layer's `conf` directory contains the `layer.conf` configuration file. In this example, the `conf/layer.conf` is the following:

```
# We have a conf and classes directory, add to BBPATH
BBPATH .= ":${LAYERDIR}"

# We have recipes-* directories, add to BBFILES
BBFILES += "${LAYERDIR}/recipes-*/*/*.bb \
            ${LAYERDIR}/recipes-*/*/*.bbappend"

BBFILE_COLLECTIONS += "yoctobsp"
BBFILE_PATTERN_yoctobsp = "^${LAYERDIR}/"
BBFILE_PRIORITY_yoctobsp = "5"
LAYERVERSION_yoctobsp = "4"
LAYERSERIES_COMPAT_yoctobsp = "thud"
```

The variables used in this file configure the layer. A good way to learn about layer configuration files is to examine various files for BSP from the Source Repositories.

For a detailed description of this particular layer configuration file, see "step 3 in the discussion that describes how to create layers in the Yocto Project Development Tasks Manual.

1.8.2. BSP Machine Configuration Example¶

As mentioned earlier in this section, the existence of a machine configuration file is what makes a layer a BSP layer as compared to a general or kernel layer.

Machine configuration files exist in the *bsp_layer*`/conf/machine/` directory of the layer:

bsp_layer`/conf/machine/`*machine*`.conf`

For example, the machine configuration file for the BeagleBone and BeagleBone Black development boards is located in the container layer `poky/meta-yocto-bsp/conf/machine` and is named `beaglebone-yocto.conf`:

```
#@TYPE: Machine
#@NAME: Beaglebone-yocto machine
#@DESCRIPTION: Reference machine configuration for http://beagleboard.org/bone and http://beagleboar

PREFERRED_PROVIDER_virtual/xserver ?= "xserver-xorg"
XSERVER ?= "xserver-xorg \
           xf86-video-modesetting \
           "

MACHINE_EXTRA_RRECOMMENDS = "kernel-modules kernel-devicetree"

EXTRA_IMAGEDEPENDS += "u-boot"

DEFAULTTUNE ?= "cortexa8hf-neon"
include conf/machine/include/tune-cortexa8.inc

IMAGE_FSTYPES += "tar.bz2 jffs2 wic wic.bmap"
EXTRA_IMAGECMD_jffs2 = "-lnp "
WKS_FILE ?= "beaglebone-yocto.wks"
IMAGE_INSTALL_append = " kernel-devicetree kernel-image-zimage"
do_image_wic[depends] += "mtools-native:do_populate_sysroot dosfstools-native:do_populate_sysroot"

SERIAL_CONSOLES = "115200;ttyO0"

PREFERRED_PROVIDER_virtual/kernel ?= "linux-yocto"
PREFERRED_VERSION_linux-yocto ?= "4.12%"

KERNEL_IMAGETYPE = "zImage"
KERNEL_DEVICETREE = "am335x-bone.dtb am335x-boneblack.dtb am335x-bonegreen.dtb"
KERNEL_EXTRA_ARGS += "LOADADDR=${UBOOT_ENTRYPOINT}"

SPL_BINARY = "MLO"
UBOOT_SUFFIX = "img"
UBOOT_MACHINE = "am335x_boneblack_config"
UBOOT_ENTRYPOINT = "0x80008000"
UBOOT_LOADADDRESS = "0x80008000"

MACHINE_FEATURES = "usbgadget usbhost vfat alsa"

IMAGE_BOOT_FILES ?= "u-boot.${UBOOT_SUFFIX} MLO"
```

The variables used to configure the machine define machine-specific properties. For example, machine-dependent packages, machine tunings, the type of kernel to build, and U-Boot configurations.

The following list provides some explanation for the statements found in the example reference machine configuration file for the BeagleBone development boards. Realize that much more can be defined as part of a machines configuration file. In general, you can learn about related variables that this example does not have by locating the variables in the "Yocto Project Variables Glossary" in the Yocto Project Reference Manual.

- `PREFERRED_PROVIDER_virtual/xserver`: The recipe that provides "virtual/xserver" when more than one provider is found. In this case, the recipe that provides "virtual/xserver" is "xserver-xorg", which exists in `poky/meta/recipes-graphics/xserver-xorg`.
- `XSERVER`: The packages that should be installed to provide an X server and drivers for the machine. In this example, the "xserver-xorg" and "xf86-video-modesetting" are installed.
- `MACHINE_EXTRA_RRECOMMENDS`: A list of machine-dependent packages not essential for booting the image. Thus, the build does not fail if the packages do not exist. However, the packages are required for a fully-featured image.

Tip

Many `MACHINE*` variables exist that help you configure a particular piece of hardware.

- `EXTRA_IMAGEDEPENDS`: Recipes to build that do not provide packages for installing into the root filesystem but building the image depends on the recipes. Sometimes a recipe is required to build the final image but is not needed in the root filesystem. In this case, the U-Boot recipe must be built for the image.
- `DEFAULTTUNE`: Machines use tunings to optimize machine, CPU, and application performance. These features, which are collectively known as "tuning features", exist in the OpenEmbedded-Core (OE-Core) layer (e.g. `poky/meta/conf/machine/include`). In this example, the default tunning file is "cortexa8hf-neon".

Note

The `include` statement that pulls in the `conf/machine/include/tune-cortexa8.inc` file provides many tuning possibilities.

- `IMAGE_FSTYPES`: The formats the OpenEmbedded build system uses during the build when creating the root filesystem. In this example, four types of images are supported.
- `EXTRA_IMAGECMD`: Specifies additional options for image creation commands. In this example, the "-lnp " option is used when creating the JFFS2 image.
- `WKS_FILE`: The location of the Wic kickstart file used by the OpenEmbedded build system to create a partitioned image (image.wic).
- `IMAGE_INSTALL`: Specifies packages to install into an image through the `image` class. Recipes use the `IMAGE_INSTALL` variable.
- `do_image_wic[depends]`: A task that is constructed during the build. In this example, the task depends on specific tools in order to create the sysroot when buiding a Wic image.
- `SERIAL_CONSOLES`: Defines a serial console (TTY) to enable using getty. In this case, the baud rate is "115200" and the device name is "ttyO0".
- `PREFERRED_PROVIDER_virtual/kernel`: Specifies the recipe that provides "virtual/kernel" when more than one provider is found. In this case, the recipe that provides "virtual/kernel" is "linux-yocto", which exists in the layer's `recipes-kernel/linux` directory.
- `PREFERRED_VERSION_linux-yocto`: Defines the version of the recipe used to build the kernel, which is "4.12" in this case.
- `KERNEL_IMAGETYPE`: The type of kernel to build for the device. In this case, the OpenEmbedded build system creates a "zImage" image type.
- `KERNEL_DEVICETREE`: The name of the generated Linux kernel device tree (i.e. the `.dtb`) file. All the device trees for the various BeagleBone devices are included.
- `KERNEL_EXTRA_ARGS`: Additional `make` command-line arguments the OpenEmbedded build system passes on when compiling the kernel. In this example, "LOADADDR=${UBOOT_ENTRYPOINT}" is passed as a command-line argument.
- `SPL_BINARY`: Defines the Secondary Program Loader (SPL) binary type. In this case, the SPL binary is set to "MLO", which stands for Multimedia card LOader.

The BeagleBone development board requires an SPL to boot and that SPL file type must be MLO. Consequently, the machine configuration needs to define `SPL_BINARY` as "MLO".

> **Note**
> For more information on how the SPL variables are used, see the `u-boot.inc` include file.

- `UBOOT_*`: Defines various U-Boot configurations needed to build a U-Boot image. In this example, a U-Boot image is required to boot the BeagleBone device. See the following variables for more information:
  - `UBOOT_SUFFIX`: Points to the generated U-Boot extension.
  - `UBOOT_MACHINE`: Specifies the value passed on the make command line when building a U-Boot image.
  - `UBOOT_ENTRYPOINT`: Specifies the entry point for the U-Boot image.
  - `UBOOT_LOADADDRESS`: Specifies the load address for the U-Boot image.
- `MACHINE_FEATURES`: Specifies the list of hardware features the BeagleBone device is capable of supporting. In this case, the device supports "usbgadget usbhost vfat alsa".
- `IMAGE_BOOT_FILES`: Files installed into the device's boot partition when preparing the image using the Wic tool with the `bootimg-partition` source plugin. In this case, the "u-boot.${UBOOT_SUFFIX}" and "MLO" files are installed.

1.8.3. BSP Kernel Recipe Example¶

The kernel recipe used to build the kernel image for the BeagleBone device was established in the machine configuration:

```
PREFERRED_PROVIDER_virtual/kernel ?= "linux-yocto"
PREFERRED_VERSION_linux-yocto ?= "4.12%"
```

The `meta-yocto-bsp/recipes-kernel/linux` directory in the layer contains metadata used to build the kernel. In this case, a kernel append file is used to override an established kernel recipe, which is located in http://git.yoctoproject.org/cgit/cgit.cgi/poky/tree/meta/recipes-kernel/linux and named `linux-yocto_4.12.bb`.

Following is the contents of the append file:

```
KBRANCH_genericx86  = "standard/base"
KBRANCH_genericx86-64  = "standard/base"

KMACHINE_genericx86 ?= "common-pc"
KMACHINE_genericx86-64 ?= "common-pc-64"
KBRANCH_edgerouter = "standard/edgerouter"
KBRANCH_beaglebone-yocto = "standard/beaglebone"
KMACHINE_beaglebone-yocto = "beaglebone"
KBRANCH_mpc8315e-rdb = "standard/fsl-mpc8315e-rdb"

SRCREV_machine_genericx86    ?= "1c4ad569af3e23a77994235435040e322908687f"
SRCREV_machine_genericx86-64 ?= "1c4ad569af3e23a77994235435040e322908687f"
SRCREV_machine_edgerouter ?= "257f843ea367744620f1d92910afd2f454e31483"
SRCREV_machine_beaglebone-yocto ?= "257f843ea367744620f1d92910afd2f454e31483"
SRCREV_machine_mpc8315e-rdb ?= "014560874f9eb2a86138c9cc35046ff1720485e1"


COMPATIBLE_MACHINE_genericx86 = "genericx86"
COMPATIBLE_MACHINE_genericx86-64 = "genericx86-64"
COMPATIBLE_MACHINE_edgerouter = "edgerouter"
COMPATIBLE_MACHINE_beaglebone-yocto = "beaglebone-yocto"
COMPATIBLE_MACHINE_mpc8315e-rdb = "mpc8315e-rdb"

LINUX_VERSION_genericx86 = "4.12.20"
LINUX_VERSION_genericx86-64 = "4.12.20"
LINUX_VERSION_edgerouter = "4.12.19"
LINUX_VERSION_beaglebone-yocto = "4.12.19"
LINUX_VERSION_mpc8315e-rdb = "4.12.19"
```

This particular append file works for all the machines that are part of the `meta-yocto-bsp` container layer. The relevant statements are appended with the "beaglebone-yocto" string. The OpenEmbedded build system uses these statements to override similar statements in the kernel recipe:

- `KBRANCH`: Identifies the kernel branch that is validated, patched, and configured during the build.
- `KMACHINE`: Identifies the machine name as known by the kernel, which is sometimes a different name than what is known by the OpenEmbedded build system.
- `SRCREV`: Identifies the revision of the source code used to build the image.
- `COMPATIBLE_MACHINE`: A regular expression that resolves to one or more target machines with which the recipe is compatible.

- `LINUX_VERSION`: The Linux version from kernel.org used by the OpenEmbedded build system to build the kernel image.