



# Customize your Mainline or LTSI Linux Kernel using the Yocto Project

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# Abstract

- This advanced tutorial shows how to build a custom Linux kernel using the Yocto Project kernel tooling, which includes the linux-yocto repository with mainline source and configuration metadata.
- It discusses the 2 most common methods of managing kernel configuration and BSP patches.
- First, we create a BSP using the upstream mainline kernel with local patches and defconfig.
- Then, we create a new BSP with linux-yocto style metadata and explain some of the advantages of this method.
- The talk follows the process of creating a complete kernel config file and then moving to break it down to config fragments that can be pushed upstream to the linux-yocto repository for all to use, and also includes hints and suggestions on kernel configuration debugging

# Agenda

- **Kernel Recipes**
- **Motivation**
- **Approach**
- **Live Tutorial**
  - Iterative development
  - Recipe-based development
  - In-tree development
  - Devtool usage

# Kernel Recipes

- **Linux kernels are recipes**
- **Kernel recipes inherit kernel.bbclass**
- **Adding a custom kernel is “easy”:**
  - meta-skeleton/recipes-kernel/linux/linux-yocto-custom.bb
  - SRC\_URI
  - SRCREV\_machine
  - COMPATIBLE\_MACHINE
  - Provide a machine defconfig

# Complexity

- **Security fixes**
- **Bug fixes**
- **Whiz-bang features**
- **New target hardware**
- **An explosion of linux-\*.bb recipes, patch queues, defconfigs, etc.**

# Motivation for Consolidation

- **Reduce duplication of effort**
  - Security fixes
  - Bug fixes
  - Feature ports
- **Collaborate on a common core**
  - Construct dynamic source trees
  - Support Linux development methods (i.e. 'git bisect')
  - Manage config fragments
- **Differentiate where it matters**

## Yocto Project Kernel Architecture and User Manual

# Approach: Components

- **Components**

- Kernel class  
meta/classes/kernel.bbclass
- Linux-Yocto recipe  
meta/recipes-kernel/linux/linux-yocto\*bb
- Linux-Yocto git repository  
<http://git.yoctoproject.org/cgi/cgit.cgi/linux-yocto-4.1>  
<http://git.yoctoproject.org/cgi/cgit.cgi/yocto-kernel-cache>

- **Kernel Versions**

- linux-yocto: 3.14.39 (LTSI)
- linux-yocto: 4.1.8
- linux-yocto-dev: 4.3 (mainline)

# Linux Yocto Git Tree

**yocto** · index : meta-intel  
PROJECT  
light theme Layer containing Intel hardware support metadata git repository hostin

about **summary** refs log tree commit diff stats log msg  search

Branch	Commit message	Author	Age
1.4_M5	romley romley-ivb: Move BSPs to the v3.8 kernel	Kishore Bodke	2 years
daisy	meta-valleyisland: Update linux-yocto v3.10 SRCREVs to v3.10.65	Ng Wei Tee	6 months
danny	cedartrail: Update maintainer info	Foo Chien Haw	2 years
dizzy	meta-valleyisland: Update README.sources with latest information	Ng, Wei Tee	11 days
dora	meta-valleyisland: Update linux-yocto v3.10 SRCREVs to v3.10.65	Ng Wei Tee	6 months
dylan	meta-valleyisland: Update README with extra notes	Chang Rebecca Swee Fun	18 months
fido	meta-crystalforest: move qat and zlib-qat to meta-isg	Anuj Mittal	3 weeks
master	meta-crystalforest: move qat and zlib-qat to meta-isg	Anuj Mittal	3 weeks
master-next	meta-valleyisland: Update the PREFERRED_VERSION of linux-yocto-3.10 to 3.14	Ng Wei Tee	7 months
tzanussi/valleyisland-64-test	valleyisland: Update kernel SRCREV to version 3.10.43	Chang Rebecca Swee Fun	12 months
[...]			

Tag	Download	Author	Age
3.1-fido-1.8	meta-intel-3.1-fido-1.8.zip meta-intel-3.1-fido-1.8.tar.gz meta-intel-3.1-fido-1.8.tar.bz2	Beth Flanagan	3 months
3.0-fido-1.8	meta-intel-3.0-fido-1.8.zip meta-intel-3.0-fido-1.8.tar.gz meta-intel-3.0-fido-1.8.tar.bz2	Beth Flanagan	4 months
2.0-dizzy-1.7	meta-intel-2.0-dizzy-1.7.zip meta-intel-2.0-dizzy-1.7.tar.gz meta-intel-2.0-dizzy-1.7.tar.bz2	Darren Hart	10 months
2.0-rc4-dizzy-1.7	meta-intel-2.0-rc4-dizzy-1.7.zip meta-intel-2.0-rc4-dizzy-1.7.tar.gz meta-intel-2.0-rc4-dizzy-1.7.tar.bz2	Darren Hart	10 months
2.0-rc2-dizzy-1.7-rc2	meta-intel-2.0-rc2-dizzy-1.7-rc2.zip meta-intel-2.0-rc2-dizzy-1.7-rc2.tar.gz meta-intel-2.0-rc2-dizzy-1.7-rc2.tar.bz2	Darren Hart	11 months
1.0-daisy-1.6.1	meta-intel-1.0-daisy-1.6.1.zip meta-intel-1.0-daisy-1.6.1.tar.gz meta-intel-1.0-daisy-1.6.1.tar.bz2	Darren Hart	14 months
1.6_M2	meta-intel-1.6_M2.zip meta-intel-1.6_M2.tar.gz meta-intel-1.6_M2.tar.bz2	Beth Flanagan	19 months
dora-10.0.1.final	dora-10.0.1.final.zip dora-10.0.1.final.tar.gz dora-10.0.1.final.tar.bz2	Beth Flanagan	20 months
dora-10.0.1	dora-10.0.1.zip dora-10.0.1.tar.gz dora-10.0.1.tar.bz2	Beth Flanagan	20 months
yocto-1.5.1.final	yocto-1.5.1.final.zip yocto-1.5.1.final.tar.gz yocto-1.5.1.final.tar.bz2	Beth Flanagan	20 months
[...]			

Age	Commit message	Author	Files	Lines
2015-09-01	meta-crystalforest: move qat and zlib-qat to meta-isg <b>HEAD</b> <b>master</b>	Anuj Mittal	8	-0/+0
2015-09-01	meta-crystalforest: zlib: Add COMPATIBLE_MACHINE	Anuj Mittal	1	-0/+2
2015-09-01	iucode-tool: bump version to 1.3	Doug Goldstein	1	-5/+7
2015-09-01	intel-microcode: bump version to 20150121	Doug Goldstein	1	-5/+4
2015-08-28	intel-core2-32: Allow for multiple tty console types	Saul Wold	1	-2/+2
2015-08-28	Remove older platform specific BSPs	Saul Wold	64	-2101/+3
2015-08-28	linux-yocto-tiny: Add 4.1 bbappend	Saul Wold	1	-0/+9
2015-08-28	linux-yocto_4.1: Update to 4.1.6 stable kernel	Saul Wold	1	-9/+9
2015-08-28	meta-isg: enable dpdk v2.1.0 for grantley	Anuj Mittal	2	-0/+47
2015-08-28	meta-isg: dpdk: intel-corei7-64 as COMPATIBLE_MACHINE	Anuj Mittal	1	-0/+3
[...]				

**Clone**  
git://git.yoctoproject.org/meta-intel  
http://git.yoctoproject.org/git/meta-intel

generated by cgit v0.10.2 at 2015-09-21 20:56:12 (GMT)



# Approach: Branch Hierarchy

- HEAD
- refs/heads/master
- refs/heads/standard/arm-versatile-926ejs
- refs/heads/standard/base
- refs/heads/standard/beagleboard
- refs/heads/standard/beaglebone
- refs/heads/standard/edgerouter
- refs/heads/standard/fsl-mpc8315e-rdb
- refs/heads/standard/mti-malta32
- refs/heads/standard/mti-malta64
- refs/heads/standard/preempt-rt
- refs/heads/standard/qemuarm64
- refs/heads/standard/qemuppc
- refs/heads/standard/tiny/base
- refs/heads/standard/tiny/common-pc

# Approach: Kernel Types - Multiple kernel types are supported

- HEAD
- refs/heads/master
- refs/heads/standard/arm-versatile-926ejs
- refs/heads/standard/base
- refs/heads/standard/beagleboard
- refs/heads/standard/beaglebone
- refs/heads/standard/edgerouter
- refs/heads/standard/fsl-mpc8315e-rdb
- refs/heads/standard/mti-malta32
- refs/heads/standard/mti-malta64
- refs/heads/standard/preempt-rt
- refs/heads/standard/qemuarm64
- refs/heads/standard/qemuppc
- refs/heads/standard/tiny/base
- refs/heads/standard/tiny/common-pc

# Approach: Meta-data – yocto-kernel-cache

**yocto** PROJECT · index : yocto-kernel-cache  
light theme Patches and configuration for the linux-yocto kernel tree git repository hosting

master ▾ switch

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summary | refs | log | tree | commit | diff | stats log msg ▾  search

Branch	Commit message	Author	Age
master	intel-common: include i40e networking feature	Anuj Mittal	2 weeks
yocto-3.10	kver: update to v3.10.62	Bruce Ashfield	9 months
yocto-3.14	beagleboard: remove BSP definition	Bruce Ashfield	7 weeks
yocto-3.19	bsp: add coretemp to intel-common-drivers	California Sullivan	5 weeks
yocto-3.4	kver: bump to v3.4.88	Bruce Ashfield	17 months
yocto-3.5	perf: add SLANG_INC for slang.h	Bruce Ashfield	3 years
yocto-3.6	CrystalForest: Enable PCI extended config space for CrystalForest Machine.	Kishore Bodke	3 years
yocto-3.7	unionfs: refresh to 2.5.11	Bruce Ashfield	3 years
yocto-3.8	valleyisland-io: spi/pxa2xx-pci: Add support for Intel BYT SPI	Ong Boon Leong	20 months
yocto-4.1	aufs: call mutex.owner only when DEBUG_MUTEXES or MUTEX_SPIN_ON_OWNER is defined	Bruce Ashfield	3 days

Age	Commit message	Author	Files	Lines
2015-09-04	intel-common: include i40e networking feature <span style="color: red;">HEAD</span> <span style="color: green;">master</span>	Anuj Mittal	1	-0/+1
2015-08-31	kver: bump dev kernel to v4.2	Bruce Ashfield	1	-1/+1
2015-08-27	graphics: disable CIRRUS DRM for qemuarm	Bruce Ashfield	1	-2/+0
2015-08-26	Omit to optimize vsprintf.c/kasprintf.c	Bruce Ashfield	2	-0/+34
2015-08-25	graphics: disable CIRRUS DRM for qemumips and qemuppc	Bruce Ashfield	2	-4/+0
2015-08-25	intel-quark: Enable thermal support	Saul Wold	1	-0/+1
2015-08-24	aufs: drop for 4.2-dev kernel	Bruce Ashfield	6	-35779/+0
2015-08-24	ext4: enable EXT4_USE_FOR_EXT23	Bruce Ashfield	1	-1/+1
2015-08-24	qemu*: enable DRM_CIRRUS_QEMU	Bruce Ashfield	4	-0/+7
2015-08-24	v4.2: patch cleanups	Bruce Ashfield	268	-35820/+0
[...]				

**Clone**  
[git://git.yoctoproject.org/yocto-kernel-cache](https://git.yoctoproject.org/yocto-kernel-cache)  
<http://git.yoctoproject.org/git/yocto-kernel-cache>

generated by cggit v0.10.2 at 2015-09-21 21:09:27 (GMT)

## Approach: Meta-data – separate repo

- **yocto-kernel-cache/**
  - **arch**
  - **backports**
  - **bsp**
  - **cfg**
  - **features**
  - **ktypes**
  - **kver**
  - **patches**
  - **scripts**
  - **small**
  - **staging**

# Yocto Kernel Cache Metadata

- **File Types**
  - .patches
  - .scc
  - .cfg
- **Kernel Configuration Fragments**
- **Patches**
- **Consolidation Points**
  - Features
  - BSP

## Patch FileType

- **Standard patch format**
- **Backports**
- **Bug Fixes pending upstream**

## SCC File Type

- **KFEATURE\_DESCRIPTION**
- **KFEATURE\_COMPATIBILITY**
  - all
  - arch
  - Board
- **kconf type**
  - hardware
  - Non-hardware
- **Includes of other .scc**

# SCC Example – BSP

```
define KMACHINE common-pc
define KMACHINE qemu86
define KTYPE standard
define KARCH i386

include ktypes/standard/standard.scc

include common-pc.scc

# default policy for standard kernels
include cfg/boot-live.scc
include cfg/usb-mass-storage.scc
include features/latencytop/latencytop.scc
include features/profiling/profiling.scc
include cfg/virtio.scc
include features/media/media-usb-webcams.scc
include features/sound/snd_hda_intel.scc
```



## SCC Example 2 – Feature

```
define KFEATURE_DESCRIPTION "Enable USB-based  
Bluetooth hardware modules"  
define KFEATURE_COMPATIBILITY board  
  
include bluetooth.scc  
  
kconf hardware bluetooth-usb.cfg
```

# CFG File Type

- **Standard Kconfig format**
- **CONFIG\_<ITEM>=y**
- **# CONFIG\_<ITEM> is not set**

## Local Development – Using devtool

- **modify -x linux-yocto src/linux-yocto**
  - Adds layer to bblayers.conf
  - Sets up a bbappend pointing to local src
  - Creates a git source tree of upstream code
- **build**
- **build-image**
- **update-recipe**
  - Creates a patch from modified source
- **reset**

# Tutorial

- Patch from devtool
- Setting `CONFIG_YOCTO_TESTMOD`
- Creating `.scc` file

# Tutorial Extended – Harden linux-yocto

- **Standard kernel build with defconfig**
- **Create new ktype**
  - Modify standard/base ktype
- **Add new features**
-

# Resources

- <http://www.yoctoproject.org>
- <http://www.yoctoproject.org/docs/kernel-manual/kernel-manual.html>
- <http://www.yoctoproject.org/docs/bsp-guide/bsp-guide.html>

# Questions

# Backup



# Recipe Example: linux-yocto

```
KBRANCH ?= "standard/base"

require recipes-kernel/linux/linux-yocto.inc

# board specific branches
KBRANCH_qemuarm ?= "standard/arm-versatile-926ejs"
KBRANCH_qemuarm64 ?= "standard/qemuarm64"
KBRANCH_qemumips ?= "standard/mti-malta32"
KBRANCH_qemuppc ?= "standard/qemuppc"
KBRANCH_qemux86 ?= "standard/base"
KBRANCH_qemux86-64 ?= "standard/base"
KBRANCH_qemumips64 ?= "standard/mti-malta64"

SRCREV_machine_qemuarm ?= "3c1245d162ccb55de1af42bcf3dbf690457bf9e4"
SRCREV_machine_qemuarm64 ?= "59b8c4f5e8ddb9c33c62fff22204fe2b0d8c703e"
SRCREV_machine_qemumips ?= "4132a691d0908d10b8f07ce7ece02e6dc94e17bc"
SRCREV_machine_qemuppc ?= "59b8c4f5e8ddb9c33c62fff22204fe2b0d8c703e"
SRCREV_machine_qemux86 ?= "59b8c4f5e8ddb9c33c62fff22204fe2b0d8c703e"
SRCREV_machine_qemux86-64 ?= "59b8c4f5e8ddb9c33c62fff22204fe2b0d8c703e"
SRCREV_machine_qemumips64 ?= "033e1aa633465449edf544eb81adda0caf16ec60"
SRCREV_machine ?= "59b8c4f5e8ddb9c33c62fff22204fe2b0d8c703e"
SRCREV_meta ?= "429f9e2ff0649b8c9341345622545d874d5e303a"

SRC_URI = "git://git.yoctoproject.org/linux-yocto-4.1.git;name=machine;branch=${KBRANCH}; \
          git://git.yoctoproject.org/yocto-kernel-cache;type=kmeta;name=meta;branch=yocto-4.1;destsuffix=${KMETA}"

LINUX_VERSION ?= "4.1.6"

PV = "${LINUX_VERSION}+git${SRCPV}"

KMETA = "kernel-meta"
KCONF_BSP_AUDIT_LEVEL = "2"

COMPATIBLE_MACHINE = "qemuarm|qemuarm64|qemux86|qemuppc|qemumips|qemumips64|qemux86-64"
```

# Append Example: linux-yocto

```
KBRANCH_genericx86 = "standard/base"
```

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

```
KMACHINE_genericx86 ?= "common-pc"
```

```
KMACHINE_genericx86-64 ?= "common-pc-64"
```

```
SRCREV_machine_genericx86 ?= "4e30e64c44df9e59bd13239951bb8d2b5b276e6f"
```

```
SRCREV_machine_genericx86-64 ?= "4e30e64c44df9e59bd13239951bb8d2b5b276e6f"
```

```
COMPATIBLE_MACHINE_genericx86 = "genericx86"
```

```
COMPATIBLE_MACHINE_genericx86-64 = "genericx86-64"
```

# Machine Example: qemux86

```
#@TYPE: Machine
#@NAME: common_pc
#@DESCRIPTION: Machine configuration for running a common x86

PREFERRED_PROVIDER_virtual/xserver ?= "xserver-xorg"
PREFERRED_PROVIDER_virtual/libgl ?= "mesa"
PREFERRED_PROVIDER_virtual/libgles1 ?= "mesa"
PREFERRED_PROVIDER_virtual/libgles2 ?= "mesa"

require conf/machine/include/qemu.inc
require conf/machine/include/tune-i586.inc

KERNEL_IMAGETYPE = "bzImage"

SERIAL_CONSOLES = "115200;ttyS0 115200;ttyS1"

XSERVER = "xserver-xorg \
    ${@bb.utils.contains('DISTRO_FEATURES', 'opengl', 'mesa-driver-swrast', '', d)} \
    xf86-input-vmmouse \
    xf86-input-keyboard \
    xf86-input-evdev \
    xf86-video-cirrus \
    xf86-video-fbdev \
    xf86-video-vmware"

MACHINE_FEATURES += "x86"

MACHINE_ESSENTIAL_EXTRA_RDEPENDS += "v86d"
```

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## Basic Text

- Emphasize with **red** or **blue** color only
- Initial caps for titles and sentence case for bullets
- Follow the guidance for bulleted lists on the following page

## Example of a Bulleted List for Coding

- This is the first level
  - This is a second level bullet
  - 1 This is a numbered second level
  - This is an unbulleted second level
  - \$ This is a code second level (fixed width)
  - # This is a privileged code second level (fixed width)
  - This is a third level bullet




**This is an Example of a Longer Section Name for  
this Divider**

**This is an example of a section divider subhead**

A decorative graphic consisting of a cluster of overlapping, semi-transparent hexagons in shades of gray, located in the upper-left quadrant of the page.

**This is an Example of a Longer Section  
Name for this Divider**



A decorative pattern of semi-transparent grey hexagons is located in the upper-left corner of the slide.

**Thank you for your  
participation!**

**yocto** ·  
PROJECT

 THE  
**LINUX**  
FOUNDATION