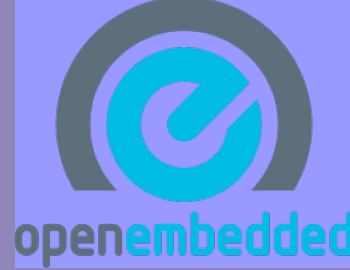




# Yocto Crash Course



## Welcome to the SCaLE 13x Yocto Crash Course – Build Your Own Embedded Linux OS for Fun and Profit

*Prepared / Presented by*

*Stephen Arnold, Principal Scientist VCT Labs*

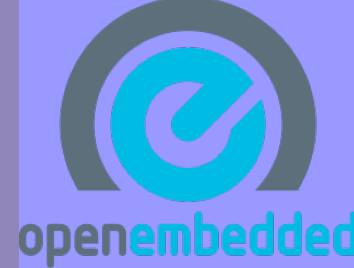
*Donald Burr, Senior Software Engineer VCT Labs*

*Nick Lockwood, Senior Software Engineer VCT Labs*





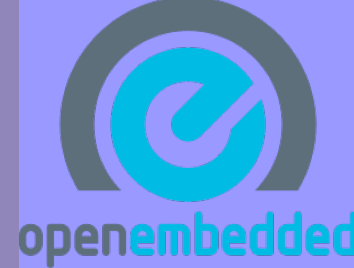
# Build Host Reqs and Potential Issues



- Officially Supported Distributions
  - Debian/Ubuntu, CentOS, Fedora, OpenSUSE
- Other “unsupported” Distributions
  - Gentoo x86, Arch, Slackware, etc
- Gentoo amd64, VMs, and chroots
  - libpseudo fails on Gentoo x86\_64 multilib
  - Build in a VM or chroot environment
- Common Build errors: "command not found..."
  - “hidden” build deps
    - bc, lzop, u-boot-tools, etc
    - Can depend on kernel config
  - Connectivity issues



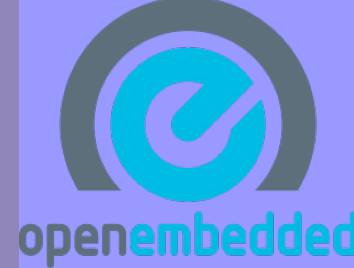
# Inside the OE Environment



- User Configuration, Metadata, Machine Configuration
  - Distro Layers: poky, ångstrom, custom, “distro-less”
  - BSP Layers
    - yocto reference bsp
  - Software Layers
    - meta-beagleboard-extras
    - meta-fsl-demos
    - meta-openstack
  - Kernel Recipes and Versions
    - linux-yocto (meta-yocto-bsb)
    - linux-mainline (meta-ti, meta-beagleboard)
    - linux-ti-staging (meta-ti)
    - 3.14 to 3.8+ (and older)



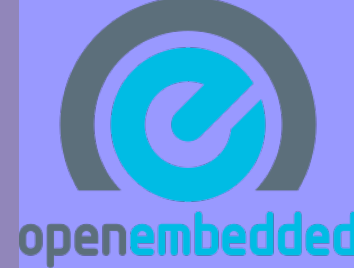
# Inside the OE Environment cont.



- Image Features and Package Configuration
  - Grep is your friend / read the comments
    - IMAGE/EXTRA\_IMAGE\_FEATURES
    - PACKAGECONFIG (sort of like USE flags)
- Recipes and Sources
  - File Types (recipes, bbclass, includes, configs)
  - Upstream Releases/Repos, Local Projects
    - Source tarballs
    - git/svn/hg/cvs
  - Source Mirror(s)
    - Make a local mirror for downloads



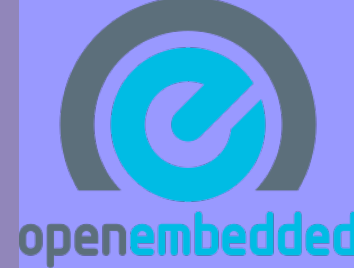
# Inside the OE Environment cont.



- Kernel Selection
  - Defaults to linux-yocto
  - Use `PREFERRED_PROVIDER/VERSION` to change
    - `PREFERRED_PROVIDER_virtual/kernel` = "linux-mainline"
    - `PREFERRED_VERSION_linux-mainline` = "3.17%"
- Package Feeds
  - Ipk Feed Support
    - `PACKAGE_CLASSES` = "package\_ipk"
    - Point apache doc root at build tree deploy root – tmp/deploy
    - Point feed URL at tmp/deploy/ipk
  - RPM and Deb Feeds
    - Exercise left for the reader...



# Inside the OE Environment cont.



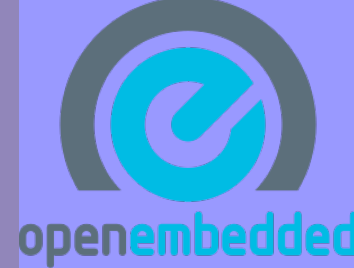
- BitBake Tips and Tricks
  - Recipes and Tasks
    - Use the -c argument to bitbake to execute one task
    - Use the -b argument to ignore recipe build depends
    - Use the -D argument to get more debug output
  - Source Fetching, Patching, Configuration, and Compilation
    - Use “-c fetchall” to prefetch sources for a build target
  - Package Splitting, Image Generation, SDK Generation
    - One recipe, many packages
  - Custom Recipes and Layers

<http://layers.openembedded.org/layerindex/branch/master/layers/>

<https://github.com/sarnold/meta-alt-desktop-extras>



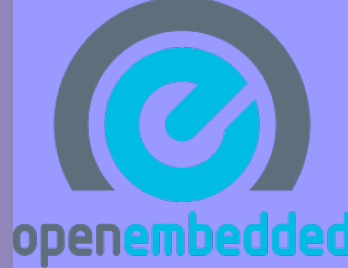
# Hands-On Poky



- Qemux86 extra-quick quick start:
  - Clone poky repo
  - Source OE environment script
  - Configure local.conf
  - Source environment script again
  - Build target image and deploy
- Beaglebone
  - Make new build directory
  - Configure local.conf
- RaspberryPi
  - Clone meta-raspberrypi BSP
  - Make new build directory
  - Configure local.conf



# Adding an Upstream BSP

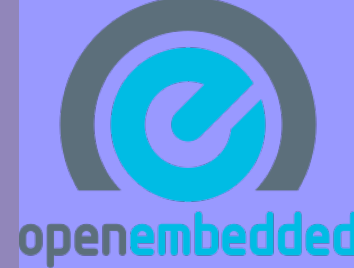


- RaspberryPi layer
  - <https://github.com/agherzan/meta-raspberrypi>
  - See the README for build requirements
  - Should build with poky, oe-core, ångstrom
- BeagleBoard / TI layers
  - <http://git.yoctoproject.org/cgit/cgit.cgi/meta-ti> (official)
  - <https://github.com/beagleboard/meta-beagleboard>  
(somewhat stale, forks may be more current)
- Freescale Build Scripts
  - <http://git.yoctoproject.org/cgit/cgit.cgi/meta-fsl-arm>
  - Uses repo manifest and build script for setup





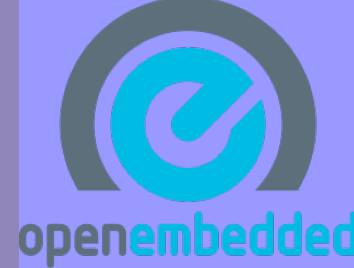
# Customizing Your Build



- Kernel Version and Configuration
  - RaspberryPi – override `PREFERRED_VERSION`
  - BeagleBone – above plus override `COMPATIBLE_MACHINE`
  - Small number of global config options
- New / Modified Kernel Recipe
  - Make or modify an existing `linux-yocto_3.X.bbappend`
    - Create/obtain patches and config fragments
    - Append new files to `SRC_URI`
    - Update the `md5sums`
  - Create your own `linux-custom_X.X.bb` kernel recipe
    - See `linux-yocto-custom.bb`
  - Inherit vs. Include
    - `.bbclass` and `.inc` files



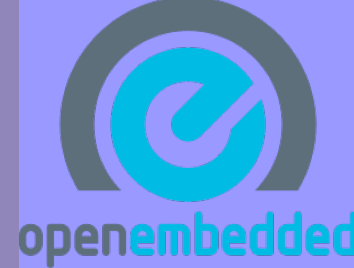
# Customizing Your Build cont.



- Image Recipes
  - Inherit/include and IMAGE\_\* options
  - IMAGE\_INSTALL packagegroups and packages
- Package Recipes
  - Inherit/include and PACKAGECONFIG
  - IMAGE/MACHINE\_FEATURES drive package options
- Modifying and Adding Packages
  - .bbappend is your friend
  - The scripts directory and docs are also your friends
    - create-recipe, yocto-layer, runqemu, and more
- devshell and TERM config settings
  - TERMCMD and TERMCMDRUN
  - <http://www.openembedded.org/wiki/Devshell>

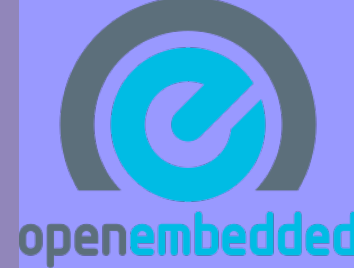


# Deployment and Debugging



- Deploy Tips and Hacks
  - Image types: rpi-sdimg, ext3, tar.bz2, tar.gz, jffs2
  - Where does U-boot look for the kernel?
  - Use “-c deploy” for incremental kernel testing
  - Create custom deploy tasks (eg, kernel configme task)
  - Local .ipk package feeds
    - Image build updates package index
    - Can add/update packages as needed
- SDK Tools
  - bitbake targets: meta-toolchain vs. populate\_sdk
  - IMAGE tweaks: see local.conf EXTRA\_IMAGE\_FEATURES
- GDB / GDB Server vs. Eclipse / TCF Agent
  - Choose your FEATUREs and tools

- Toaster
  - Install django-1.6 and south-0.8.4
  - Enable in local.conf:
    - `INHERIT += "toaster"`
    - `INHERIT += "buildhistory"`
    - `BUILDHISTORY_COMMIT = "1"`
  - `$ cd <poky-dir> && source oe-init-build-env`
  - `$ source toaster start (stop)`
  - `$ bitbake core-image-minimal`
  - `$ xdg-open http://localhost:8000`
  - Default DB is sqlite3
  - Make sure you have a valid timezone set
  - [https://wiki.yoctoproject.org/wiki/Setting\\_up\\_a\\_local\\_instance\\_of\\_Toaster](https://wiki.yoctoproject.org/wiki/Setting_up_a_local_instance_of_Toaster)



This work is an original work by Stephen Arnold <[sarnold@vctlabs.com](mailto:sarnold@vctlabs.com)>.

<<http://www.vctlabs.com>>

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# Yocto Crash Course

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### Upstream docs:

Quick Start:

<http://tinyurl.com/yocto-1-7>

Reference:

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

Project wiki:

[http://openembedded.org/wiki/Main\\_Page](http://openembedded.org/wiki/Main_Page)

Training:

<https://www.yoctoproject.org/training/kernel-lab>

Git repos:

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

<https://github.com/openembedded/meta-openembedded>

Vendors:



<http://beagleboard.org/project/yocto-project/>

<https://community.freescale.com/docs/DOC-1616>

Other:

<https://github.com/sarnold/meta-alt-desktop-extras>

<http://www.vctlabs.com/archives.html>



## Build Host Reqs and Potential Issues

- Officially Supported Distributions
  - Debian/Ubuntu, CentOS, Fedora, OpenSUSE
- Other “unsupported” Distributions
  - Gentoo x86, Arch, Slackware, etc
- Gentoo amd64, VMs, and chroots
  - libpseudo fails on Gentoo x86\_64 multilib
  - Build in a VM or chroot environment
- Common Build errors: "command not found..."
  - “hidden” build deps
    - bc, lzop, u-boot-tools, etc
    - Can depend on kernel config
  - Connectivity issues

See the getting-started guide and wiki for details; essentially you need python, git, tar, and the rest of the “normal” development tools and libraries, plus a few others. For example, a Gentoo x86 system with an ARM cross-compiler and U-boot tools should be almost ready to go:

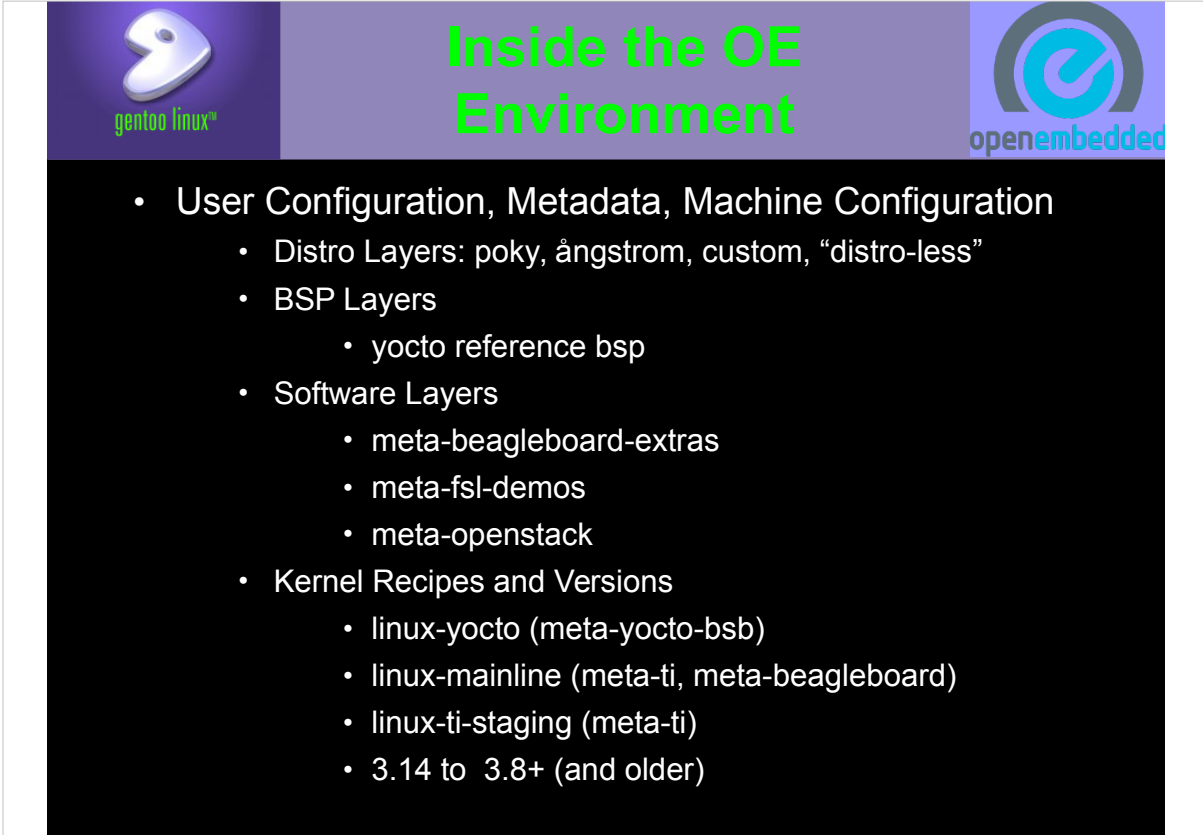
<http://tinyurl.com/yocto-1-7>

<http://www.openembedded.org/wiki/OEandYourDistro>

The wiki page above includes details for some of the “unsupported” distributions.

Other general considerations include disk space (you need plenty of it) and VM support (ie, KVM, qemu, libvirt, etc).

Network problems such as dropouts, bad name resolution, etc, can stop a build but you can pre-fetch required source packages and share downloads and cache data between builds.



The slide features a purple header bar. On the left is the Gentoo Linux logo (a white swirl on a purple background). In the center, the title "Inside the OE Environment" is written in large green letters. On the right is the OpenEmbedded logo (a blue swirl on a purple background). Below the header, on a black background, is a bulleted list of topics.

- User Configuration, Metadata, Machine Configuration
  - Distro Layers: poky, ångstrom, custom, “distro-less”
  - BSP Layers
    - yocto reference bsp
  - Software Layers
    - meta-beagleboard-extras
    - meta-fsl-demos
    - meta-openstack
  - Kernel Recipes and Versions
    - linux-yocto (meta-yocto-bsb)
    - linux-mainline (meta-ti, meta-beagleboard)
    - linux-ti-staging (meta-ti)
    - 3.14 to 3.8+ (and older)

Typical (manual) directory layout has poky as the top-level directory, with base BSP and additional layers inside.

The default environment script creates local build directories at the same level, however, user-configuration options are provided to specify paths for downloads, build output, and shared cache data (by default each build tree is self-contained). Sharing downloads and cache data between builds is a good way to both speed up builds/rebuilds and save space.



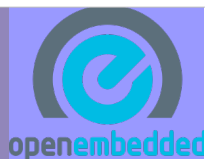
You can add additional software layers as needed, however only one BSP layer should be enabled for a given build.

The two main local config files are `conf/{bblayers.conf,local.conf}` and `local.conf` is probably the easiest place to keep your custom build settings unless you're creating your own BSP or software layer.

Useful config options in `local.conf` include:

```
PREFERRED_VERSION
PREFERRED_PROVIDER
DISTRO_FEATURES
IMAGE_FEATURES / EXTRA_IMAGE_FEATURES
PACKAGECONFIG
```



- Image Features and Package Configuration
  - Grep is your friend / read the comments
    - IMAGE/EXTRA\_IMAGE\_FEATURES
    - PACKAGECONFIG (sort of like USE flags)
- Recipes and Sources
  - File Types (recipes, bbclass, includes, configs)
  - Upstream Releases/Repos, Local Projects
    - Source tarballs
    - git/svn/hg/cvs
  - Source Mirror(s)
    - Make a local mirror for downloads

build-foo/conf/bblayers.conf



- Enable new metadata (software) layers
- Specify a BSP layer
- Set the full path to poky root

build-foo/conf/local.conf

- Set INHERIT options
- Set PKG\_CLASS and PACKAGECONFIG options
- Set LICENSE options
- Set MACHINE and IMAGE options

Metadata file types include package and image recipes (.bb and .bbappend), include files for both recipes and configuration (.inc), configuration files (.conf), and class files (.bbclass). All of them are used to create and extend layers.

Package recipes can include everything from local files to remote git repos in their SRC\_URIs (some control over remote fetching is provided via MIRROR settings).



## Inside the OE Environment cont.

- Kernel Selection
  - Defaults to linux-yocto
  - Use PREFERRED\_PROVIDER/VERSION to change
    - PREFERRED\_PROVIDER\_virtual/kernel = "linux-mainline"
    - PREFERRED\_VERSION\_linux-mainline = "3.17"
- Package Feeds
  - Ipk Feed Support
    - PACKAGE\_CLASSES = "package\_ipk"
    - Point apache doc root at build tree deploy root – tmp/deploy
    - Point feed URL at tmp/deploy/ipk
  - RPM and Deb Feeds
    - Exercise left for the reader...

### References:

<http://www.yoctoproject.org/docs/1.7.1/kernel-dev/kernel-dev.html>

<https://www.yoctoproject.org/training/kernel-lab>

There are many ways to “skin” the kernel, depending on the specific BSP and kernel recipe:

- 1) KERNEL\_FEATURES (poky-lsb distro config file)
- 2) Config parameters (linux-raspberrypi/linux.inc)
- 3) Config “fragment” (kernel recipe/.bbappend SRC\_URI)
- 4) Custom defconfig (kernel recipe/.bbappend SRC\_URI)
- 5) Kernel patches (kernel recipe/.bbappend SRC\_URI)
- 6) Custom recipes or .bbappends (meta-mybsp)

When modifying kernel recipes, adding fragments/patches, etc, bitbake will normally detect the changes and rebuild the recipe. For example, the new kernel can be rebuilt, deployed, and then run with the following commands:

```
$ bitbake virtual/kernel -c deploy
$ runqemu tmp/deploy/images/bzImage-blah.bin \
  tmp/deploy/images/core-image-minimal-blah.ext3
```



## Inside the OE Environment cont.

- BitBake Tips and Tricks
  - Recipes and Tasks
    - Use the -c argument to bitbake to execute one task
    - Use the -b argument to ignore recipe build depends
    - Use the -D argument to get more debug output
  - Source Fetching, Patching, Configuration, and Compilation
    - Use “-c fetchall” to prefetch sources for a build target
  - Package Splitting, Image Generation, SDK Generation
    - One recipe, many packages
  - Custom Recipes and Layers
    - <http://layers.openembedded.org/layerindex/branch/master/layers/>
    - <https://github.com/sarnold/meta-alt-desktop-extras>

### References:

[http://www.openembedded.org/wiki/Bitbake\\_cheat\\_sheet](http://www.openembedded.org/wiki/Bitbake_cheat_sheet)

<https://community.freescale.com/docs/DOC-94953>

<http://tinyurl.com/bitbake-1-6>

To keep an image build going after non-critical failure:

```
$ bitbake -k <recipe_name>
```

To list the contents of your build environment (can be large):

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

```
$ bitbake -e redis-ipc
```

To open a shell in the package source tree with the correct build environment:

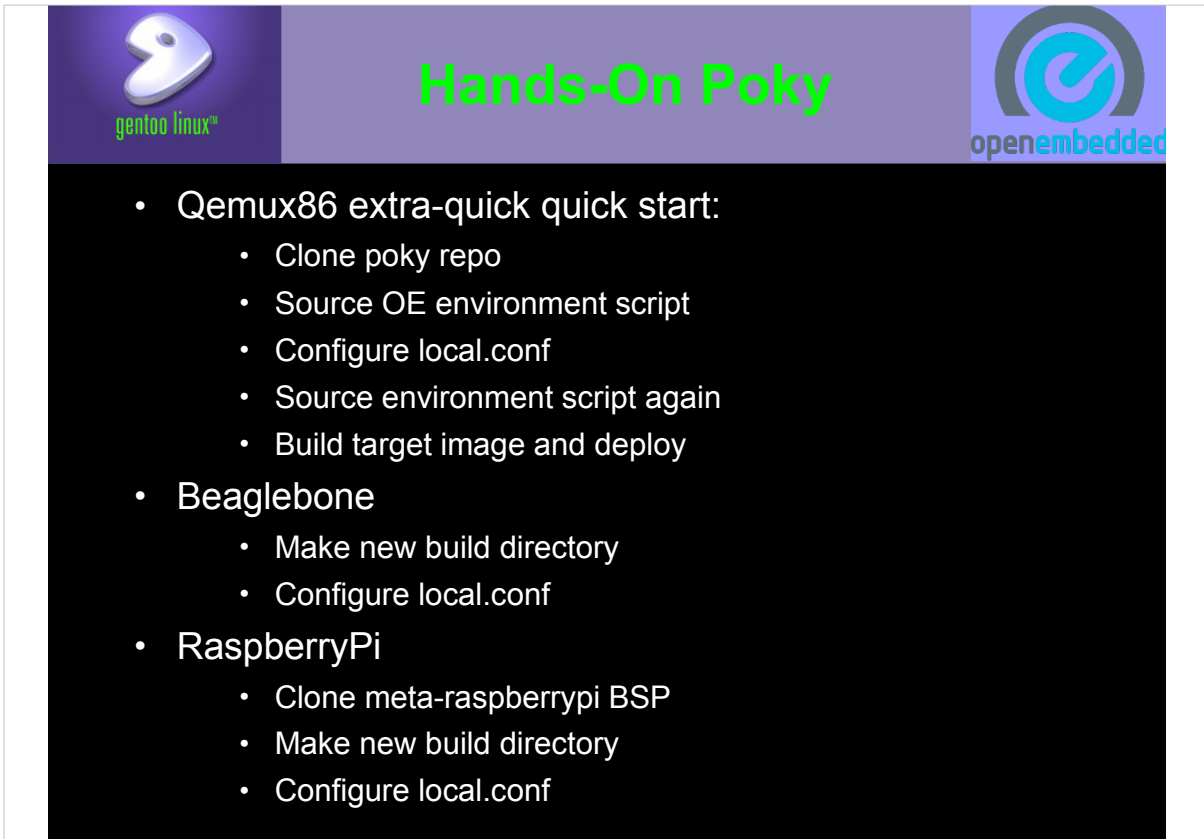
```
$ bitbake <recipe_name> -c devshell
```

To list the available tasks for a given build target:

```
$ bitbake <recipe_name> -c listtasks
```

To generate an SDK specific to a given image target:

```
$ bitbake <image_name> -c populate_sdk
```



The slide is titled "Hands-On Poky" in green text on a purple background. It features the Gentoo Linux logo on the left and the OpenEmbedded logo on the right. The main content is a list of steps for setting up Poky on different hardware targets, displayed on a black background with white text.

- Qemux86 extra-quick quick start:
  - Clone poky repo
  - Source OE environment script
  - Configure local.conf
  - Source environment script again
  - Build target image and deploy
- Beaglebone
  - Make new build directory
  - Configure local.conf
- RaspberryPi
  - Clone meta-raspberrypi BSP
  - Make new build directory
  - Configure local.conf

### Clone poky, check out release/master branch

```
$ git clone http://git.yoctoproject.org/git/poky
$ cd <poky-dir> && git checkout master
$ source oe-init-build-env build-x86
```

### Changes to <poky-dir>/<build-dir>/conf/local.conf:

```
MACHINE = "qemux86"
DL_DIR ?= "/home/user/downloads"
SSTATE_DIR ?= "/home/user/shared-state/poky-std"
PACKAGE_CLASSES ?= "package_ipk"
INHERIT += "rm_work"
INHERIT += "buildhistory"
INHERIT += "toaster"
DISTRO_FEATURES_append = " pam"

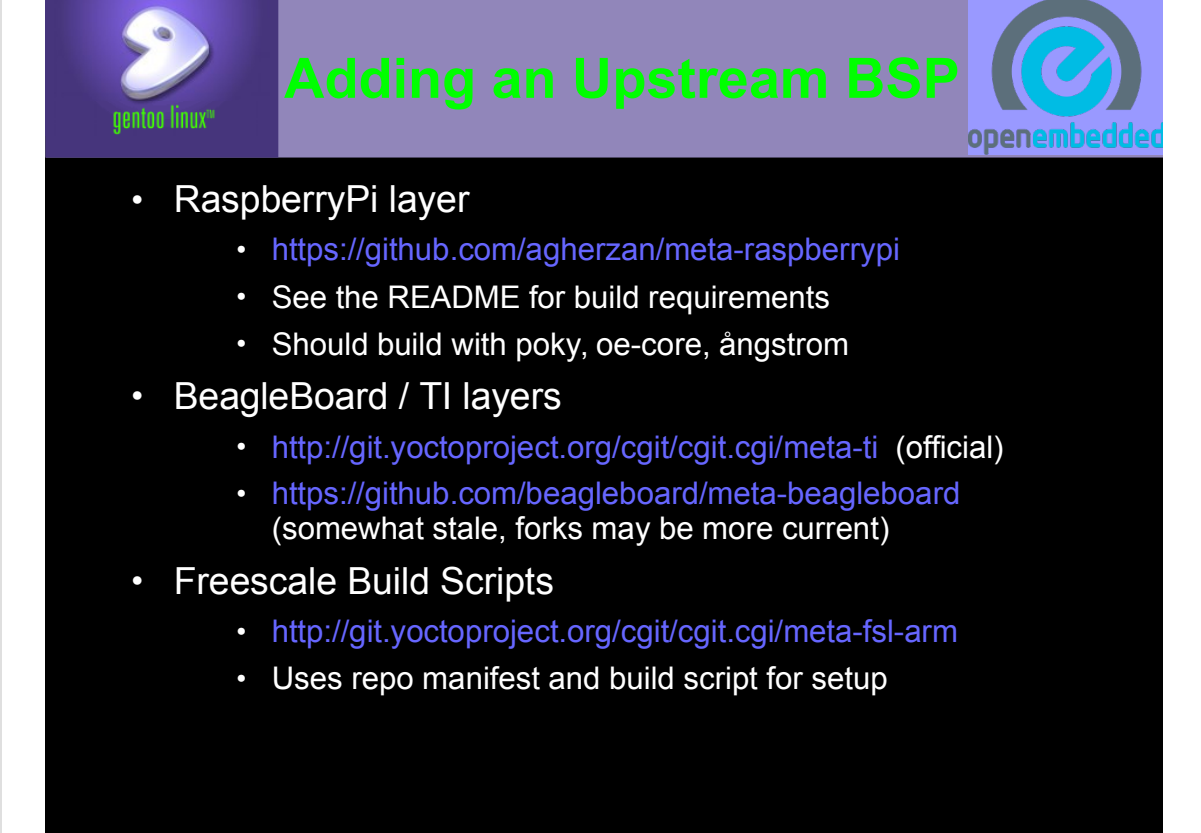
$ cd <poky-dir> && source oe-init-build-env build-x86
$ bitbake core-image-minimal
$ runqemu /path/to/kernel.bin /path/to/image.ext3
```

### Official Yocto Project Quick Start Guide

<http://tinyurl.com/yocto-1-7>

### OpenEmbedded OE-Core Quick Start

[http://openembedded.org/wiki/OE-Core\\_Standalone\\_Setup](http://openembedded.org/wiki/OE-Core_Standalone_Setup)



## Adding an Upstream BSP

- RaspberryPi layer
  - <https://github.com/agherzan/meta-raspberrypi>
  - See the README for build requirements
  - Should build with poky, oe-core, ångstrom
- BeagleBoard / TI layers
  - <http://git.yoctoproject.org/cgit/cgit.cgi/meta-ti> (official)
  - <https://github.com/beagleboard/meta-beagleboard> (somewhat stale, forks may be more current)
- Freescale Build Scripts
  - <http://git.yoctoproject.org/cgit/cgit.cgi/meta-fsl-arm>
  - Uses repo manifest and build script for setup

Since the meta-yocto-bsp layer supports the first two machines we built for this crash course, the defaults in bblayers.conf should work fine for the basic demo images and yocto BSP machines (eg, qemu86, beaglebone, etc). Other machines with Yocto support will have their own BSP and possibly application layers, eg, RaspberryPi.

The typical practice for Yocto-compliant layers is to document the build and layer requirements in the readme; notice it supports multiple OE build configurations, but only one is typically tested upstream (ie, poky + meta-raspberrypi).

The Yocto beaglebone support is both basic and somewhat less than current, so feel free to add the meta-ti layer and try their kernel recipes with support for the TI vendor blobs, etc.

The FreeScale Yocto support is somewhat different in that they do not document a “manual” layer setup as above, but do provide a repo manifest and set of build scripts that mostly automates the initial cloning and setup for building the fsl “community” layers for some of their iMX.6-based machines (eg, Wandboard).



## Customizing Your Build



- Kernel Version and Configuration
  - RaspberryPi – override PREFERRED\_VERSION
  - BeagleBone – above plus override COMPATIBLE\_MACHINE
  - Small number of global config options
- New / Modified Kernel Recipe
  - Make or modify an existing linux-yocto\_3.X.bbappend
    - Create/obtain patches and config fragments
    - Append new files to SRC\_URI
    - Update the md5sums
  - Create your own linux-custom\_X.X.bb kernel recipe
    - See linux-yocto-custom.bb
  - Inherit vs. Include
    - .bbclass and .inc files

### References:

<http://www.yoctoproject.org/docs/latest/kernel-dev/kernel-dev.html>

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

<http://www.yoctoproject.org/docs/latest/adt-manual/adt-manual.html>

Different kernel recipes from various BSPs can take somewhat different approaches to kernel builds and configuration (see the linux-raspberrypi vs. linux-yocto recipes). The following config fragment method is from the latest Yocto Kernel Dev Guide.

### 1) Complete a kernel build at least through the configuration task:

```
$ bitbake linux-yocto -c kernel_configme -f
```

### 2) Run the menuconfig command:

```
$ bitbake linux-yocto -c menuconfig
```

### 3) Run the diffconfig command to prepare a configuration fragment. fragment.cfg will be in the \${WORKDIR} directory:

```
$ bitbake linux-yocto -c diffconfig
```

The diffconfig command creates a file that is a list of kernel CONFIG\_ assignments.



gentoo linux®

# Customizing Your Build cont.



openembedded

- Image Recipes
  - Inherit/include and IMAGE\_\* options
  - IMAGE\_INSTALL packagegroups and packages
- Package Recipes
  - Inherit/include and PACKAGECONFIG
  - IMAGE/MACHINE\_FEATURES drive package options
- Modifying and Adding Packages
  - .bbappend is your friend
  - The scripts directory and docs are also your friends
    - create-recipe, yocto-layer, runqemu, and more
- devshell and TERM config settings
  - TERMCMD and TERMCMDRUN
  - <http://www.openembedded.org/wiki/Devshell>

With recipes, less is more. See core-image-minimal.bb vs. core-image-sato.bb and <poky-dir>/meta-skeleton for examples. Don't copy a recipe - do make a .bbappend instead. Don't replicate an existing task - do use an append/prepend to add your changes instead. *Inherit*, *include*, or *require* as needed.

So what did we do to update the beaglebone kernel?

1) We made changes to local.conf

```
COMPATIBLE_MACHINE_beaglebone = "beaglebone"
PREFERRED_VERSION_linux-yocto = "3.17.%"
```


But, the linux-yocto recipe only sets qemu-compatible machines, and we also need to change the kernel configuration, so:

2) We created a new config fragment and .bbappend for linux-yocto\_3.17.bb:


```
FILESEXTRAPATHS_prepend := "${THISDIR}/${PN}:"
SRC_URI_append_beaglebone = " file://ohci.cfg "
KBRANCH_beaglebone = "standard/beaglebone"
SRCREV_machine_beaglebone ?= "0409b1fbed221e61212e17b7637fa54f908d83f6"
COMPATIBLE_MACHINE_beaglebone = "beaglebone"
```

The config fragment in this case simply enables the OHCI OMAP support:

```
CONFIG_USB_OHCI_HCD=y
CONFIG_USB_OHCI_HCD_OMAP3=y
```



# Deployment and Debugging



- Deploy Tips and Hacks
  - Image types: rpi-sdimg, ext3, tar.bz2, tar.gz, jffs2
  - Where does U-boot look for the kernel?
  - Use “-c deploy” for incremental kernel testing
  - Create custom deploy tasks (eg, kernel configme task)
  - Local .ipk package feeds
    - Image build updates package index
    - Can add/update packages as needed
- SDK Tools
  - bitbake targets: meta-toolchain vs. populate\_sdk
  - IMAGE tweaks: see local.conf EXTRA\_IMAGE\_FEATURES
- GDB / GDB Server vs. Eclipse / TCF Agent
  - Choose your FEATURES and tools

## References:

<http://tinyurl.com/local-pkg-feed>

[http://wiki.chumby.com/index.php?title=Advanced\\_OpenEmbedded](http://wiki.chumby.com/index.php?title=Advanced_OpenEmbedded)

Different BSPs add/modify .bbclass files to provide additional image types (such as the RaspberryPi SDCard image type). As seen, the base beaglebone build produces both a jffs2 and tar.bz2 rootfs images, plus kernel, dtb, and u-boot files. In this case you must follow the TI version of the u-boot deploy dance:

- 1) Copy MLO first, then u-boot.img to boot **partition**
- 2) untar rootfs to root partition (use -p switch)
- 3) Copy zImage and am335x-boneblack.dtb to /boot **directory**

You can also create your own package feed by pointing your web server at:

```
<poky-dir>/build/tmp/deploy/ipk
```


And adding this to local.conf:

```
FEED_DEPLOYDIR_BASE_URI = "http://ip-address/<machine>/ipk"
```


From your running device as root, try:

```
# opkg update && opkg list-installed
```





# Graphical User Interfaces



- Toaster
  - Install django-1.6 and south-0.8.4
  - Enable in local.conf:
    - INHERIT += "toaster"
    - INHERIT += "buildhistory"
    - BUILDHISTORY\_COMMIT = "1"
  - `$ cd <poky-dir> && source oe-init-build-env`
  - `$ source toaster start (stop)`
  - `$ bitbake core-image-minimal`
  - `$ xdg-open http://localhost:8000`
  - Default DB is sqlite3
  - Make sure you have a valid timezone set
  - [https://wiki.yoctoproject.org/wiki/Setting\\_up\\_a\\_local\\_instance\\_of\\_Toaster](https://wiki.yoctoproject.org/wiki/Setting_up_a_local_instance_of_Toaster)

## References:

<https://www.yoctoproject.org/documentation/toaster-manual-17>

<https://wiki.yoctoproject.org/wiki/Toaster>




## How to use a GUI:

- 1) Click stuff
- 2) Scroll
- 3) Click more stuff

Stop at the Gentoo Booth and see the hardware!

irc.freenode.net: nerdboy

<http://dev.gentoo.org/~nerdboy>




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<<http://www.vctlabs.com>>

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