

# Yocto Exercises

## Prerequisite

- Ubuntu 18.04 or higher based host PC or VM with a minimum of 50GB free disk space & better to have atleast 8GB of RAM
- Stable Internet connection to download the packages

## Host Environment Setup

- Install the required packages with below command:
- `sudo apt-get install gawk wget git-core diffstat unzip texinfo gcc-multilib build-essential chrpath socat cpio python python3 python3-pip python3-pexpect xz-utils debianutils iputils-ping libssl1.2-dev xterm minicom`

## Yocto Setup

### Setting up the Yocto for Beaglebone Black

1. `$ mkdir sources`
2. `$ cd sources`
3. Get the required layers  
`$ git clone -b dunfell git://git.yoctoproject.org/poky.git`  
`$ git clone -b dunfell git://git.openembedded.org/meta-openembedded`  
`$ cd ..`  
`$ source sources/poky/oe-init-build-env build_bbb`
4. Modify the local.conf to add the support for the machine  
`$ MACHINE ??= "beaglebone-yocto"`
5. Build the image  
`$ bitbake core-image-minimal`  
This would generate the image under `build_bbb/tmp/deploy/images/beaglebone-yocto/core-image-minimal-beaglebone-yocto-xxx.rootfs.wic` (where xxx would be image generation date & time)

## Flashing the image

1. Insert the uSD card in PC/laptop & flash the image:  
`$ cd build_bbb/tmp/deploy/images/beaglebone-yocto`  
`$ dd if=core-image-minimal-beaglebone-yocto-xxx.rootfs.wic of=/dev/<uSD device file> bs=1M`  
This would flash the image on the uSD
2. Umount & remove the uSD for the PC. With USB to ttl connected, insert it into the target board & power up the target. As board comes up, the boot up message should appear on the serial terminal i.e minicom

## Linux Device Drivers

### Setting up the build environment

The idea over here is to prepare the SDK, so as to use it for building out of tree kernel modules.

1. Source the yocto environment & start the SDK build  

```
$ source sources/poky/oe-init-build-env build_bbb  
$ bitbake meta-toolchain
```
2. Once the build is complete, the SDK installation script would be placed under build\_bbb/tmp/deploy/sdk/ with the name poky-glibc-x86\_64-meta-toolchain-cortexa8hf-neon-beaglebone-yocto-toolchain-3.1.14.sh
3. Next step is to install the toolchain. For this, create the directory with name Toolchain (May be under home dir) & execute the script  

```
$ mkdir Toolchain  
$ cd Toolchain  
$ <path_to_buid_bbb>/tmp/deploy/sdk/poky-glibc-x86_64-meta-toolchain-cortexa8hf-neon-beaglebone-yocto-toolchain-3.1.14.sh
```

This would extract the yocto toolchain under Toolchain directory
4. Further to this, for compiling a driver or applicaton, source the environment using:  

```
$ source <SDK_installation_path>/environment-setup-cortexa8hf-neon-poky-linux-gnueabi
```

## Driver Fundamentals

### Write a simple Linux Kernel Module

1. Navigate to the FirstDriver directory under Drivers folder  

```
$ cd <path_to_training_dir>/Drivers/FirstDriver
```
2. Update the KERNEL\_SOURCE variable in the Makefile to point to the compiled kernel source (Compiled in the above assignment)
3. Build the kernel module with make. This would generate the kernel module by name first\_driver.ko
4. Transfer the kernel module to the board.  

```
$ scp first_driver.ko root@<board_ip>:
```

The board\_ip for bbb is 192.168.7.2
5. Load the kernel module  

```
$ insmod first_driver.ko
```

This should display “driver registered” on the console
6. Unload the kenel module  

```
$ rmmod first_driver
```

This should display “driver deregistered” on the console

### Statically building the driver into the Kernel

This activity intends to describe the steps required to integrate any driver into the Kernel build system.

1. Open the devshell for the kernel  

```
$ bitbake -c devshell virtual/kernel
```

- 2 Copy the file *first\_driver.c* from the Drivers/FirstDriver/ to kernel-source/drivers/char/  
\$ cp Drivers/FirstDriver/first\_driver.c /drivers/char
- 3 Edit the Kconfig file under drivers/char and add the following:  
config MY\_DRIVER  
    tristate "My Driver"  
    help  
    Adding this small driver to the kernel
- 4 Edit the makefile under drivers/char to add the following entry:  
obj-\$(CONFIG\_MY\_DRIVER) += first\_driver.o
- 5 Once the modifications are done, configure the kernel:  
\$ make menuconfig  
Under the Driver Driver->Character Devices, there will be a menu option *MY Driver*. Just select it, exit and save the config.
- 6 This will add the *CONFIG\_MY\_DRIVER=y* entry in the .config, which in turn would be used by Makefile
- 7 Compile the kernel  
\$ make zImage
- 8 Transfer the newly build kernel to the target board  
\$ mount /dev/mmcbk0p1 /mnt (On board)  
\$ scp arch/arm/boot/zImage root@<board\_ip>:/mnt/
- 9 Unmount & reboot the board to boot up with updated kernel  
\$ umount /mnt  
\$ reboot (On board)
- 10 Verify if the driver is registered during the boot up  
\$ dmesg | grep "driver registered"  
Reference: <https://www.linuxjournal.com/content/kbuild-linux-kernel-build-system>

## Character Driver

### Character Driver Registration

The idea over here is to write a basic character driver to demonstrate the character driver registration and de-registration. Below are the steps:

1. Navigate to the CharDriver directory under Drivers folder  
\$ cd Drivers/CharDriver
2. Make sure that the KERNEL\_SOURCE variable in the Makefile is updated to point to the compiled kernel source
3. Complete all the TODOs (1 and 2) in first\_driver.c (Refer apis.txt file in CharDriver for the corresponding APIs)
4. Build the kernel module with make. This would generate the kernel module by name first\_char\_driver.ko
5. Transfer the kernel module to the board.  
\$ scp first\_char\_driver.ko root@<board\_ip>:  
The board\_ip for bbb is 192.168.7.2
6. Load the kernel module  
\$ insmod first\_char\_driver.ko
7. This should display "<Major, Minor>: <240, 0>"

NB: The major/minor number may vary in your case

8. Verify if the driver is registered for corresponding major number  
\$ cat /proc/devices (first\_char\_driver should be displayed against Major number 240)

## Register the file operations

The idea over is to register the call back handlers with VFS. Below are the steps:

1. Complete all the TODOs (1, 2 & 3) in null.c (Refer apis.txt file in CharDriver for the corresponding APIs)
2. Build the kernel module with make. This would generate the kernel module by name null.ko
3. Transfer the kernel module to the board.  
\$ scp null.ko root@<board\_ip>:  
The board\_ip for bbb is 192.168.7.2
4. Load the kernel module  
\$ insmod null.ko
5. This should display “<Major, Minor>: <240, 0>”  
NB: The major/minor number may vary in your case
6. Create the device file as per the major number allocated above  
\$ mknod /dev/abc c 240 0
7. Test the write operation  
\$ echo “Welcome” > /dev/abc  
(Should display the ascii value of the above string in user space)
8. Test the read operation  
\$ cat /dev/abc

## Enhancing the driver to send data to user space

In the previous example, invocation of read had no effect except printing the messages from the my\_open and my\_read. Below are the steps to enhance read operation:

1. Complete TODO 4 in null.c (Refer apis.txt file in CharDriver for the corresponding APIs)
2. Build the kernel module with make. This would generate the kernel module by name null.ko
3. Transfer the kernel module to the board.  
\$ scp null.ko root@<board\_ip>:  
The board\_ip for bbb is 192.168.7.2
4. Load the kernel module  
\$ insmod null.ko  
his should display “<Major, Minor>: <240, 0>”  
NB: The major/minor number may vary in your case
5. Create the device file as per the major number allocated above  
\$ mknod /dev/abc c 240 0
6. Test the write operation  
\$ echo “Welcome” > /dev/abc  
(Should display the ascii value of the above string)
7. Test the read operation

\$ cat /dev/abc (Should display 'e', which is last character of string provided during write operation)

### Automatic device file creation

- 1 Complete TODOs (1 to 4) in final\_char\_driver.c (Refer apis.txt file in CharDriver for the corresponding APIs)
- 2 Build the kernel module with make. This would generate the kernel module by name final\_char\_driver.ko
- 3 Transfer the kernel module to the board.  
\$ scp final\_char\_driver.ko root@<board\_ip>:  
The board\_ip for bbb is 192.168.7.2
- 4 Load the kernel module  
\$ insmod final\_char\_driver.ko  
This should create the device file by name say *finalchar0* under /dev and there would corresponding entry /sys/class/char/finalchar0/dev  
NB Class name *char* and device file name *finalchar0* depend on the corresponding strings using in class\_create and device\_create respectively
- 5 Test the read operation  
\$ cat /dev/finalchar0 (Should display 'A')
- 6 Test the write operation  
\$ echo "1" > /dev/finalchar0 (Nothing is displayed)
- 7 Unload the driver  
\$ rmmod final\_char\_driver  
The enteries /dev/finalchar0 and /sys/class/char/finalchar0 should disappear

### Autoloading the driver

The intention of this activity is to demonstrate the mdev rules

- 1 Unpack the autoload.tgz. This would create the folder with the name Autoload  
\$ tar -xvf autoload.tgz
- 2 Register mdev as hotplug manager on the board. Each time Linux kernel detects a new device, it will call /sbin/mdev with specific parameters  
\$ echo "/sbin/mdev" > /proc/sys/kernel/hotplug (To be execute on board)
- 3 Create the directory for mdev scripts on the board  
\$ mkdir /lib/mdev/ (To be execute on the board)
- 4 Transfer the mdev configuration file to the board  
\$ scp AutoLoad/mdev.conf root@192.168.7.2:/etc/
- 5 Transfer the autoloader script to the board  
\$ scp AutoLoad/autoloader.sh root@192.168.7.2:/lib/mdev/
- 6 Transfer the driver to the board  
\$ scp Templates/CharDriver/final\_char\_driver.ko root@192.168.7.2:
- 7 Change the permissions for autoloader.sh on the board  
\$ chmod a+x /lib/mdev/autoloader.sh (To be executed on the board)
- 8 Next step is to plug the pen drive or either carefully remove & re-insert the uSD. This should load the final\_char\_driver.ko
- 9 Unplug the pen drive or carefully remove the uSD. This should unload the driver

## Controlling the on-board Led

The idea over is to demonstrate controlling the hardware with character driver.

Below are the steps:

- 1 Complete all the TODOs (1 & 2) in CharDriver/led.c (Refer apis.txt file in CharDriver for the corresponding APIs).
- 2 Use pin no. 56 as an argument to gpio\_set\_value and gpio\_get\_value. There is macro called GPIO\_NUMBER for this.
- 3 Build the kernel module with make. This would generate the kernel module by name led.ko
- 4 Transfer the kernel module to the board.  
\$ scp led.ko root@192.168.7.2:
- 5 Compile the application. It can be found under Drivers/Apps  
\$ make  
This would generate the executable with name led\_ops
- 6 Transfer the application to the board  
\$ scp Apps/led\_ops root@192.168.7.2:
- 7 Load the kernel module  
\$ insmod led.ko
- 8 Execute the application  
./led\_ops /dev/gpio\_drv0  
Select open, Try write & read to play around with led

## Controlling the on-board Leds using ioctl

The idea over is to demonstrate controlling the hardware by using the ioctl.

Below are the steps:

- 1 Complete all the TODOs in led\_ioctl.c & led\_ioctl.h under CharDriver/ (Refer apis.txt file in CharDriver for the corresponding APIs)
- 2 Copy led\_ioctl.h to Apps/
- 3 Build the kernel module with make. This would generate the kernel module by name led\_ioctl.ko
- 4 Transfer the kernel module to the board.  
\$ scp led\_ioctl.ko root@192.168.7.2:
- 5 Compile the application. It can be found under Drivers/Apps  
\$ make  
This would generate the executable with name led\_ioctl
- 6 Transfer the application to the board  
\$ scp Apps/led\_ioctl root@192.168.7.2:
- 7 Load the kernel module  
\$ insmod led\_ioctl.ko
- 8 Execute the application  
./led\_ioctl /dev/gpio\_drv0  
Select open and then try playing around with ioctls for selecting the leds & switching on/off the leds

## Platform Drivers & Device Tree

### Platform Driver & Device Registration

The idea over here is to demonstrate the usage of platform driver

1. Navigate to Drivers/PlatformDrivers. Execute 'make' & this would generate platform\_driver.ko and platform\_device.ko
2. Transfer platform\_driver.ko & platform\_device.ko
3. Load the drivers  
\$ insmod platform\_driver.ko  
\$ insmod platform\_device.ko  
This should invoke the probe for the Platform Driver

### Enhance led driver to enable the platform driver support

The idea over here is to remove the hardcoding of the gpio number in led driver and provide the same through the led device.

1. Navigate to Drivers/PlatformDrivers. Copy CharDriver/led.c as platform\_led.c and platform\_device.c as led\_device.c
2. Modify platform\_led.c to add the support for platform driver.
3. Update led\_device.c to pass led number as platform data.
4. Build the drivers with make. This would generate the platform\_led.ko and led\_device.ko.
5. Transfer both the above files to the board and load the same.  
\$ insmod platform\_led.ko  
\$ insmod led\_device.ko  
This should create the device file /dev/gpio\_drv0
6. Transfer & execute the application  
./led\_ioctl /dev/gpio\_drv0  
Select open and then try playing around with ioctls for selecting the leds & switching on/off the leds

### Enhance the platform driver to use Device Tree

The objective here is to enhance the platform drivers to enable the support for device tree

1. Navigate to Drivers/PlatformDrivers. Copy platform\_led\_driver.c as platform\_led\_dtb.c
2. Modify platform\_led.c to add the support for dtb node. Refer, gpio-led.c for the same.
3. Next step is to update the dtb to add the corresponding device tree node. Refer 'am335x-boneblack-common.dtsi' for the same. Compile the dtb by executing the following command:  
\$ make dtbs
4. Next step is to transfer the dtb to the board & update it accordingly  
\$ mount /dev/mmcbk0p1 /mnt (on board)  
\$ scp am335x-boneblack.dtb [root@192.168.7.2](mailto:root@192.168.7.2):/mnt/  
\$ umount /mnt (On board)  
\$ reboot (Reboot the board)
5. Build the drivers with make. This would generate the platform\_led\_dtb.ko. Transfer it to the board and load the same.

```
$ insmod platform_led_dtb.ko
```

This should invoke the driver's probe, which in turn would create the device file.

## Bitbake Hands-On

### Bitbake Setup

1. Clone the bitbake  

```
$ cd ${HOME}/Bitbake
```

```
$ git clone https://github.com/openembedded/bitbake
```
2. Export the required paths  

```
$ export PATH=${HOME}/Bitbake/bitbake/bin/:$PATH
```

```
$ export PYTHONPATH=${HOME}/Bitbake/bitbake/lib:$PYTHONPATH
```
3. Verify  

```
$ bitbake --version
```
4. Create a bitbake project. For this create the directory structure as below:

```
BbTutorial
├── build
│   └── conf
└── meta-tutorial
    ├── classes
    └── conf

5 directories, 0 files
```

5. Add the files as per below:

```
BbTutorial
├── build
│   └── conf
│       └── bblayers.conf
└── meta-tutorial
    ├── classes
    │   └── base.bbclass
    └── conf
        ├── bitbake.conf
        └── layer.conf

5 directories, 4 files
```



6. Create the bblayers.conf file with following contents:
 

```
BBPATH := "${TOPDIR}"
BBFILES ?= ""
BBLAYERS = "${TOPDIR}/../meta-tutorial"
```
7. Create meta-tutorial/conf/layer.conf with following contents:
 

```
BBPATH .= ":${LAYERDIR}"
BBFILES += ""
```
8. Copy base.bbclass from bitbake/classes to meta-tutorial/classes & bitbake.conf from bitbake/conf/ to meta-tutorial/conf/
9. Naviage to build directory & execute the bitbake
 

```
$ cd BbTutorial/build
$ bitbake
```

This should report:  
Nothing to do. Use 'bitbake world' to build everything or run 'bitbake -help' for usage information

## Adding the recipe

1. Execute the bitbake as below:
 

```
$ bitbake -s
```
2. Set the cache location by adding the below things in meta-tutorial/conf/bitbake.conf
 

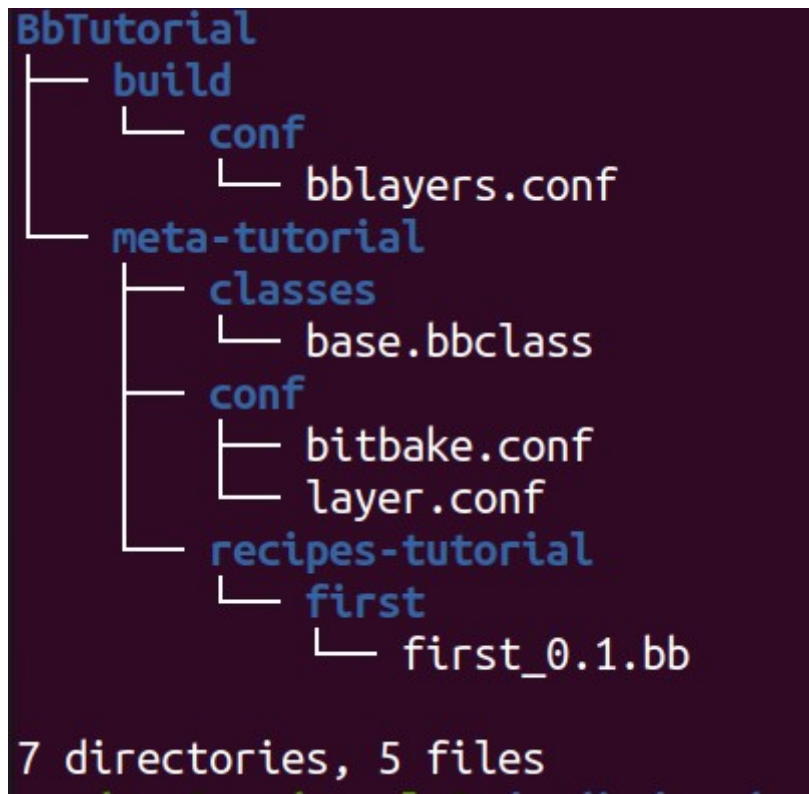
```
CACHE = "${TMPDIR}/cache/default"
```
3. Adding the recipe location to the layer. For this, edit meta-tutorial/conf/layer.conf to add the below:
 

```
BBFILES += "${LAYERDIR}/recipes-*/*/*.bb"
```
4. Create directory for the recipes. This is needed to group the related recipes in the same directory.
 

```
$ cd BbTutorial
$ mkdir -p meta-tutorial/recipes-tutorial/first
```
5. Next, create first recipe in the first group & add the contents as well
 

```
$ vi meta-tutorial/recipes-tutorial/first/first_0.1.bb
Description = "I am the first recipe"
PR= "r1"
do_build () {
    echo "first: Running the build shell script"
}
```

The directoy structure looks as below:



6. Execute the bitbake command as below:  
\$ cd BbTutorial/build  
\$ bitbake -s  
If everything is correct, the bitbake would list the first recipe
7. Bitbake the first recipe  
\$ bitbake first  
This would generate the logs file – build/tmp/work/first-0.1-r1/temp/log.do\_build

### Adding the class & using the same

1. Create the file for the class & add the contents  
Add following in meta-tutorial/classes/mybuild.bbclass  
addtask build  
mybuild\_do\_build() {  
    echo "Executing mybuild\_do\_build."  
}  
EXPORT\_FUNCTIONS do\_build
2. Add the new recipe folder & add the file  
\$ mkdir meta-tutorial/recipes-tutorial/second  
Add the following in meta-tutorial/recipes-tutorial/second\_1.0.bb  
DESCRIPTION = "I am the second recipe"  
PR = "r1"  
inherit mybuild  
def pyfunc(o):  
    print (dir(o))  
    python do\_mypatch () {

- ```

        bb.note ("running mypatch")
        pyfunc(d)
    }
    addtask mypatch before do_build
3. List the recipes & tasks
    $ bitbake -s
    $ bitbake -c listtasks second
4. Build one recipe
    $ bitbake second
5. Executing the specific task
    bitbake -c mypatch second
6. Build everything
    bitbake world
7. Verify the logs
    $ build/tmp/work/first_1.0-r1/temp

```

## Adding an additional layer

- Create a new folder named meta-two
 

```

$ cd BbTutorial
$ mkdir meta-two

```
- Configure the new layer
 

```

$ mkdir meta-two/conf

```

 Copy the layer.conf from meta-tutorial/conf to meta-two/conf
- Updating the bitbake configuration to add the support for new layer. For this, edit build/conf/bblayers.conf and extend the BBLAYERS variable
 

```

BBLAYERS = " \
    ${TOPDIR}/../meta-tutorial \
    ${TOPDIR}/../meta-two \
"

```
- Enhancing the Layer Configuration. Add the following in meta-tutorial/conf/layer.conf
 

```

BBFILE_COLLECTIONS += "tutorial"
BBFILE_PATTERN_tutorial = "^${LAYERDIR}"
BBFILE_PRIORITY_tutorial = "5"

```
- Add above things for meta-two as well:
 

```

BBFILE_COLLECTIONS += "two"
BBFILE_PATTERN_two = "^${LAYERDIR}"
BBFILE_PRIORITY_two = "5"

```
- Examine the layers
 

```

$ bitbake-layers show-layers

```
- Layer Compatibility
 

Define the Layer series core name by defining the project core name.

Add the following to meta-tutorial/conf/layer.conf

```

LAYERSERIES_CORENAME = "bitbakeguide"

```

Next define the LAYERSERIES\_COMPAT variable in meta-tutorial/conf/layer.conf

```

LAYERSERIES_COMPAT_tutorial = "bitbakeguide"

```

Add the similar line to meta-two/conf/layer.conf  
LAYERSERIES\_COMPAT\_two = "bitbakeguide"

8. Layer dependency

Add the dependency for 'tutorial' layer in layer 'two' conf  
LAYERDEPENDS\_two = "tutorial"

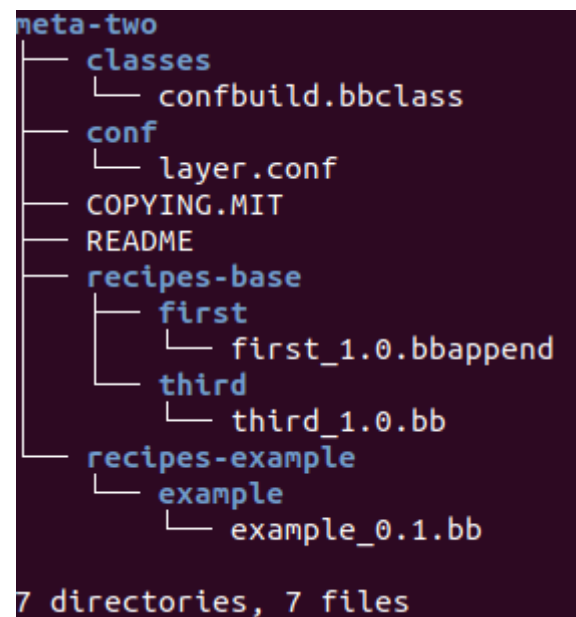
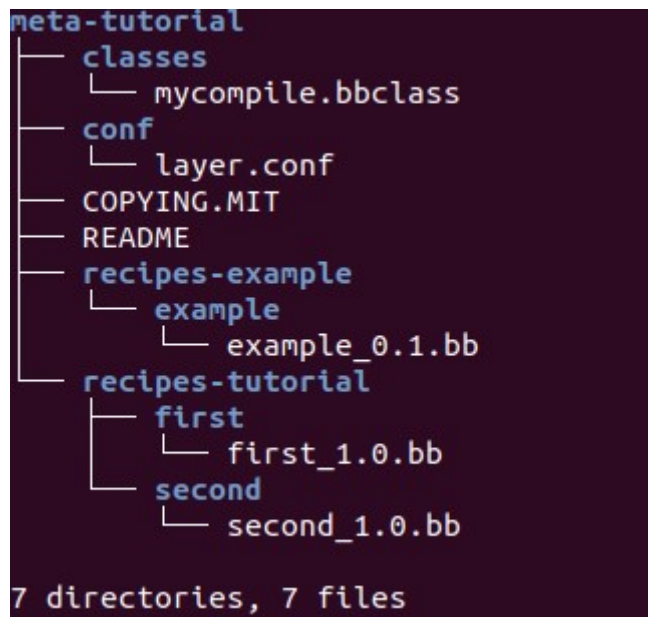
9. Class Inheritance – The idea over here is to reuse the 'mybuild' class. First, create a class confbuild.bbclass under meta-two/classes and add the following:

```
inherit mybuild
confbuild_do_configure () {
    echo "running confbuild_do_configure"
}
addtask do_configure before do_build
EXPORT_FUNCTIONS do_configure
```

10. Next step is to define the new recipe & use the confbuild

Create the file with name meta-two/recipes-base/third/third\_0.1.bb and add the following:

```
DESCRIPTION = "I am a third recipe"
PR = "r1"
inherit confbuild
```



11. Next, build the 'third' recipe

\$ bitbake third (This would execute the configure & build tasks for the third)

## Extending an existing recipe

1. The append files have an extension of .bbappend. To be able to use append files, the layers needs to be set up to load also them in addition to normal recipes. For this, modify 'BBFILES' variable as follows:

```
BBFILES += "${LAYERDIR}/recipes-*/*/*.bb \
${LAYERDIR}/recipes-*/*/*.bbappend
```

- Next step is to reuse & extend the existing 'first' recipe in the meta-two layer. That's the reason to use LAYERDEPENDS\_two. The requirement is to run a patch function before running the build task. For this, create the bbappend file first  
`$ mkdir -p meta-two/recipes-base/first`  
Add the following to meta-two/recipes-base/first/first\_0.1.bbappend file:  

```
python do_patch () {
    bb.note ("first: do_patch")
}
addtask patch before do_build
```
- Next, list the tasks with  
`$ bitbake -c listtasks first`  
This should show up do\_patch task as well

## Including files

The idea over here is to demonstrate the usage of include & require directives. Its worth mentioning that include & require file name is relative to any directory in BBPATH

- Modify bitbake.conf to include the local.conf as below:  
require local.conf
- Execute bitbake. This would show a error message. To fix this, create local.conf under build directory

## Using Variables

### Global Variables

- Variables helps in writing the configurable recipes. The users of the such recipes can give those variables the desired values ,which in turn can then be used by the recipes. First step is to define the global variable in local.conf  
`$ echo 'MYVAR="hello from MYVAR"' > build/local.conf`
- Next step is to access the global variable. For this, let's create the new recipe group recipe-vars and a recipe myvar in it:  
Add following to meta-two/recipes-vars/myvar/myvar\_0.1.bb  

```
DESCRIPTION = "Show access to global MYVAR"
PR = "r1"
do_build () {
    echo "myvar_sh: ${MYVAR}"
}
python do_myvar_py() {
    print ("myvar:" +d.getVar('MYVAR', True))
}
addtask myvar_py before do_build
```
- If we now run `bitbake myvar` and check the log output in the tmp directory, we will see that we indeed have access to the global MYVAR variable. If you are looking for the log file, search for a file like this:  
`build/tmp/work/myvar-0.1-r1/temp/log.do_myvar_py.`

## Local Variables

1. Create the class by name `varbuild.bbclass` under `meta-two/classes`

```
varbuild_do_build () {  
    echo "build with args: ${BUILDARGS}"  
}
```

```
addtask build
```

```
EXPORT_FUNCTIONS do_build
```

2. Use the above class in the recipe.

```
$ vi meta-two/recipes-vars/varbuild/varbuild_0.1.bb  
DESCRIPTION = "Demonstrate variable usage \  
for setting up a class task"  
PR = "r1"
```

```
BUILDARGS = "my build arguments"
```

```
inherit varbuild
```

3. Running `bitbake varbuild` will produce log files that shows that the build task respects the variable value which the recipe has set.

This is a very typical way of using BitBake. The general task is defined in a class, like for example `download`, `source`, `configure`, `make` and others, and the recipe sets the needed variables for the task.

## Adding the Custom BSP layer

1. Add the new layer

```
$ cd build_bbb
```

```
$ bitbake-layers show-layers
```

```
$ bitbake-layers create-layer ../sources/meta-mt
```

```
$ bitbake-layers add-layer ../sources/meta-mt
```

```
$ bitbake-layers show-layers
```

2. Add the support for the machine

```
$ cd ../sources/meta-mt
```

```
$ cd conf
```

```
$ mkdir machine
```

```
$ cp ../sources/poky/meta-yocto-bsp/conf/machine/beaglebone-yocto.conf  
machine/demo-board.conf
```

3. Change the few things here:

```
$ vi machine/demo-board.conf
```

Change the `@Name` and `@Description` to something suitable

4. Modify `MACHINE` `??= demo-board`

5. Build the image for the machine

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

## Adding the support for the custom kernel

1. `$ cd meta-mt`

2. `$ mkdir -p .recipes-kernel/linux`

3. Add the following in `recipes-kernel/linux/linux-yocto_5.4.bbappend`

```
COMPATIBLE_MACHINE += "|demo-board"
```

- Next, refer ../sources/poky/meta-yocto-bsp/recipes-kernel/linux/linux-yocto\_5.4.bbappend and as per that add the following:  
KBRANCH\_demo-board = "v5.4/standard/beaglebone"  
KMACHINE\_demo-board ?= "beaglebone"  
SRCREV\_machine\_demo-board ?= "706efec4c1e270ec5dda92275898cd465dfdc7dd"  
LINUX\_VERSION\_demo-board = "5.4.58"
- Next step is to prepare the image  
\$ bitbake core-image-minimal
- The kernel image would be generated under tmp/deploy/images/demo-board/zImage

## Adding the custom defconfig for the Kernel

The idea over here is to configure the kernel to add the support for usb ethernet.

- Execute the menuconfig task for the kernel using the following command  
\$ bitbake -c menuconfig virtual/kernel  
Enable Device Drivers -> USB Support -> USB Gadget Support -> USB Gadget precomposed configurations (CDC Composite (Ethernet & ACM)
- Save the config as myconfig & exit the menuconfig
- The configuration 'myconfig' would be found under  
build\_bbb/tmp/work/demo\_board-poky-linux-gnueabi/linux-yocto/5.4.58+gitAUTOINC+e8c675c7e1\_706efec4c1-r0/linux-demo\_board-standard-build/myconfig
- Next step is to add the myconfig as a defconfig for the kernel. For this, first let's create the directory by name linux-yocto & copy the myconfig under that:  
\$ cd meta-mt  
\$ mkdir recipes-kernel/linux/linux-yocto  
Copy myconfig as defconfig under this folder  
\$ cp ../../build\_bbb/tmp/work/demo\_board-poky-linux-gnueabi/linux-yocto/5.4.58+gitAUTOINC+e8c675c7e1\_706efec4c1-r0/linux-demo\_board-standard-build/myconfig recipes-kernel/linux/linux-yocto/defconfig
- Next step is modify the kernel recipe to enable the support for defconfig. For this, add the following in recipes-kernel/linux/linux-yocto\_5.4.bbappend  
FILESEXTRAPATHS\_prepend := "\${THISDIR}/\${PN}:"  
SRC\_URI += "file://defconfig"
- Next, build the kernel as follows:  
\$ bitbake -c compile virtual/kernel
- Next, copy the kernel image from build\_bbb/tmp/work/demo\_board-poky-linux-gnueabi/linux-yocto/5.4.58+gitAUTOINC+e8c675c7e1\_706efec4c1-r0/linux-demo\_board-standard-build/arch/arm/boot/zImage to the uSD card.
- Boot up the target board & execute 'ifconfig'. This should show 'usb0' interface

## Creating & applying the configuration fragments to the kernel

- Launch the menuconfig for kernel  
\$ bitbake -c menuconfig virtual/kernel  
Make the configuration changes such as modifying the host & kernel log buffer under general setup. Save and exit the menuconfig
- Create the configuration fragment  
\$ bitbake -c diffconfig virtual/kernel

This would generate fragment.cfg under build\_bbb/tmp/work/demo\_board-poky-linux-gnueabi/linux-yocto/5.4.58+gitAUTOINC+e8c675c7e1\_706efec4c1-r0/

3. Copy the configuration fragment as myconfig.cfg under recipes-kernel/linux/linux-yocto/
4. Modify recipes-kernel/linux/linux-yocto\_5.4.bbappend to add the following:  
SRC\_URI += "<file:///myconfig.cfg>"
5. Build the kernel  
\$ bitbake -c compile virtual/kernel

## Patching the Kernel

1. Open the devshell  
\$ bitbake -c devshell virtual/kernel
2. Open drivers/char/misc.c and add a printk in the init\_module
3. Close the devshell
4. Test the changes by compiling the Kernel
5. Next step is to create the patch. For this, open the devshell  
\$ bitbake -c devshell virtual/kernel
6. git status
7. git add drivers/char/misc.c
8. Commit the changes with git commit
9. Create the patch  
\$ git format-patch -1
10. Exit the devshell
11. Copy the patch to recipes-kernel/linux/files/ with the name test.patch
12. Modify recipes-kernel/linux/linux-yocto\_5.4.bbappend to add the following:  
SRC\_URI += "<file:///test.patch>"
13. Compile the kernel  
\$ bitbake -c virtual/kernel
14. compile the core-image-minimal

## Applying the patches using the SCC scripts

1. Open Kernel devshell  
\$ bitbake -c devshell virtual/kernel
2. Copy Kconfig, first\_driver.c & Makefile from <mtts\_repo>/KernelChanges into the <kernel-source>/drivers/char/
3. Next, commit the changes & create the patch  
\$ git format-patch -1 -o <path to meta-mt>/recipes-kernel/linux/files/test.patch  
Exit the devshell
4. Next step is to run the menuconfig task  
\$ bitbake -c menuconfig virtual/kernel  
Select the 'My Test Driver' under Drivers->Character Driver  
Save & exit the menuconfig
5. Create the configuration fragment  
\$ bitbake -c diffconfig virtual/kernel

This would generate fragment.cfg under build\_bbb/tmp/work/demo\_board-poky-linux-gnueabi/linux-yocto/5.4.58+gitAUTOINC+e8c675c7e1\_706efec4c1-r0/



6. Copy the configuration fragment as myconfig.cfg under recipes-kernel/linux/linux-yocto/
7. Next step is create the .SCC file. For this, refer the test.scc file under <mtts\_repo>/KernelChanges. And on the similar lines, create the corresponding test.scc file
8. Modify the linux/linux-yocto\_5.4.bbappend to add the following:  
SRC\_URI += "test.scc"
9. Compile the kernel  
\$ bitbake -c virtual/kernel

## Building the out of tree Module

1. \$ cd meta-mt
2. \$ mkdir recipes-kernel/hello-world/files
3. Copy the recipe and driver code  
\$ cp <mtts\_repo>/Yocto/KernelModule/hello-work.bb recipes-kernel/hello-world/  
\$ cp <mtts\_repo>/Yocto/KernelModule/hello\_world.c recipes-kernel/hello-world/files  
\$ \$ cp <mtts\_repo>/Yocto/KernelModule/Makefile recipes-kernel/hello-world/files
4. Get into the build\_bbb directoy  
\$ cd build\_bbb  
\$ bitbake hello-world  
This generates hello\_world.ko under ../../build\_bbb/tmp/work/demo\_board-poky-linux-gnueabi/hello-world/1.0-r0/

## Customize the u-boot

1. Open the devshell  
\$ bitbake -c devshell virtual/bootloader
2. Get into the cmd directory  
\$ cd cmd
3. \$ cp Day2/Uboot/my\_print.c .
4. Close the devshell
5. Test the changes by compiling the uboot  
\$ bitbake -f -c virtual/bootloader
6. \$ bitbake core-image-minimal

## Add the support for custom uboot

1. Navigate to meta-mt  
\$ cd meta-mt
2. Create the respective directories for uboot  
\$ mkdir -p recipes-bsp/u-boot/files
3. Create the file 'u-boot\_%.bbappend'  
\$ vi recipes-bsp/u-boot/  
Add FILESEXTRAPATHS\_prepend := "\${THISDIR}/files:"
4. Open the devshell  
\$ bitbake -c devshell virtual/bootloader
5. git status
6. git add my\_print.c Makefile
7. Commit the changes

8. Create the patch  
\$ git format-patch -1 -o <build\_bbb>/sources/meta-mt/recipes-bsp/u-boot/files/
9. Exit the devshell
10. Rename the patch  
\$ cd recipes-bsp/u-boot/files  
\$ mv <patch\_name> cmd\_test.patch
11. Open the u-boot\_%.bbappend file and add  
SRC\_URI += "[file:///cmd\\_test.patch](file:///cmd_test.patch)"
12. Build the u-boot  
\$ bitbake -c virtual/bootloader
13. Build the the core-image-minimal

## Enabling the Package Management Support

1. Create the directory by recipes-mt under meta-mt
2. Extend the core-image-minimal.bb recipe by creating the file 'core-image-minimal.bbappend' under recipes-mt
3. Add the following in core-image-minimal.bbappend  
EXTRA\_IMAGE\_FEATURES += "package-management"
4. Next, build the core-image-minimal with:  
\$ bitbake core-image-minimal

## Building the C Program

1. Create the recipe with the name helloworld\_1.0.bb under recipe-examples/helloworld and include the following contents:  
DESCRIPTION, SECTION and SRC\_URI
2. Next, create the file by name helloworld.c under  
recipe-examples/helloworld/helloworld/
3. Build the application:  
\$ bitbake helloworld  
This would generate the executable under build\_bbb/tmp/work/cortexa8hf-neon-poky-linux-gnueabi/helloworld/1.0-r0
4. Next step is to modify the program & create the patch for the same. For this, open the devshell:  
\$ bitbake -c devshell helloworld  
Next, create the git repo & add the helloworld.c  
\$ git init  
\$ git add helloworld.c  
\$ git commit -s -m "Original revision"  
Open helloworld.c & modify the printf message and commit the changes  
\$ git add helloworld.c  
\$ git commit -s -m "Change print message"
5. Next step is to create the patch  
\$ git format-patch -1 -o  
<path\_to\_bbb>/sources/meta-mt/recipes-example/helloworld/helloworld/
6. Update the recipe to add the patch file to SRC\_URI and build the helloworld package

```
$ bitbake -c cleanall helloworld
$ bitbake helloworld
This should generate the executable under WORKDIR
```

## Building the Program located on git

1. Get into the meta-mt/recipes-example/helloworld directory & make a copy of helloworld\_1.0.bb

```
$ cd meta-mt/recipe-example/helloworld
$ mkdir recipes-example
$ cp helloworld_1.0.bb helloworld-git_1.0.bb
```
2. Modify SRC\_URI in helloworld-git\_1.0.bb to point to the git repo
3. Next, build the recipe

```
$ bitbake helloworld-git
```
4. Fix the errors if any

## Static Library based build

1. Create a directory with Libraries and under that another directory by StaticLib

```
$ mkdir Libraries
$ cd Libraries
$ mkdir StaticLib
$ cd StaticLib
```
2. Next thing is to create two files hello.c and world.c with following contents

```
hello.c:
char *hello()
{
    return "Hello";
}
world.c:
char *world()
{
    return "World";
}
```
3. Next, source the build environment

```
$ source Toolchain/environment-setup-cortexa8hf-neon-poky-linux-gnueabi
```
4. Compile the libraries

```
${CC} -c hello.c world.c
${AR} -cvq libhelloworld.a hello.o world.o
${AR} -t libhelloworld.a
```
5. Next, create the helloworld.c which invokes the library functions

```
helloworld.c
#include <stdio.h>
int main (void)
{
    return printf("%s %s\n",hello(),world());
}
```
6. Compile the applications

```
${CC} -o helloworld helloworld.c libhelloworld.a
```

This would generate the executable 'helloworld'

## Static Library based Yocto recipe

1. Create the directory with the name libhello-static under recipes-example  

```
$ cd recipe-example
```

```
$ mkdir -p libhello-static/libhello-static
```
2. Next step is to copy hello.c, helloworld.h, world.c from  
<mts\_repo>/Yocto/Application/StaticLib to recipes-example/libhello-static/libhello-static
3. Next step is to create the pkg-config build settings file with .pc suffix. It is distributed with the library and is installed in a common location known to the pkg-tool. Place the helloworld.pc pkg-config file inside libhello-static/libhello-static/
4. Next step is to create the recipe say libhello-static\_1.0.bb, which builds the library libhelloworld.a. For this, copy the helloworld\_1.0.bb recipe and do the necessary changes such as:  
Create the \${D}\${includedir} & \${D}\${libdir} and install helloworld.h in \${includedir} and libhelloworld.a in libdir  

```
$ bitbake libhello-static
```
5. Next step is to build the program which uses the above library. For this, first create the directories hello-static/hello-static and copy the helloworld.c file under it.  
helloworld.c:

```
#include <stdio.h>
#include "helloworld.h"
int main (void)
{
    return printf("%s %s\n",hello(),world());
}
```
6. Next, create the recipe hello-static/hello-static\_1.0.bb by copying helloworld\_1.0.bb. Add the following to compile the program:  

```
${CC} ${LDFLAGS} -o helloworld helloworld.c -l helloworld
```
7. Fix the error if any and build the package  

```
$ bitbake hello-static
```

## Static Library based build

1. Create a directory with Libraries and under that another directory by StaticLib  

```
$ mkdir Libraries
```

```
$ cd Libraries
```

```
$ mkdir SharedLib
```

```
$ cd SharedLib
```
2. Next thing is to create two files hello.c and world.c with following contents  
hello.c:

```
char *hello()
{
    return "Hello";
}
```

```
world.c:
char *world()
{
    return "World";
}
```

3. Next, source the build environment  
\$ source Toolchain/environment-setup-cortexa8hf-neon-poky-linux-gnueabi
4. Compile the libraries  
\${CC} -fPIC -g -c hello.c world.c  
\${CC} -shared -Wl,-soname,libhelloworld.so.1 -o libhelloworld.so.1.0 hello.o

world.o

5. Next, create the helloworld.c which invokes the library functions  
helloworld.c  
#include <stdio.h>  
int main (void)  
{  
 return printf("%s %s\n",hello(),world());  
}
6. Compile the applications  
\${CC} helloworld.c libhelloworld.so.1.0 -o helloworld  
This would generate the executable 'helloworld'
7. readelf -d helloworld  
This should show the dependency on the library

## Dynamic/Shared Library based Yocto recipe

1. Create the directory with the name libhello-dyn under recipes-example  
\$ cd recipe-example  
\$ mkdir -p libhello-dyn/libhello-dyn
2. Next step is to copy hello.c, helloworld.h & world.c to  
recipes-example/libhello-dyn/libhello-dyn
3. Next step is to create the pkg-config build settings file with .pc suffix. It is distributed with the library and is installed in a common location known to the pkg-tool. Place the helloworld.pc pkg-config file inside libhello-dyn/libhello-dyn/
4. Next step is to create the recipe say libhello-dyn\_1.0.bb, which builds the library libhelloworld.a. For this, copy the libhello-static\_1.0.bb. Change the compilation commands as below:  
\${CC} \${LDFLAGS} -fPIC -g -c hello.c world.c  
\${CC} \${LDFLAGS} -shared -Wl,-soname,libhelloworld.so.1 -o libhelloworld.so.1.0  
hello.o world.o
5. Next add the following:  
install -m 0755 libhelloworld.so.1.0 \${D}/\${libdir}  
ln -s libhelloworld.so.1.0 \${D}/\${libdir}/libhelloworld.so.1  
ln -s libhelloworld.so.1 \${D}/\${libdir}/libhelloworld.so
6. Finally build the package  
\$ bitbake libhello-dyn

7. Next step is to build the program which uses the above library. For this, first create the directories hello-dyn/hello-dyn and copy the helloworld.c file under it.  
\$ bitbake hello-dync

## Building the Makefile based project

1. Create the recipe for the same by copying helloworld\_1.0.bb as hellomake\_1.0.bb under meta-mt/recipes-example/hellomake/
2. Next, copy the files (hello.c, helloprint.c/h, Makefile from HelloMake)
3. Modify the recipe to add the following:  
EXTRA\_OEMAKE = "CC=\${CC}' 'RANLIB=\${RANLIB}' 'AR=\${AR}' \\  
'CFLAGS=\${CFLAGS} -I\${S}/. -DWITHOUT\_XATTR' 'BUILDDIR=\${S}'"  
  
do\_install () {  
    oe\_runmake install DESTDIR=\${D} BINDIR=\${bindir} SBINDIR=\${sbindir} \  
        MANDIR=\${mandir} INCLUDEDIR=\${includedir}  
}  
4. Next build the recipe.

## Creating a simple recipe and installing it in the rootfs

8. Get into the meta-mt  
\$ cd meta-mt
9. Create the recipe directory  
\$ mkdir -p recipes-example/helloworld/files  
\$ cp Recipes/helloworld.c recipes-example/helloworld/files/
10. Copy the recipe & the simple program  
\$ cp Recipes/helloworld\_0.1.bb recipes-example/helloworld/  
\$ cp Recipes/helloworld.c recipes-example/helloworld/files/
11. Test the recipe  
\$ bitbake hellloworld
12. Create the .bbappend file for core-image-minimal  
\$ cd meta-mt  
\$ mkdir -p recipes-mt/images/  
Add the following in core-image-minimal.bbappend  
\$ vi recipes-mt/images/core-image-minimal.bbaappend  
Add 'IMAGE\_INSTALL += " helloworld"'
13. Build the image  
\$ bitbake core-image-minimal

## Creating a simple sysV init service and installing it in the rootfs

1. Get into the meta-mt  
\$ cd meta-mt
2. Create the recipe directory for initd  
\$ mkdir -p recipes-example/initd/files  
\$ cp Initd/sysvtest recipes-example/initd/files/
3. Copy the recipe & the systemd service  
\$ cp Initd/systvinit\_1.0.bb recipes-example/initd/

- \$ cp Initd/sysvtest recipes-example/initd/files/
- 4. Install the recipe into the image
  - Add the following in core-image-minimal.bbappend
  - \$ vi recipes-mt/images/core-image-minimal.bbaappend
  - Add 'IMAGE\_INSTALL += " sysvinit"
- 5. Build the image
  - \$ bitbake core-image-minimal

## Creating a simple systemd service and installing it in the rootfs

- 1. Get into the meta-mt
  - \$ cd meta-mt
- 2. Create the recipe directory for systemd
  - \$ mkdir -p recipes-example/systemd/files
- 3. Copy the recipe & the systemd service
  - \$ cp Systemd/hellosystemd\_1.0.bb recipes-example/systemd/
  - \$ cp Recipes/helloworld.service recipes-example/systemd/files/
- 4. Install the recipe into the image
  - Add the following in core-image-minimal.bbappend
  - \$ vi recipes-mt/images/core-image-minimal.bbaappend
  - Add 'IMAGE\_INSTALL += " hellosystemd"
- 5. Build the image
  - \$ bitbake core-image-minimal
- 6. Insert the uSD in the PC and flash the rootfs by using the following command:
  - \$ sudo tar -C <second partition mount point> -xvf
  - tmp/deploy/images/demo-board/core-image-minimal-demo-board-xxx.rootfs.tar.bz2
- 7. Once contents are copied, insert the uSD in the board & boot up with the same.
  - Execute the following command to check if the systemd service had started
  - \$ systemctl status hellosystem.service
- 8. Execute below to verify the logs
  - \$ journalctl | grep World
  - PS To enable systemd init manager, Add the following in local.conf
  - DISTRO\_FEATURES\_append = " systemd"
  - VIRTUAL-RUNTIME\_init\_manager = "systemd"

## Preparing eSDK & installing the same

- 1. Create the eSDK by executing the following command:
  - \$ bitbake -c populate\_sdk\_ext core-image-minimal
  - The SDK would be generated under tmp/deploy/sdk/poky-glibc-x86\_64-core-image-minimal-cortexa8hf-neon-demo-board-toolchain-ext-3.1.14.sh
- 2. Install the SDK by executing the above script

## Using devtool to create the new recipe

- 1. Get the Source Code
  - \$ cp -r Day4/TestProg \$HOME/
- 2. Get into the eSDK
  - \$ cd \$HOME/poky\_sdk

3. Use devtool to set up the workspace and create the recipe  
`$ devtool add testdev $HOME/TestProg/`  
 This would create the recipe by name testdev\_0.1.bb under <esdk\_dir>/workspace/recipes/testdev
4. Build the recipe  
`$ devtool build testdev`  
 The corresponding binary would be generated under  
 <eSDK\_dir>/tmp/work/aarch64-poky-linux/testdev/0.1-r0/image/usr/bin/test
5. Test the generated binary

## Using devtool to modify the existing application

1. Use the 'devtool modify' command to locate, extract and prepare the package files.  
 The command locates the source based on the information in the existing recipe, unpacks the source into the 'workspace', applies patches and parses all related recipes  
`$ devtool modify helloworld`  
 The package is unpacked at <eSDK\_dir>/workspace/sources/helloworld/
2. Modify helloworld.c
3. Rebuild helloworld  
`$ devtool build helloworld`
4. Test the helloworld application
5. Once tested, the next step is to commit the changes  
`$ cd <eSDK_dir>/workspace/sources/helloworld/`  
`$ git status`  
`$ git helloworld.c`  
`$ git commit`
6. Turn the commit you have made into the patch  
`$ cd <eSDK_dir>`  
`$ devtool update-recipe helloworld`  
 The patch would be placed under  
 <eSDK\_dir>/layers/meta-philips/recipes-example/helloworld/files/0001-Modification-to-test-the-dev-tool.patch

## Using devtool to modify the existing kernel module

1. Use the 'devtool modify' command to locate, extract and prepare the package files.  
 The command locates the source based on the information in the existing recipe, unpacks the source into the 'workspace', applies patches and parses all related recipes  
`$ devtool modify hello-world`  
 The package is unpacked at <eSDK\_dir>/workspace/sources/hello-world/
2. Modify hello\_world.c
3. Rebuild hello-world  
`$ devtool build hello-world`
4. Test the hello-world.ko module

## Using Packagegroups in Yocto

The idea over here is to create 2 images, one for development and other for production.



1. Get into the meta-philips
2. Copy the image recipes into images folder  
\$ cp Day4/PackageGroups/demo-board-\* recipes-philips/images/
3. Create the directory by name packagegroups under recipes-philips & copy the packagegroup from Day4  
\$ cp Day4/PackageGroups/packagegroup-philips-testapps.bb recipes-philips/packagegroup/
4. The image recipe demo-board-image-dev.bb utilizes the packagroup

## Remote debugging with gdbserver

1. Get into the SDK directory and source the environment  
\$ cd /opt/poky/3.1.10  
\$ source environment-setup-aarch64-poky-linux
2. Start the program with gdbserver on the target
3. gdbserver :10000 helloworld  
This should show the message:  
Attached; pid = 160  
Listening on port 10000
4. On the host, start the gdb client  
\$ gdb sysroots/aarch64-poky-linux/usr/bin/helloworld
5. Set the sysroot  
\$ set sysroot /opt/poky/3.1.10/sysroots/aarch64-poky-linux/
6. \$ target remote <ip\_addr>:10000  
This would establish the connection between the gdb client & the server

## Custom image partitioning with wic

1. Get into the meta-philips
2. Create a directory by name wic and copy the .wks file  
\$ mkdir wic  
\$ cp \$Day5/Wic/sdimage-demo-board.wks wic/
3. Modify the meta-philips/conf/demo-board.conf to add the following  
WKS\_FILE = "sdimage-demo-board.wks"
4. Rebuild the image  
\$ bitbake core-image-minimal  
This should image with 3 partitions

## Wic related commands

Wic related commands are available once the bitbake environment is sourced or as part of SDK

1. \$ wic ls <image>  
This would list the partition details on the wic file
2. Mounting the partition of wic file  
\$ loopdev1=`losetup -f`
3. Use losetup to create the loop device.  
\$ sudo losetup -o <starting offset> --sizelimit <size of partition> \$loopdev1 <image>  
starting offset and size can be figured out from the 'wic ls'

4. Mount the partition  
\$ sudo mount \$loodev1 /mnt
5. Once done unmount and delete the loop device  
\$ sudo umount /mnt  
\$ losetup -d \$loopdev1