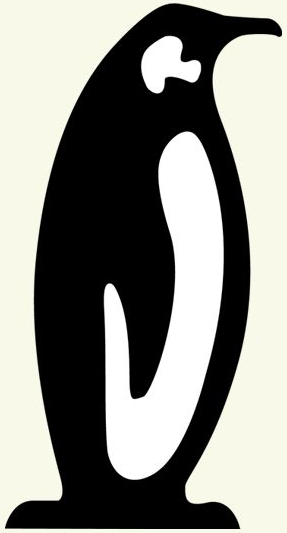

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Building for Heterogeneous Systems

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Outline

- Heterogeneous Devices
- Linux Flow vs Baremetal Flow
- Baremetal / RTOS build
- Working with SDKs (Rpi Pico / Zephyr)
- Bitbake's Solution (Multiconfig)
- Testing

Heterogeneous Devices

Heterogeneous Devices

- Multiple Architectures on the same device
  - Typically “Big” core runs Linux, “small” core runs RTOS/Baremetal
- Power Consumption
- Safety Critical
- Processing power
- Efficiency

Heterogeneous Builds

- Linux
- Linux + Baremetal
- Linux + RTOS
- Baremetal
- RTOS
- Linux + Linux (RT/Tiny)

Heterogeneous Builds

- Create cross toolchain for arch X
- Create cross toolchain for arch Y
- Cross compile package A for arch X
- Cross compile package B for arch Y
- Package Images / Binaries to be flashed

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Developer Workflows

Linux Flow vs Baremetal Flow

Linux:

- Git repository
- Toolchain (host)
- IDE of your choice

Baremetal

- Git repository
- Vendor provided toolchain
- Vendor provided SDK
- Vendor provided IDE

Devtool works

Baremetal Toolchain

ARM Embedded Toolchain

- GCC
- Binutils
- Newlib

Bitbake can provide it by using TCLIBC=”newlib”

Baremetal / RTOS

Baremetal / RTOS

1.- Clone the required repositories (Use -b dunfell or -b kirkstone if you want a stable release)

```
$ git clone https://git.yoctoproject.org/git/poky
$ cd poky
```

2.- Source the build environment file

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

3.- Add the required variables to your local.conf (Supported MACHINES are qemuarm64,qemuarm,armuarmv5)

```
$ echo "MACHINE = \"qemuarm64\"" >> ./conf/local.conf
$ echo "TCLIBC = \"baremetal\"" >> ./conf/local.conf
```

4.- Build the application

```
$ bitbake baremetal-helloworld
```

Build Status

master	Azure Pipelines succeeded
kirkstone	Azure Pipelines succeeded
dunfell	Azure Pipelines succeeded

https://github.com/ahcbb6/baremetal-helloqemu

Baremetal / RTOS

5.- Run the baremetal application on QEMU:

```
$ runqemu nographic
```

Example output:

```
runqemu - INFO - Running bitbake -e ...
runqemu - INFO - Continuing with the following parameters:
KERNEL: [tmp/deploy/images/qemuarm64/baremetal-helloworld-qemuarm64.bin]
MACHINE: [qemuarm64]
FSTYPE: [bin]
ROOTFS: [tmp/deploy/images/qemuarm64/baremetal-helloworld-qemuarm64.bin]
CONFFILE: [tmp/deploy/images/qemuarm64/baremetal-helloworld-qemuarm64.qemuboot.conf]

Hello OpenEmbedded!
```

Baremetal / RTOS

1.- Clone the required repositories

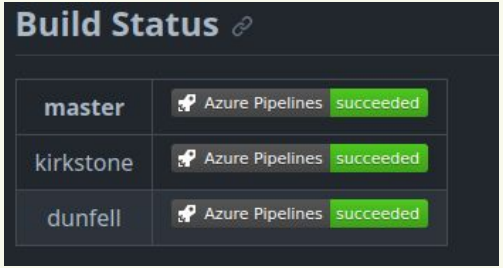
```
$ git clone https://git.yoctoproject.org/git/poky
$ cd poky
$ git clone https://github.com/ahcbb6/meta-freertos.git
```

2.- Add meta-freertos to your bblayers.conf

```
$ source oe-init-build-env
$ bitbake-layers add-layer ../meta-freertos
```

3.- Add the required variables to your local.conf

```
$ echo "DISTRO = \"freertos\"" >> ./conf/local.conf
# If building for QEMU use:
$ echo "MACHINE = \"qemuarmv5\"" >> ./conf/local.conf
# If, instead, building for STM32 use:
$ echo "MACHINE = \"stm32f446\"" >> ./conf/local.conf
```



https://github.com/ahcbb6/meta-freertos

Baremetal / RTOS

4.- Build a sample FreeRTOS standalone application:

```
# For QEMU:
$ bitbake freertos-demo
# For STM32:
$ bitbake freertos-demo-stm32
```

5.- Run the application on QEMU (or flash the .hex file on the deploy directory for STM32):

```
$ runqemu nographic
```

Baremetal / RTOS

```
###### - FreeRTOS sample application -######

A text may be entered using a keyboard.
It will be displayed when 'Enter' is pressed.

Periodic task 10 secs
Waiting For Notification - Blocked...
Task1
Task1
You entered: "HelloFreeRTOS"
Unblocked
Notification Received
Waiting For Notification - Blocked...
```

Working with SDKs

Working with SDKs (Raspberry PI Pico / Zephyr)

Approach 1:

- Create a native recipe to provide an SDK
  - Fetch
  - Install
- DEPEND on it on application recipe
- Use the SDK from recipe-sysroot whilst building the application

https://git.yoctoproject.org/meta-zephyr/tree/meta-zephyr-core/recipes-devtools/zephyr-sdk/zephyr-sdk_0.16.3.bb
https://github.com/ahcbb6/meta-raspberrypi-baremetal/blob/master/recipes-devtools/pico-sdk/pico-sdk_git.bb

Working with SDKs (Raspberry PI Pico / Zephyr)

Approach 2:

- On application recipe
  - Fetch app source code
  - Fetch SDK
  - Wire and use SDK

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Bitbake Multiconfig

Bitbake Multiconfig Builds

- Manually configure bitbake to parse an additional conf
- Multiconfig dependencies allow bitbake to use the same build
- Shared State can be reused across multiconfigs (native)

Bitbake Multiconfig Builds

local.conf

```
MACHINE="stm32f446"
DISTRO="freertos"
BBMULTICONFIG = "dummy-aarch64"
```

multiconfig/dummy-aarch64.conf

```
MACHINE="qemuarm64"
DISTRO="poky"
TMPDIR="${TOPDIR}/tmp-${MACHINE}-${TCLIBC}"
```

core-image-minimal.bb

```
do_image[mcdepends] = "multiconfig:dummy-aarch64::freertos-demo-stm32:do_image"
```

Bitbake Multiconfig Builds

```
Build Configuration (mc:default):
BB_VERSION           = "2.6.0"
BUILD_SYS            = "x86_64-linux"
NATIVELSBSTRING      = "universal"
TARGET_SYS           = "arm-oe-eabi"
MACHINE              = "stm32f446"
DISTRO               = "freertos"
DISTRO_VERSION       = "1.0"
TUNE_FEATURES        = "armv7em cortexm4 thumb callconvention-hard vfpv4spd16"
TARGET_FPU           = "hard"
meta
meta-poky
meta-yocto-bsp       = "master:a9befd527e173a0b8d7e684691e287e5c1587baa"
meta-freertos        = "master:0033a5eb73c1f5ce5c005218dc870f6684fb2b5b"


Build Configuration (mc:dummy):
BB_VERSION           = "2.6.0"
BUILD_SYS            = "x86_64-linux"
NATIVELSBSTRING      = "universal"
TARGET_SYS           = "aarch64-poky-linux"
MACHINE              = "qemuarm64"
DISTRO               = "poky"
DISTRO_VERSION       = "4.3+snapshot-a9befd527e173a0b8d7e684691e287e5c1587baa"
TUNE_FEATURES        = "aarch64 armv8a crc cortexa57"
TARGET_FPU           = ""
meta
meta-poky
meta-yocto-bsp       = "master:a9befd527e173a0b8d7e684691e287e5c1587baa"
meta-freertos        = "master:0033a5eb73c1f5ce5c005218dc870f6684fb2b5b"
```

Bitbake Multiconfig Builds

```
NOTE: Executing Tasks
Setscene tasks: 1319 of 1319
Currently  2 running tasks (3707 of 3728)  99% |################################################
0: freertos-demo-FreeRTOSv10.5.1+gitAUTOINC+391c79958f_4b08f3a14b-r0 do_fetch - 4s (pid 3857779)
1: mc:dummy-aarch64:core-image-minimal-1.0-r0 do_rootfs - 1s (pid 3857915)   3% |##
```

Bitbake Multiconfig Builds

```
└❯ ls tmp-qemuarm64-glibc/deploy/images/qemuarm64/
Image
Image--6.5.10+git0+e4aaaaddfa_e709bc7ca8-r0-qemuarm64-20231114055059.bin
Image-qemuarm64.bin
core-image-minimal-qemuarm64.rootfs-20231114150137.ext4
core-image-minimal-qemuarm64.rootfs-20231114150137.manifest
core-image-minimal-qemuarm64.rootfs-20231114150137.qemuboot.conf
core-image-minimal-qemuarm64.rootfs-20231114150137.spdx.tar.zst
core-image-minimal-qemuarm64.rootfs-20231114150137.tar.bz2
core-image-minimal-qemuarm64.rootfs-20231114150137.testdata.json
core-image-minimal-qemuarm64.rootfs.ext4
core-image-minimal-qemuarm64.rootfs.manifest
core-image-minimal-qemuarm64.rootfs.qemuboot.conf
```

```
└❯ ls  tmp/deploy/images/stm32f446/
freertos-image-stm32f446-20231011013148.manifest       freertos-image-stm32f446-20231114145216.testdata.json
freertos-image-stm32f446-20231011013148.qemuboot.conf  freertos-image-stm32f446.bin
freertos-image-stm32f446-20231011013148.testdata.json  freertos-image-stm32f446.elf
freertos-image-stm32f446-20231026060335.manifest       freertos-image-stm32f446.hex
freertos-image-stm32f446-20231026060335.qemuboot.conf  freertos-image-stm32f446.manifest
freertos-image-stm32f446-20231026060335.testdata.json  freertos-image-stm32f446.qemuboot.conf
freertos-image-stm32f446-20231114145216.manifest       freertos-image-stm32f446.testdata.json
freertos-image-stm32f446-20231114145216.qemuboot.conf
```

Testing

Testing multiple OSs

- Testing different OS can be done using OpenEmbedded infrastructure (to some extent)
  - Designed for Linux
  - Emulate expectations from other OS
  - Treated as separate builds
    - bitbake mc:big:core-image-minimal -c testimage
    - bitbake mc:small:baremetal-app -c testimage

Future

Closing thoughts

- Building your own cross toolchain provides some advantages
  - Newer versions
  - Quickly fixed vs Waiting for fix to cascade
- Vendor IDE may not use upstream toolchain
- Multiconfig requires manual configuration
  - Describes the build, not the system/product.
  - Can we describe the system?
- Complicated to integrate into vendor workflows
  - How can we integrate better?