Embedded Linux Conference
North America

Developing, Building and Testing Your Baremetal Applications Using The Yocto Project and OpenEmbedded Infrastructure

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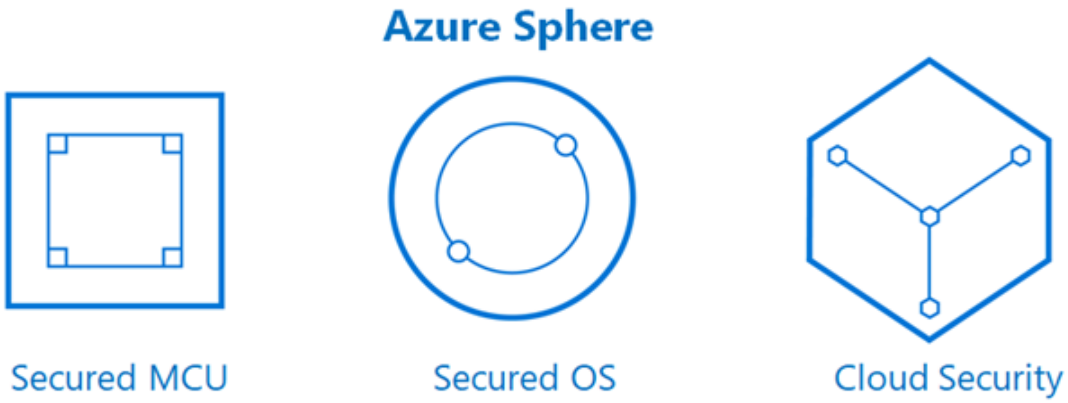
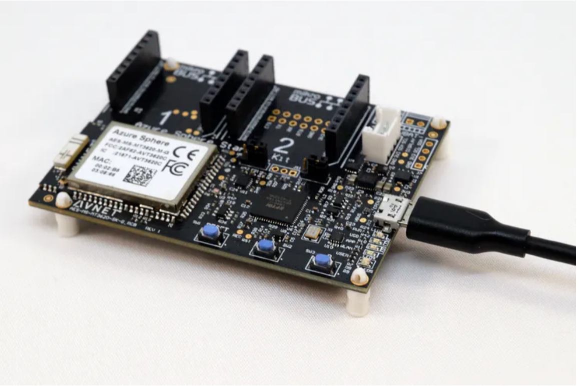
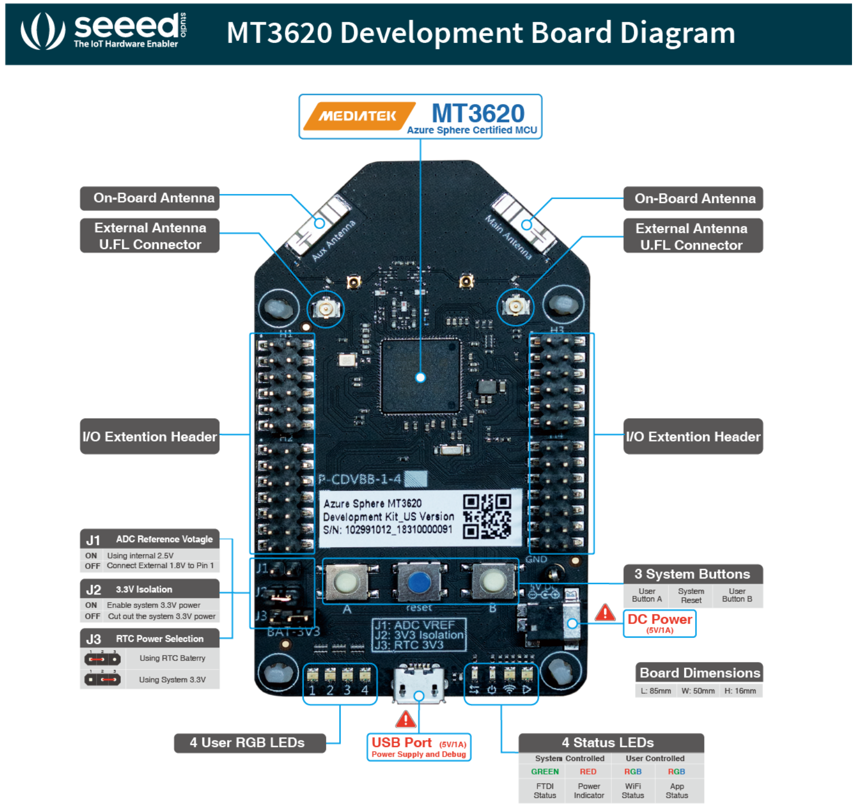
#lfelc

THE LINUX FOUNDATION

Multiarchitecture Embedded Devices



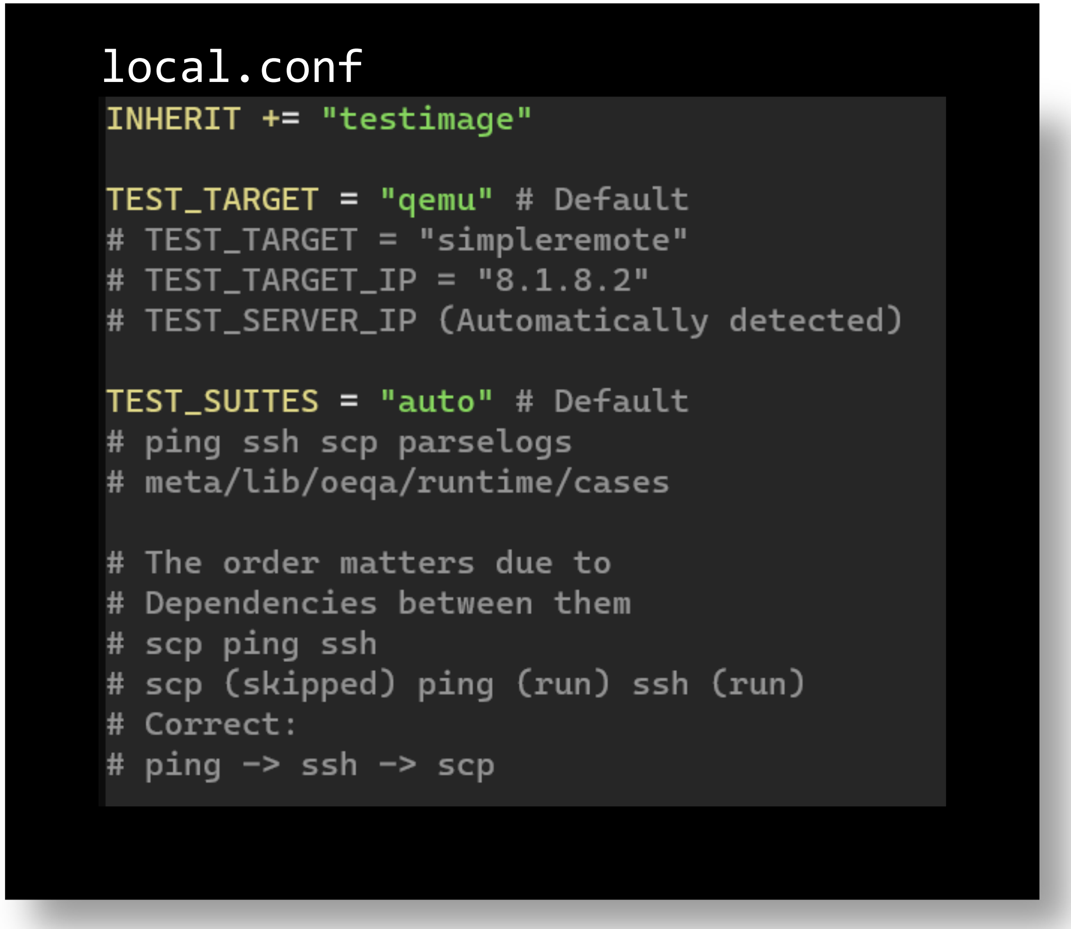




OpenEmbedded Runtime Testing Infrastructure

OpenEmbedded Runtime Testing Infrastructure

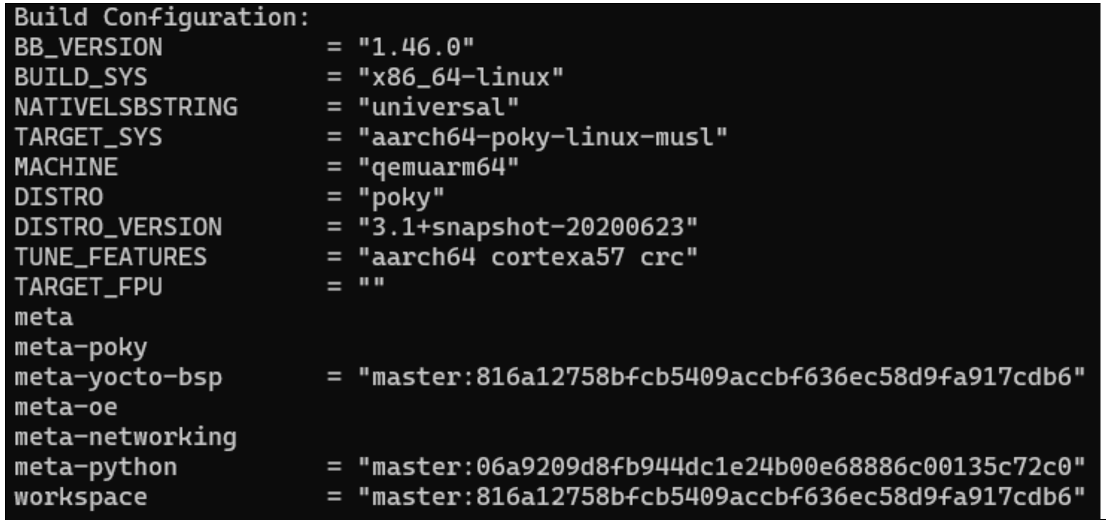
- Testing a Linux OS (Poky)
  - QEMU
  - Hardware



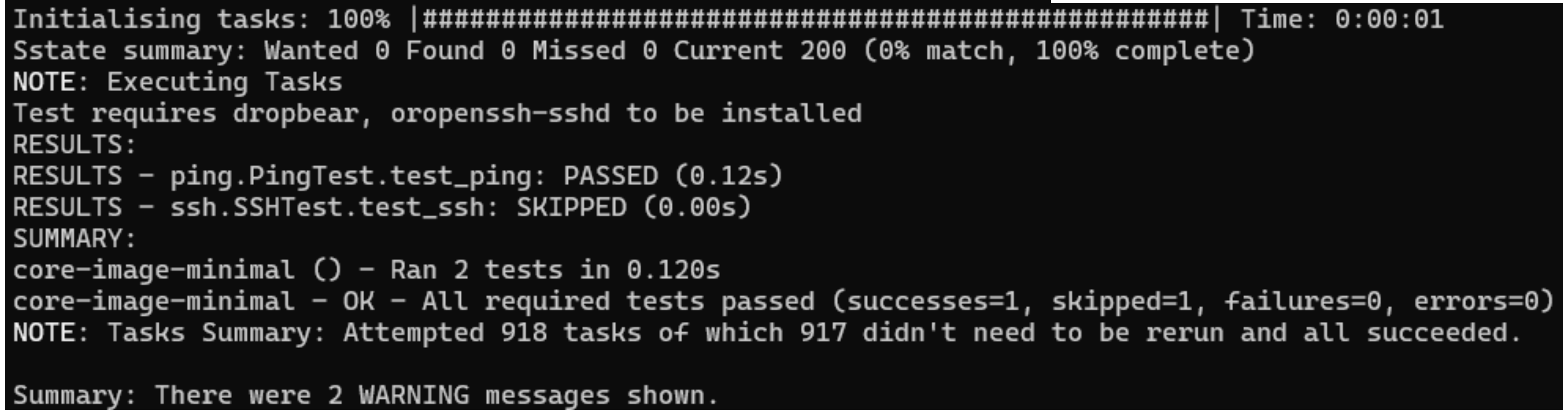
local.conf

```
INHERIT += "testimage"

TEST_TARGET = "qemu" # Default
# TEST_TARGET = "simpleremote"
# TEST_TARGET_IP = "8.1.8.2"
# TEST_SERVER_IP (Automatically detected)

TEST_SUITES = "auto" # Default
# ping ssh scp parselogs
# meta/lib/oeqa/runtime/cases

# The order matters due to
# Dependencies between them
# scp ping ssh
# scp (skipped) ping (run) ssh (run)
# Correct:
# ping -> ssh -> scp
```

OpenEmbedded Runtime Testing Infrastructure

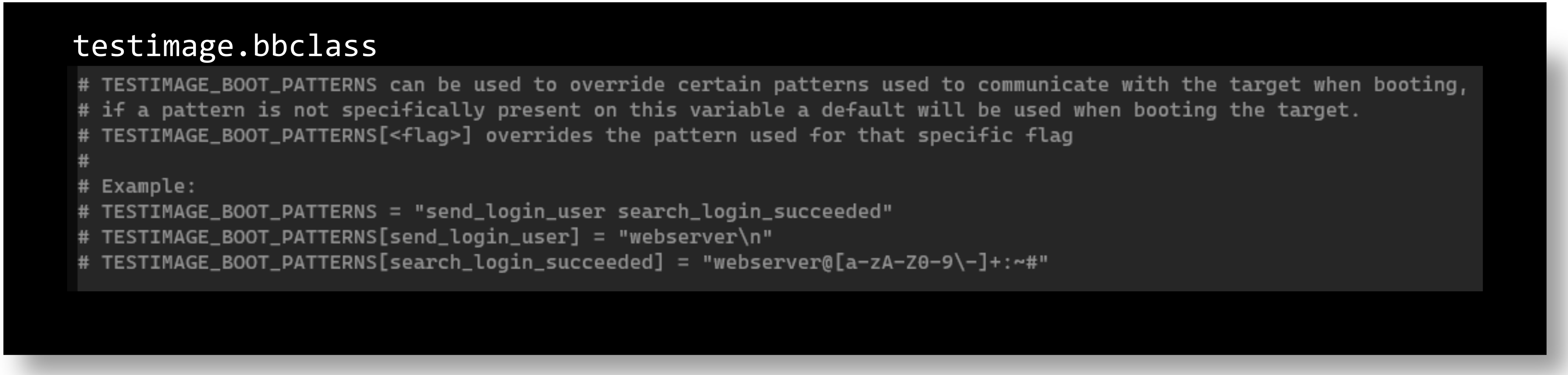


```
Build Configuration:
BB_VERSION           = "1.46.0"
BUILD_SYS            = "x86_64-linux"
NATIVELSBSTRING      = "universal"
TARGET_SYS           = "aarch64-poky-linux-musl"
MACHINE              = "qemuarm64"
DISTRO               = "poky"
DISTRO_VERSION       = "3.1+snapshot-20200623"
TUNE_FEATURES        = "aarch64 cortexa57 crc"
TARGET_FPU           = ""
meta
meta-poky
meta-yocto-bsp       = "master:816a12758bfcb5409accbf636ec58d9fa917cdb6"
meta-oe
meta-networking
meta-python          = "master:06a9209d8fb944dc1e24b00e68886c00135c72c0"
workspace            = "master:816a12758bfcb5409accbf636ec58d9fa917cdb6"
```



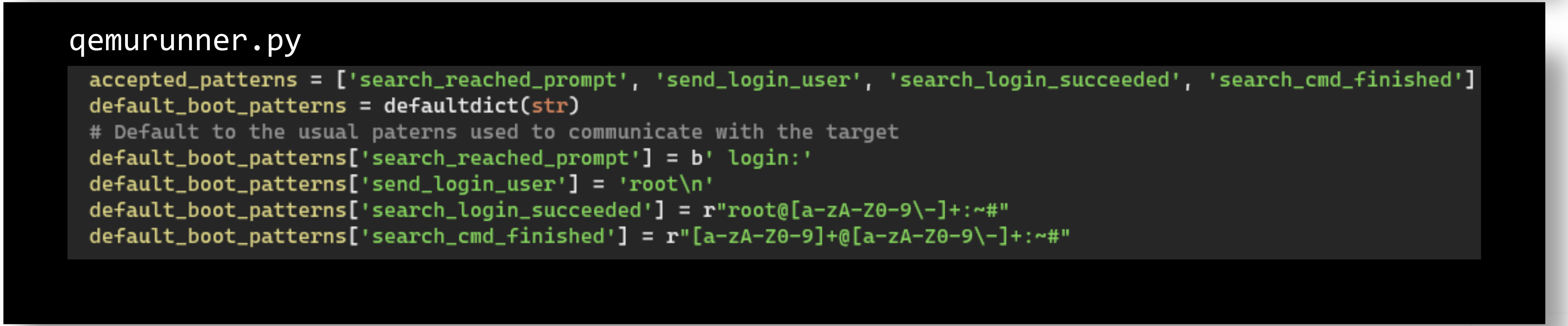
```
Initialising tasks: 100% |##################################################| Time: 0:00:01
Sstate summary: Wanted 0 Found 0 Missed 0 Current 200 (0% match, 100% complete)
NOTE: Executing Tasks
Test requires dropbear, oropenssh-sshd to be installed
RESULTS:
RESULTS - ping.PingTest.test_ping: PASSED (0.12s)
RESULTS - ssh.SSHTest.test_ssh: SKIPPED (0.00s)
SUMMARY:
core-image-minimal () - Ran 2 tests in 0.120s
core-image-minimal - OK - All required tests passed (successes=1, skipped=1, failures=0, errors=0)
NOTE: Tasks Summary: Attempted 918 tasks of which 917 didn't need to be rerun and all succeeded.

Summary: There were 2 WARNING messages shown.
```

TESTIMAGE_BOOT_PATTERNS in OE



testimage.bbclass

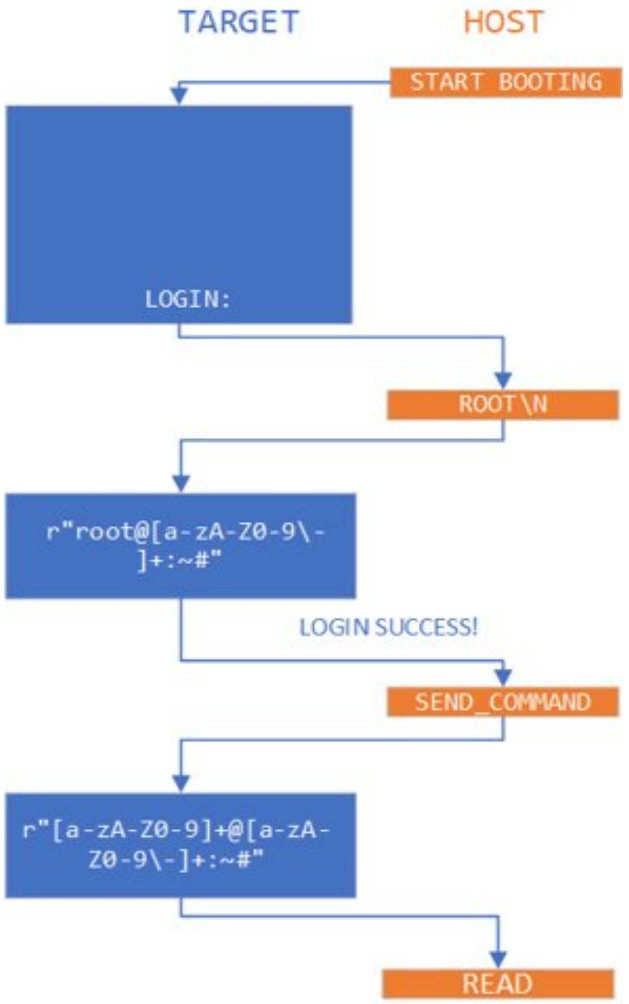
```
# TESTIMAGE_BOOT_PATTERNS can be used to override certain patterns used to communicate with the target when booting,
# if a pattern is not specifically present on this variable a default will be used when booting the target.
# TESTIMAGE_BOOT_PATTERNS[<flag>] overrides the pattern used for that specific flag
#
# Example:
# TESTIMAGE_BOOT_PATTERNS = "send_login_user search_login_succeeded"
# TESTIMAGE_BOOT_PATTERNS[send_login_user] = "webserver\n"
# TESTIMAGE_BOOT_PATTERNS[search_login_succeeded] = "webserver@[a-zA-Z0-9\-]+:~#"
```



qemurunner.py

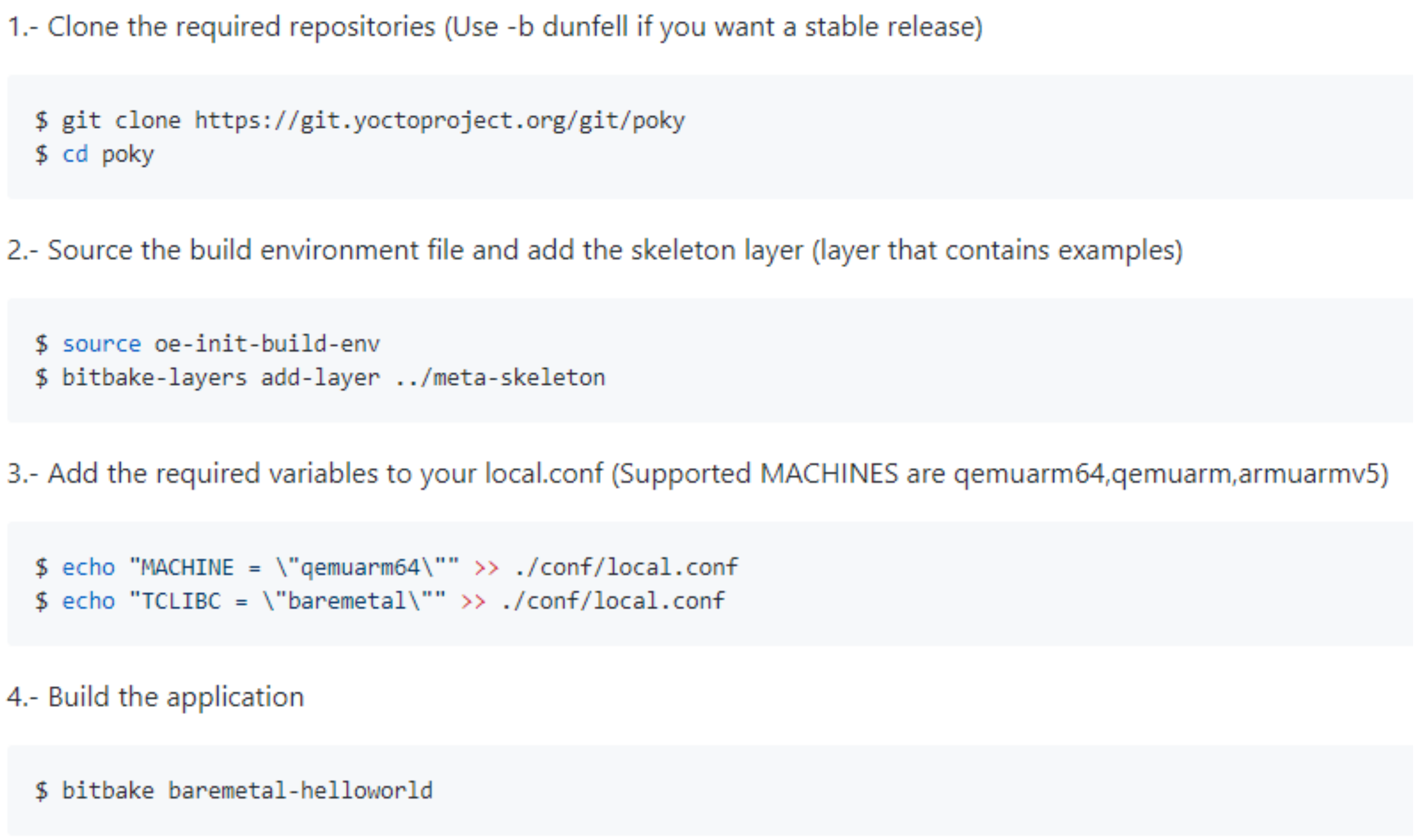
```
accepted_patterns = ['search_reached_prompt', 'send_login_user', 'search_login_succeeded', 'search_cmd_finished']
default_boot_patterns = defaultdict(str)
# Default to the usual paterns used to communicate with the target
default_boot_patterns['search_reached_prompt'] = b' login:'
default_boot_patterns['send_login_user'] = 'root\n'
default_boot_patterns['search_login_succeeded'] = r"root@[a-zA-Z0-9\-]+:~#"
default_boot_patterns['search_cmd_finished'] = r"[a-zA-Z0-9]+@[a-zA-Z0-9\-]+:~#"
```

Testimage flow



Baremetal Toolchains and Applications on The Yocto Project

Baremetal Toolchains on the Yocto Project



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

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

2.- Source the build environment file and add the skeleton layer (layer that contains examples)

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

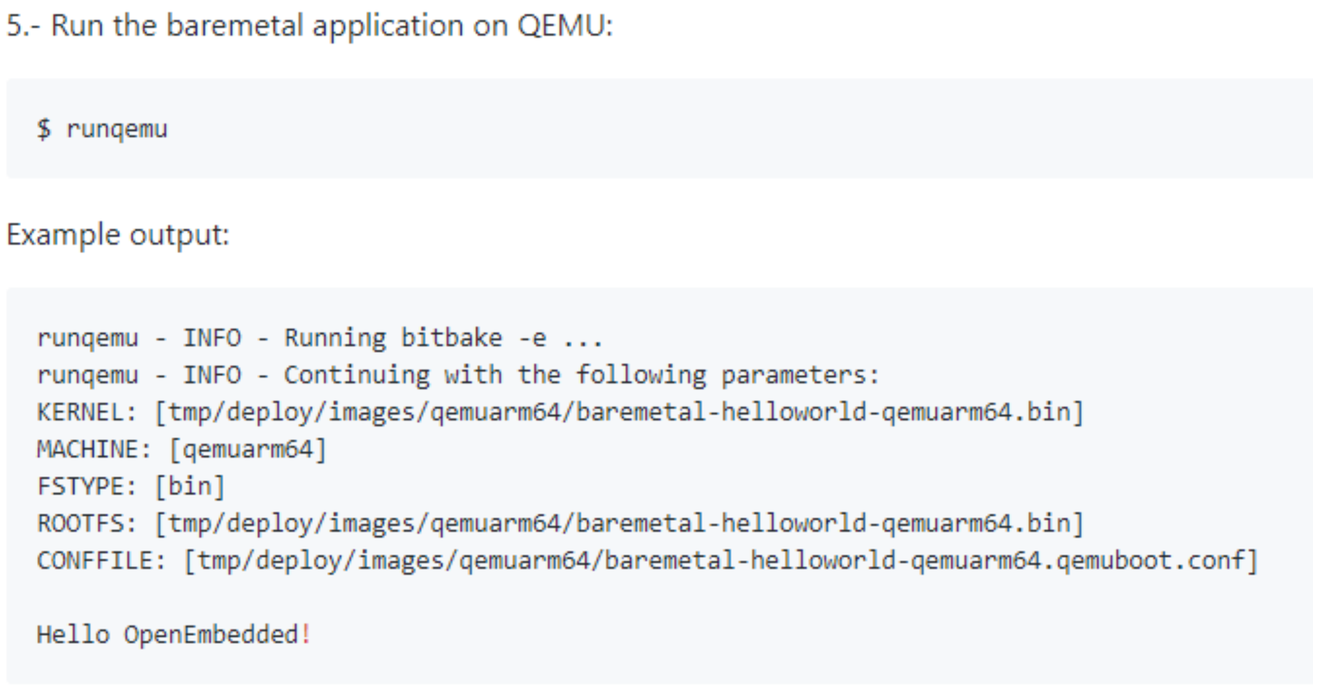
3.- Add the required variables to your local.conf (Supported MACHINES are qemuarm64,qemuarm,armuarmv5)

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

4.- Build the application

```
$ bitbake baremetal-helloworld
```

Baremetal Toolchains on the Yocto Project



5.- Run the baremetal application on QEMU:

```
$ runqemu
```

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!
```

Interesting targets:

- Meta-toolchain
- Baremetal-helloworld -c populate_sdk
- TCLIBC="newlib"

Simple Baremetal HelloWorld on Aarch64

- QEMU Source Code (Virt)
  - UART, RAM, Kernel Addresses
- ARM Developers Manual – UART PL011

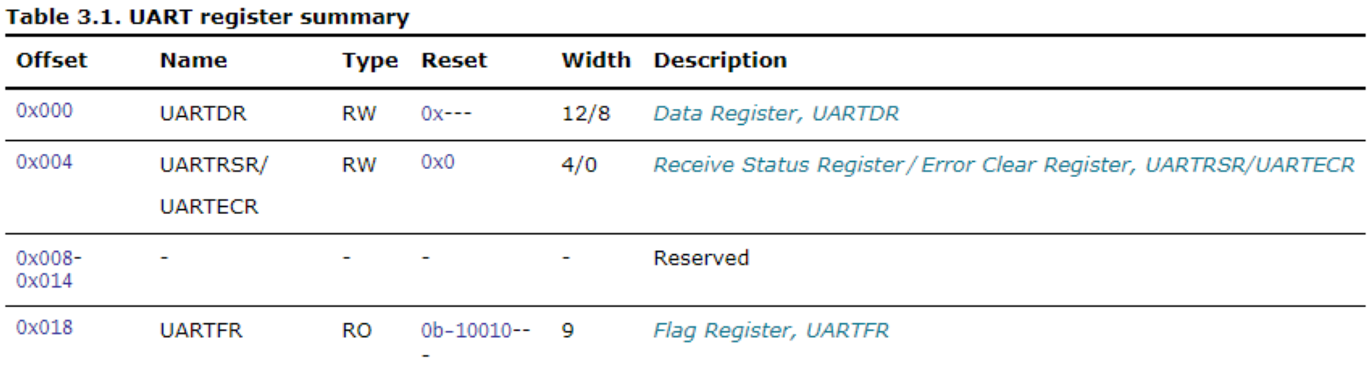


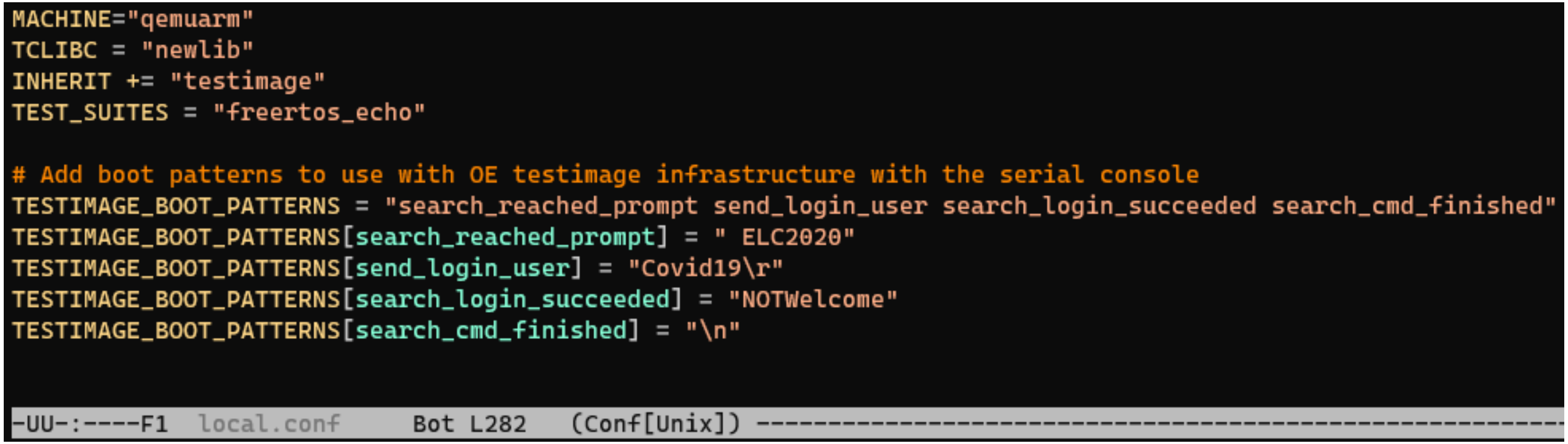
Table 3.1. UART register summary

Offset	Name	Type	Reset	Width	Description
0x000	UARTDR	RW	0x---	12/8	*Data Register, UARTDR*
0x004	UARTRSR/UARTECR	RW	0x0	4/0	*Receive Status Register / Error Clear Register, UARTRSR/UARTECR*
0x008-0x014	-	-	-	-	Reserved
0x018	UARTFR	RO	0b-10010---	9	*Flag Register, UARTFR*

- Startup Code, Linker Script

TESTIMAGE_BOOT_PATTERNS in OE

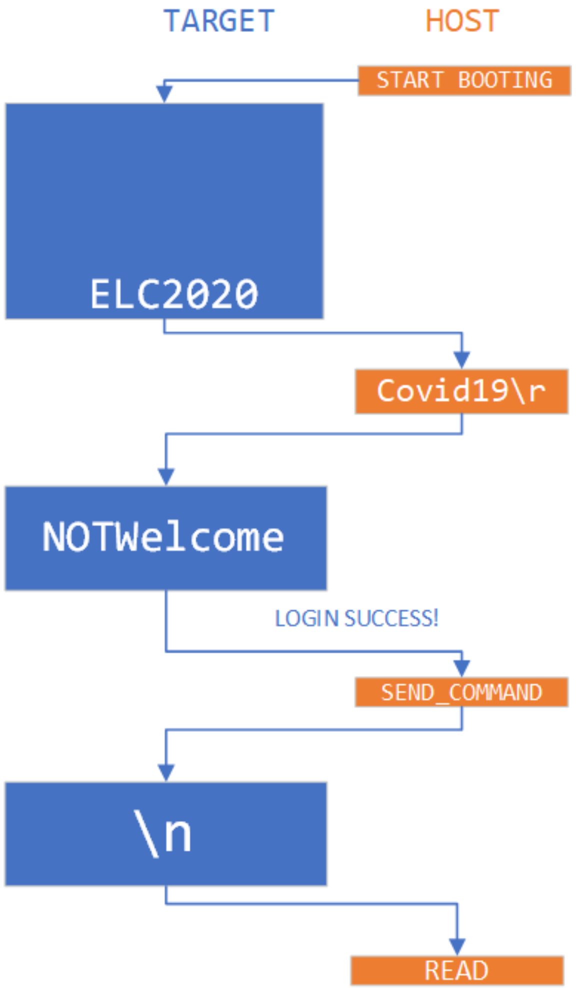
- Overriding Patterns



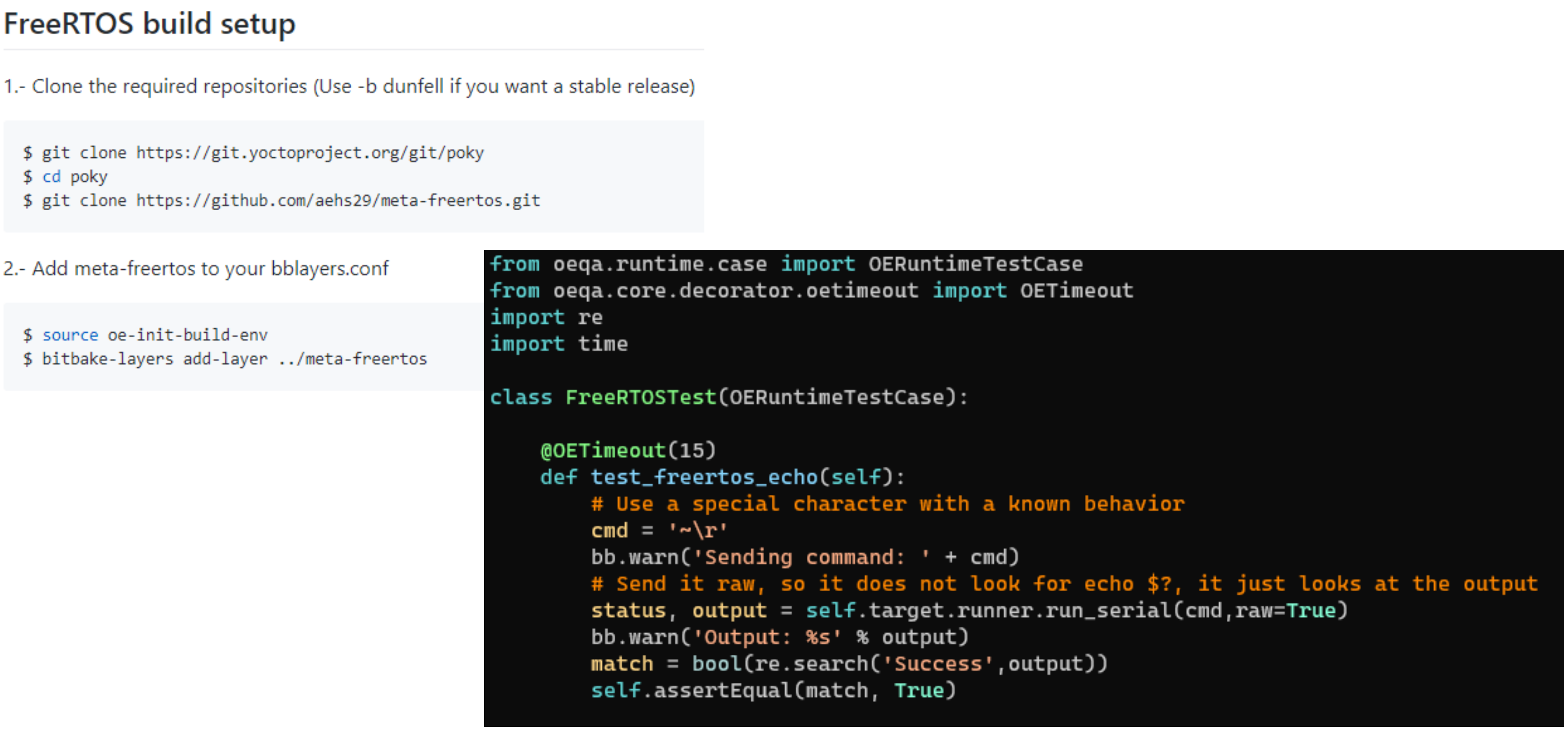
```
MACHINE="qemuarm"
TCLIBC = "newlib"
INHERIT += "testimage"
TEST_SUITES = "freertos_echo"

# Add boot patterns to use with OE testimage infrastructure with the serial console
TESTIMAGE_BOOT_PATTERNS = "search_reached_prompt send_login_user search_login_succeeded search_cmd_finished"
TESTIMAGE_BOOT_PATTERNS[search_reached_prompt] = " ELC2020"
TESTIMAGE_BOOT_PATTERNS[send_login_user] = "Covid19\r"
TESTIMAGE_BOOT_PATTERNS[search_login_succeeded] = "NOTWelcome"
TESTIMAGE_BOOT_PATTERNS[search_cmd_finished] = "\n"


-UU-:----F1  local.conf      Bot L282    (Conf[Unix]) ------------------------------------------------
```

TESTIMAGE_BOOT_PATTERNS in OE

- Overriding Patterns



Creating a Test Case



FreeRTOS build setup

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

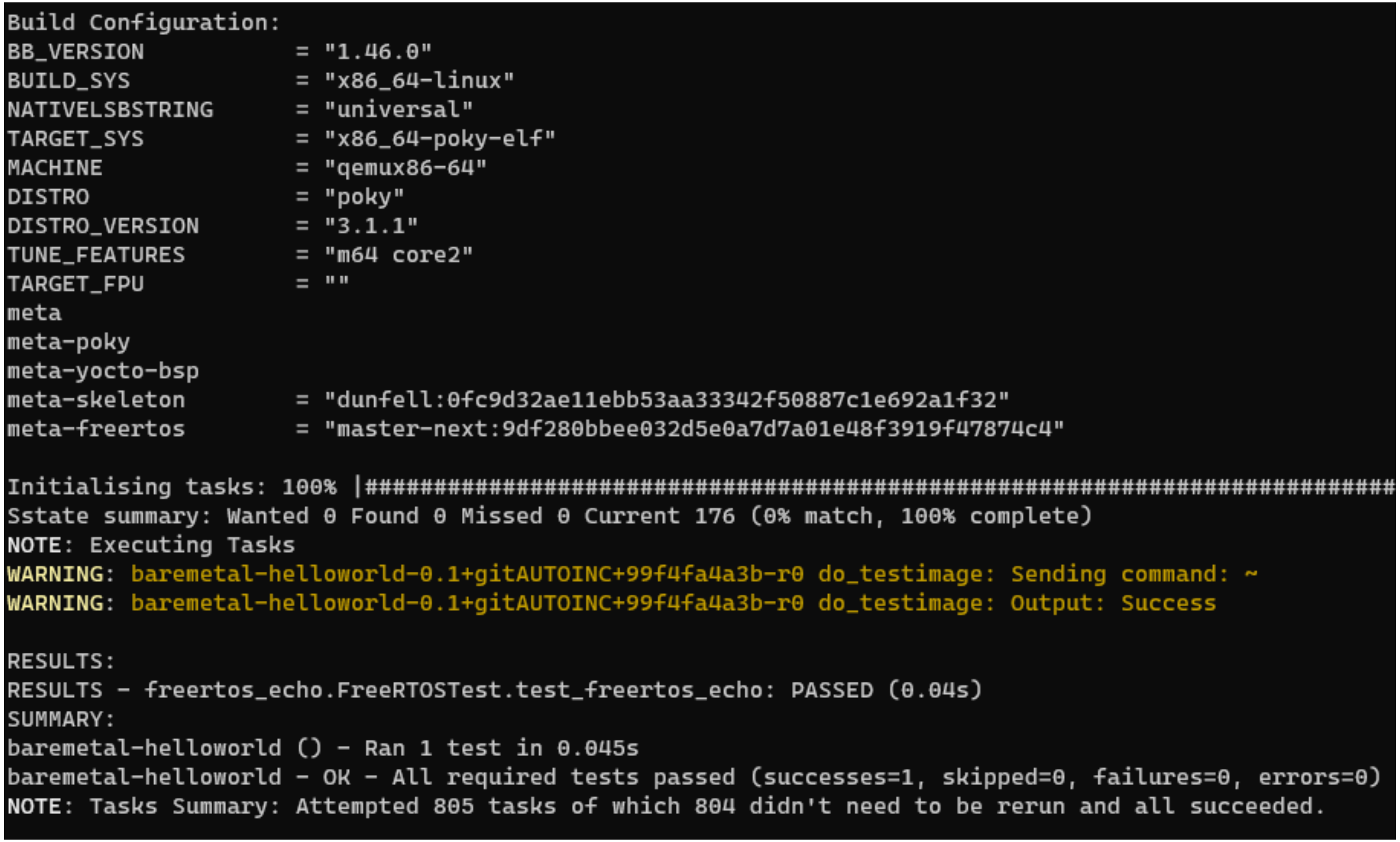
```
$ git clone https://git.yoctoproject.org/git/poky
$ cd poky
$ git clone https://github.com/aehs29/meta-freertos.git
```

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

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

```
from oeqa.runtime.case import OERuntimeTestCase
from oeqa.core.decorator.oetimeout import OETimeout
import re
import time

class FreeRTOSTest(OERuntimeTestCase):

    @OETimeout(15)
    def test_freertos_echo(self):
        # Use a special character with a known behavior
        cmd = '~\r'
        bb.warn('Sending command: ' + cmd)
        # Send it raw, so it does not look for echo $?, it just looks at the output
        status, output = self.target.runner.run_serial(cmd,raw=True)
        bb.warn('Output: %s' % output)
        match = bool(re.search('Success',output))
        self.assertEqual(match, True)
```

Testing



```
Build Configuration:
BB_VERSION           = "1.46.0"
BUILD_SYS            = "x86_64-linux"
NATIVELSBSTRING      = "universal"
TARGET_SYS           = "x86_64-poky-elf"
MACHINE              = "qemux86-64"
DISTRO               = "poky"
DISTRO_VERSION       = "3.1.1"
TUNE_FEATURES        = "m64 core2"
TARGET_FPU           = ""
meta
meta-poky
meta-yocto-bsp
meta-skeleton        = "dunfell:0fc9d32ae11ebb53aa33342f50887c1e692a1f32"
meta-freertos        = "master-next:9df280bbee032d5e0a7d7a01e48f3919f47874c4"

Initialising tasks: 100% |###########################################################################
Sstate summary: Wanted 0 Found 0 Missed 0 Current 176 (0% match, 100% complete)
NOTE: Executing Tasks
WARNING: baremetal-helloworld-0.1+gitAUTOINC+99f4fa4a3b-r0 do_testimage: Sending command: ~
WARNING: baremetal-helloworld-0.1+gitAUTOINC+99f4fa4a3b-r0 do_testimage: Output: Success

RESULTS:
RESULTS - freertos_echo.FreeRTOSTest.test_freertos_echo: PASSED (0.04s)
SUMMARY:
baremetal-helloworld () - Ran 1 test in 0.045s
baremetal-helloworld - OK - All required tests passed (successes=1, skipped=0, failures=0, errors=0)
NOTE: Tasks Summary: Attempted 805 tasks of which 804 didn't need to be rerun and all succeeded.
```

Thanks!

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