



Εθνικό Μετσόβιο Πολυτεχνείο

Σχολή Ηλεκτρολόγων Μηχανικών και Μηχανικών Υπολογιστών

## **Εργαστήριο Λειτουργικών Συστημάτων**

### **2<sup>η</sup> Εργαστηριακή Άσκηση, Linux:TNG (Εικονική Μηχανή Utopia)**

ΟΜΑΔΑ: oslab10

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Έχουμε configur-άρει και “στήσει” την εικονική μηχανή **utopia** σε Debian based host μηχανήμα (Ubuntu 22.04.1 LTS x86\_64).

Ξεκινάμε την εικονική μηχανή όπως φαίνεται παρακάτω:

```
angelos@desktop:~$ cd utopia
angelos@desktop:~/utopia$ ls
cslab_rootfs_20221102-0.raw  private.qcow2  shared  utopia.config  utopia.sh
angelos@desktop:~/utopia$ ./utopia.sh

*** Reading configuration

UTOPIA_CONFIG=./utopia.config

*** Checking configuration

QCOW2_PRIVATE_FILE=./private.qcow2
QCOW2_BACKING_FILE=./cslab_rootfs_20221102-0.raw
SHARED_FS_DIR=./shared
Ensuring shared directory './shared' exists

*** Starting your Virtual Machine ...

To connect with X2Go: See below for SSH settings
To connect with SSH: ssh -p 22223 root@localhost
To connect with vncviewer: vncviewer localhost:0
```

, και συνδεόμαστε σε αυτήν ως **root** μέσω ssh από ένα άλλο terminal:

```
angelos@desktop:~/utopia$ ssh -p 22223 root@localhost
root@localhost's password:
Linux utopia 5.10.0-19-amd64 #1 SMP Debian 5.10.149-2 (2022-10-21) x86_64

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Tue Nov  8 12:15:00 2022 from 10.0.2.2
root@utopia:~#
```

Συνδεόμαστε ξανά από ένα άλλο terminal ως απλός χρήστης (**user**) με τον ίδιο τρόπο:

```
angelos@desktop:~/utopia$ ssh -p 22223 user@localhost
user@localhost's password:
Linux utopia 5.10.0-19-amd64 #1 SMP Debian 5.10.149-2 (2022-10-21) x86_64

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
You have new mail.
Last login: Fri Nov  4 14:08:23 2022 from 10.0.2.2
user@utopia:~$
```

Αυτό το κάνουμε, διότι θα θέλουμε αργότερα να έχουμε ορισμένα τερματικά ανοιχτά για να παρακολουθούμε τα αρχεία καταγραφής του πυρήνα (**logs**) όταν προσθαφαιρούμε modules, για να κάνουμε debugging κ.λπ..

Τώρα, αφού έχουμε συνδεθεί, μεταγλωττίζουμε το “helpcode” που μας δίνεται με χρήση της εντολής make και του παρεχόμενου **Makefile**:

```
user@utopia:~/shared/linux-tng$ ls
Makefile      linux-chrdev.h  linux-module.c  linux-sensors.c  mk-linux-devs.sh
linux-attach.c linux-ldisc.c   linux-protocol.c linux-tcp.sh      mk-linux-lookup.c
linux-chrdev.c linux-ldisc.h   linux-protocol.h linux.h
user@utopia:~/shared/linux-tng$ make
gcc -Wall -Werror -o mk-linux-lookup mk-linux-lookup.c -lm
./mk-linux-lookup >linux-lookup.h
make -C /lib/modules/5.10.0-19-amd64/build M=/home/user/shared/linux-tng modules
make[1]: Entering directory '/usr/src/linux-headers-5.10.0-19-amd64'
  CC [M] /home/user/shared/linux-tng/linux-module.o
  CC [M] /home/user/shared/linux-tng/linux-chrdev.o
  CC [M] /home/user/shared/linux-tng/linux-ldisc.o
  CC [M] /home/user/shared/linux-tng/linux-protocol.o
  CC [M] /home/user/shared/linux-tng/linux-sensors.o
  LD [M] /home/user/shared/linux-tng/linux.o
  MODPOST /home/user/shared/linux-tng/Module.symvers
  CC [M] /home/user/shared/linux-tng/linux.mod.o
  LD [M] /home/user/shared/linux-tng/linux.ko
make[1]: Leaving directory '/usr/src/linux-headers-5.10.0-19-amd64'
gcc -Wall -Werror -o linux-attach linux-attach.c
user@utopia:~/shared/linux-tng$ ls
Makefile      linux-chrdev.o  linux-module.o  linux-tcp.sh  linux.o
Module.symvers linux-ldisc.c   linux-protocol.c linux.h        mk-linux-devs.sh
linux-attach  linux-ldisc.h   linux-protocol.h linux.ko       mk-linux-lookup
linux-attach.c linux-ldisc.o   linux-protocol.o linux.mod      mk-linux-lookup.c
linux-chrdev.c linux-lookup.h  linux-sensors.c  linux.mod.c   modules.order
linux-chrdev.h linux-module.c  linux-sensors.o  linux.mod.o
```

Στην συνέχεια, αναβαθμίζουμε τα δικαιώματά μας σε root και φορτώνουμε το module **linux.ko** στον πυρήνα με χρήση της εντολής **insmod**:

```
user@utopia:~/shared/linux-tng$ su -
Password:
root@utopia:~# cd ~user/shared/linux-tng
root@utopia:/home/user/shared/linux-tng# insmod ./linux.ko
```

Αποδεικνύεται ότι το module είναι φορτωμένο:

```
root@utopia:/home/user/shared/linux-tng# lsmod | grep linux
linux                1589248  0
```

, καθώς και από τα logs του πυρήνα με χρήση της εντολής **cat /var/log/kern.log**:

```
Nov 8 12:31:34 utopia kernel: [ 961.982105] linux: loading out-of-tree module taints kernel.
Nov 8 12:31:34 utopia kernel: [ 961.982555] linux: module verification failed: signature and/or required key missing - tainting kernel
Nov 8 12:31:34 utopia kernel: [ 961.983631] Initializing the Linux:TNG module [max 16 sensors]
Nov 8 12:31:34 utopia kernel: [ 961.983633] linux_module_init: initializing sensor 0
Nov 8 12:31:34 utopia kernel: [ 961.983635] linux_module_init: initialized sensor 0, ret = 0
Nov 8 12:31:34 utopia kernel: [ 961.983636] linux_module_init: initializing sensor 1
Nov 8 12:31:34 utopia kernel: [ 961.983637] linux_module_init: initialized sensor 1, ret = 0
Nov 8 12:31:34 utopia kernel: [ 961.983637] linux_module_init: initializing sensor 2
Nov 8 12:31:34 utopia kernel: [ 961.983639] linux_module_init: initialized sensor 2, ret = 0
Nov 8 12:31:34 utopia kernel: [ 961.983639] linux_module_init: initializing sensor 3
Nov 8 12:31:34 utopia kernel: [ 961.983641] linux_module_init: initialized sensor 3, ret = 0
Nov 8 12:31:34 utopia kernel: [ 961.983641] linux_module_init: initializing sensor 4
Nov 8 12:31:34 utopia kernel: [ 961.983643] linux_module_init: initialized sensor 4, ret = 0
Nov 8 12:31:34 utopia kernel: [ 961.983643] linux_module_init: initializing sensor 5
Nov 8 12:31:34 utopia kernel: [ 961.983644] linux_module_init: initialized sensor 5, ret = 0
Nov 8 12:31:34 utopia kernel: [ 961.983645] linux_module_init: initializing sensor 6
Nov 8 12:31:34 utopia kernel: [ 961.983647] linux_module_init: initialized sensor 6, ret = 0
Nov 8 12:31:34 utopia kernel: [ 961.983647] linux_module_init: initializing sensor 7
Nov 8 12:31:34 utopia kernel: [ 961.983649] linux_module_init: initialized sensor 7, ret = 0
Nov 8 12:31:34 utopia kernel: [ 961.983650] linux_module_init: initializing sensor 8
Nov 8 12:31:34 utopia kernel: [ 961.983664] linux_module_init: initialized sensor 8, ret = 0
Nov 8 12:31:34 utopia kernel: [ 961.983665] linux_module_init: initializing sensor 9
Nov 8 12:31:34 utopia kernel: [ 961.983667] linux_module_init: initialized sensor 9, ret = 0
Nov 8 12:31:34 utopia kernel: [ 961.983668] linux_module_init: initializing sensor 10
Nov 8 12:31:34 utopia kernel: [ 961.983670] linux_module_init: initialized sensor 10, ret = 0
```



```

Nov 8 12:31:34 utopia kernel: [ 961.983670] linux_module_init: initializing sensor 11
Nov 8 12:31:34 utopia kernel: [ 961.983672] linux_module_init: initialized sensor 11, ret = 0
Nov 8 12:31:34 utopia kernel: [ 961.983673] linux_module_init: initializing sensor 12
Nov 8 12:31:34 utopia kernel: [ 961.983683] linux_module_init: initialized sensor 12, ret = 0
Nov 8 12:31:34 utopia kernel: [ 961.983684] linux_module_init: initializing sensor 13
Nov 8 12:31:34 utopia kernel: [ 961.983686] linux_module_init: initialized sensor 13, ret = 0
Nov 8 12:31:34 utopia kernel: [ 961.983687] linux_module_init: initializing sensor 14
Nov 8 12:31:34 utopia kernel: [ 961.983688] linux_module_init: initialized sensor 14, ret = 0
Nov 8 12:31:34 utopia kernel: [ 961.983689] linux_module_init: initializing sensor 15
Nov 8 12:31:34 utopia kernel: [ 961.983690] linux_module_init: initialized sensor 15, ret = 0
Nov 8 12:31:34 utopia kernel: [ 961.983690] linux_ldisc_init: initializing linux_ldisc
Nov 8 12:31:34 utopia kernel: [ 961.983691] linux_ldisc_init: leaving with ret = 0
Nov 8 12:31:34 utopia kernel: [ 961.983692] linux_chrdev_init: initializing character device

```

Στην συνέχεια, ενεργοποιούμε την είσοδο δεδομένων από τη σειριακή θύρα `/dev/ttyS1` (με `linux-attach`), που έχει ανακατευθυνθεί στην θύρα `TCP linux.cslab.ece.ntua.gr:49152`, όπου και έρχονται συνεχώς μετρήσεις από τον σταθμό βάσης.

```

root@utopia:/home/user/shared/linux-tng# ./linux-attach /dev/ttyS1
tty_open: looking for lock
tty_open: trying to open /dev/ttyS1
tty_open: /dev/ttyS1 (fd=3) Line discipline set on /dev/ttyS1, press ^C to release the TTY...

```

Βλέποντας πάλι τα logs του πυρήνα (τρέχοντας `less /var/log/kern.log` και πατώντας `Shift-f`), παρατηρούμε ότι το στρώμα συλλογής δεδομένων είναι λειτουργικό:

```

Nov 8 12:58:11 utopia kernel: [ 2558.728462] linux_ldisc_receive_buf: called, 4 characters have been received. Data at *cp: { 0x7e, 0x42, 0x7d, 0x5e }
Nov 8 12:58:11 utopia kernel: [ 2558.731353] linux_ldisc_receive_buf: called, 9 characters have been received. Data at *cp: { 0x00, 0xfd, 0x8e, 0x02, 0x00, 0x00, 0x00, 0x00 }
Nov 8 12:58:11 utopia kernel: [ 2558.731361] linux_protocol_received_buf: A complete XMesh packet has been received, updating sensors
Nov 8 12:58:11 utopia kernel: [ 2559.026333] linux_ldisc_receive_buf: called, 3 characters have been received. Data at *cp: { 0x7e, 0x42, 0x7d }
Nov 8 12:58:11 utopia kernel: [ 2559.029147] linux_ldisc_receive_buf: called, 15 characters have been received. Data at *cp: { 0x5e, 0x00, 0x0b, 0x8e, 0x00 }
Nov 8 12:58:11 utopia kernel: [ 2559.033277] linux_ldisc_receive_buf: called, 20 characters have been received. Data at *cp: { 0x00, 0x7a, 0x01, 0xd3, 0x01, 0x8e, 0x01, 0x03, 0x17, 0x7e }
Nov 8 12:58:11 utopia kernel: [ 2559.033283] linux_protocol_received_buf: A complete XMesh packet has been received, updating sensors
Nov 8 12:58:11 utopia kernel: [ 2559.033284] linux_protocol_update_sensors: I have the following raw data from nodeid = 2: { batt, temp, light } = { 0x00, 0x00, 0x00 }
Nov 8 12:58:12 utopia kernel: [ 2560.246224] linux_ldisc_receive_buf: called, 2 characters have been received. Data at *cp: { 0x7e, 0x42 }
Nov 8 12:58:12 utopia kernel: [ 2560.249338] linux_ldisc_receive_buf: called, 15 characters have been received. Data at *cp: { 0x7d, 0x5e, 0x00, 0x0b, 0x81 }
Nov 8 12:58:12 utopia kernel: [ 2560.253356] linux_ldisc_receive_buf: called, 20 characters have been received. Data at *cp: { 0x00, 0x00, 0x7d, 0x5e, 0x01, 0xb9, 0x01, 0xa4, 0x01, 0xbd }
Nov 8 12:58:12 utopia kernel: [ 2560.257649] linux_ldisc_receive_buf: called, 2 characters have been received. Data at *cp: { 0xb4, 0x7e }
Nov 8 12:58:12 utopia kernel: [ 2560.257653] linux_protocol_received_buf: A complete XMesh packet has been received, updating sensors
Nov 8 12:58:12 utopia kernel: [ 2560.257655] linux_protocol_update_sensors: I have the following raw data from nodeid = 1: { batt, temp, light } = { 0x00, 0x00, 0x00 }
Nov 8 12:58:13 utopia kernel: [ 2560.833211] linux_ldisc_receive_buf: called, 3 characters have been received. Data at *cp: { 0x7e, 0x42, 0x7d }
Nov 8 12:58:13 utopia kernel: [ 2560.837563] linux_ldisc_receive_buf: called, 20 characters have been received. Data at *cp: { 0x5e, 0x00, 0x0b, 0x8e, 0x00, 0x00, 0x7a, 0x01, 0xd3, 0x01 }
Nov 8 12:58:13 utopia kernel: [ 2560.841208] linux_ldisc_receive_buf: called, 15 characters have been received. Data at *cp: { 0x36, 0x00, 0x38, 0x01, 0x7e }
Nov 8 12:58:13 utopia kernel: [ 2560.841216] linux_protocol_received_buf: A complete XMesh packet has been received, updating sensors
Nov 8 12:58:13 utopia kernel: [ 2560.841218] linux_protocol_update_sensors: I have the following raw data from nodeid = 2: { batt, temp, light } = { 0x00, 0x00, 0x00 }
Waiting for data... (interrupt to abort)

```

, αφού συνέχεια φαίνεται ότι λαμβάνονται δεδομένα.

Τέλος, τερματίζουμε την εικονική μηχανή:

```

root@utopia:/home/user/shared/linux-tng# poweroff
Connection to localhost closed by remote host.
Connection to localhost closed.
angelos@desktop:~/utopia$

```