The first Algerian Linux distribution

FennecOS

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2. The Setup Environment
3. Building
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5. Testing our Machines with Jenkins & sshpass

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Who we are !

- AZIL Hamza
- Embedded System/Linux Engeneer
- C/C++ developper
- Chess, cooking and comedy
- https://github.com/hamzastar7
- feel free to email me on `azilhamza@gmail.com`

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Who we are !

- HADJAZI Mohammed Hisham
- Master's in CS, specialized in Networks and Security
- Network/System Admin at ESI SBA
- Addicted to Containers and Kubernetes
- https://github.com/the6wheels

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2 The Setup Environment
- Work Station Hamza
- Work Station Hisham

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1 Introduction

2 The Setup Environment
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- Debian12 (kernel6.1) in DualBoot with ubuntu20.04.6 LTS(kernel5.15)
- build-essentiel, asciinema, screen
- QEMU (x86_64 & arch)

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- Ubuntu 20.04.6 LTS.
- Virtual Box 6.1.
  - VM with live disto of Ubuntu 20.04.6 LTS (8 cores 24GB RAM) with openssh-server.
- Jenkins for tests automation.
- sshpass for ssh automation.
- Ansible and Ansible modules for shell script automation.

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- HelloWorld!
- Linux From Scratch

4 Productions VMs

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2 The Setup Environment

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HelloWorld

When I wanted to create my OS from scratch for the first time, my question was **"where all of this started?"** How to make every piece of the OS and how understand what it does. I wanted to launch a HelloWorld instead of the kernel, and to make this possible, I went through a simple HelloWorld example.

```
hamza@FennecHOST: ~/hello 105x24
hamza@FennecHOST:~/hello$ cat hello.c
#include<stdio.h>
int main(int , char **){

printf("\nSALAM ALYKOM\n");

sleep(9999999);
}
hamza@FennecHOST:~/hello$ gcc -o init hello.c --static -w
hamza@FennecHOST:~/hello$ file init
file: Compiled magic version [545] does not match with shared library magic version

init: ELF 64-bit LSB executable, x86-64, version 1 (GNU/Linux), statically linked,
ec31c613cab0c6eeb5c49e26c8d6ea27, for GNU/Linux 3.2.0, not stripped
hamza@FennecHOST:~/hello$
```

HelloWorld!

we compile the hello to init (the kernel recognize as a starting point)

```
hamza@FennecHOST:~/hello$ find . | cpio -o -H newc | gzip > hello_rmfs.cpio.gz
12550 blocks
```

we will emulate the result with QEMU

```
[    1.852398] netconsole: network logging started
[    1.853351] cfg80211: Loading compiled-in X.509 certificates for regulatory database
[    1.859804] kworker/u4:0 (48) used greatest stack depth: 15032 bytes left
[    1.868045] Loaded X.509 cert 'sforshee: 00b28ddf47aef9cea7'
[    1.868703] Loaded X.509 cert 'wens: 61c038651aabdcf94bd0ac7ff06c7248db18c600'
[    1.869541] ALSA device list:
[    1.870696]   No soundcards found.
[    1.871740] platform regulatory.0: Direct firmware load for regulatory.db failed with error -2
[    1.872101] cfg80211: failed to load regulatory.db
[    1.937314] Freeing unused kernel image (initmem) memory: 2764K
[    1.937746] Write protecting the kernel read-only data: 26624k
[    1.939301] Freeing unused kernel image (rodata/data gap) memory: 1184K
[    2.099485] x86/mm: Checked W+X mappings: passed, no W+X pages found.
[    2.100221] tsc: Refined TSC clocksource calibration: 2903.983 MHz
[    2.100613] clocksource: tsc: mask: 0xffffffffffffffff max_cycles: 0x29dbf5a3d38, max_idle_ns: 44079525155
[    2.100883] clocksource: Switched to clocksource tsc
[    2.101237] Run /init as init process

SALAM ALYKOM
[    2.311025] input: ImExPS/2 Generic Explorer Mouse as /devices/platform/i8042/serio1/input/input3

tsl                                                    hamza@FennecHOST: ~/hello 100x1
hamza@FennecHOST:~/hello$ sudo kill $(pgrep qemu)
```

minimal

from this point we wanted to create a very basic rootfs that could rebuild it self from source we found that for installing a basic linux system that can build it self from the code source we need about 7 packages: linux(kernel), busybox, uClibc, gcc, binutils, make & bash

Building Linux Kernel

we get the latest code source from github at linus trovad repo:
then we clone it

```
hamza@FennecHOST:~$ git clone https://github.com/torvalds/linux.git
fatal: destination path 'linux' already exists and is not an empty directory.
hamza@FennecHOST:~$ cd linux
hamza@FennecHOST:~/linux$ make menuconfig
```

```
*** End of the configuration.
*** Execute 'make' to start the build or try 'make help'.
```

```
.config - Linux/x86 6.12.0-rc1 Kernel Configuration
  Debugging kernel
                                General setup
  Arrow keys navigate the menu.  <Enter> selects submenus ---> (or empty submenus ----).  Highlighted letters are hotkeys.  Pressing
  excludes, <M> modularizes features.  Press <Esc><Esc> to exit, <?> for Help, </> for Search.  Legend: [*] built-in  [ ] excluded  <
  module capable

        [ ] Compile also drivers which will not load
        [ ] Compile the kernel with warnings as errors
        () Local version - append to kernel release
        [*] Automatically append version information to the version string
        () Build ID Salt
            Kernel compression mode (Gzip)  --->
        () Default init path
        ((none)) Default hostname
        [*] System V IPC
        [*] POSIX Message Queues
        [ ] General notification queue
        [*] Enable process_vm_readv/writev syscalls
        [ ] uselib syscall (for libc5 and earlier)
        [*] Auditing support
            IRQ subsystem  --->
            Timers subsystem  --->
            BPF subsystem  --->
            Preemption Model (Voluntary Kernel Preemption (Desktop))  --->
```

Configuring the Kernel

```
[*] CPU isolation
    RCU Subsystem  --->
< > Kernel .config support
<M> Enable kernel headers through /sys/kernel/kheaders.tar.xz
(18) Kernel log buffer size (16 => 64KB, 17 => 128KB)
(12) CPU kernel log buffer size contribution (13 => 8 KB, 17 => 128KB)
[ ] Printk indexing debugfs interface
    Scheduler features  --->
[ ] Memory placement aware NUMA scheduler
v(+)
```

Configuring the Kernel

```
< >    I2C/SMBus Test Stub
[*]    I2C slave support
<M>      I2C eeprom slave driver
<M>      I2C testunit driver
```

Configuring the Kernel

```
hamza@FennecHOST:~/linux$ make menuconfig
configuration written to .config

*** End of the configuration.
*** Execute 'make' to start the build or try 'make help'.

hamza@FennecHOST:~/linux$ make
```

Configuring the Kernel

```
  OBJCOPY arch/x86/boot/vmlinux.bin
  AS      arch/x86/boot/header.o
  LD      arch/x86/boot/setup.elf
  OBJCOPY arch/x86/boot/setup.bin
  BUILD   arch/x86/boot/bzImage
Kernel: arch/x86/boot/bzImage is ready  (#3)
hamza@FennecHOST:~/linux$
```

Configuring the Kernel

```
hamza@FennecHOST:~/linux$ sudo make install
  INSTALL /boot
run-parts: executing /etc/kernel/postinst.d/dracut 6.12.0-rc7-00212-g4a5df3796467 /boot/vmlinuz-6.12.0-rc7-00212-g4a5df3796467
depmod: ERROR: could not open directory /lib/modules/6.12.0-rc7-00212-g4a5df3796467: No such file or directory
depmod: FATAL: could not search modules: No such file or directory
dracut: Generating /boot/initrd.img-6.12.0-rc7-00212-g4a5df3796467
dracut: Cannot find module directory /lib/modules/6.12.0-rc7-00212-g4a5df3796467/
dracut: and --no-kernel was not specified
run-parts: /etc/kernel/postinst.d/dracut exited with return code 1
make[1]: *** [arch/x86/Makefile:320: install] Error 1
make: *** [Makefile:224: __sub-make] Error 2
```

Configuring the Kernel

```
hamza@FennecHOST:~/linux$ sudo make modules_install
  SYMLINK /lib/modules/6.12.0-rc7-00212-g4a5df3796467/build
  INSTALL /lib/modules/6.12.0-rc7-00212-g4a5df3796467/modules.order
  INSTALL /lib/modules/6.12.0-rc7-00212-g4a5df3796467/modules.builtin
  INSTALL /lib/modules/6.12.0-rc7-00212-g4a5df3796467/modules.builtin.modinfo
  INSTALL /lib/modules/6.12.0-rc7-00212-g4a5df3796467/kernel/fs/efivarfs/efivarfs.ko
  INSTALL /lib/modules/6.12.0-rc7-00212-g4a5df3796467/kernel/drivers/thermal/intel/x86_pkg_temp_thermal.ko
  INSTALL /lib/modules/6.12.0-rc7-00212-g4a5df3796467/kernel/net/netfilter/nf_log_syslog.ko
  INSTALL /lib/modules/6.12.0-rc7-00212-g4a5df3796467/kernel/net/netfilter/xt_mark.ko
  INSTALL /lib/modules/6.12.0-rc7-00212-g4a5df3796467/kernel/net/netfilter/xt_nat.ko
  INSTALL /lib/modules/6.12.0-rc7-00212-g4a5df3796467/kernel/net/netfilter/xt_LOG.ko
```

testing in the current machine

```
hamza@FennecHOST:~/linux$ sudo make install
  INSTALL /boot
run-parts: executing /etc/kernel/postinst.d/dracut 6.12.0-rc7-00212-g4a5df3796467 /boot/vmlinuz-6.12.0-rc7-00212-g4a5df3796467
dracut: Generating /boot/initrd.img-6.12.0-rc7-00212-g4a5df3796467
dracut: Disabling early microcode, because kernel does not support it. CONFIG_MICROCODE_[AMD|INTEL]!=y
run-parts: executing /etc/kernel/postinst.d/initramfs-tools 6.12.0-rc7-00212-g4a5df3796467 /boot/vmlinuz-6.12.0-rc7-00212-g4a5df3796467
run-parts: executing /etc/kernel/postinst.d/zz-update-grub 6.12.0-rc7-00212-g4a5df3796467 /boot/vmlinuz-6.12.0-rc7-00212-g4a5df3796467
Generating grub configuration file ...
Found background image: /usr/share/images/desktop-base/desktop-grub.png
Found linux image: /boot/vmlinuz-6.12.0-rc7-00212-g4a5df3796467
Found initrd image: /boot/initrd.img-6.12.0-rc7-00212-g4a5df3796467
Found linux image: /boot/vmlinuz-6.12.0-rc7-00212-g4a5df3796467.old
Found initrd image: /boot/initrd.img-6.12.0-rc7-00212-g4a5df3796467
Found linux image: /boot/vmlinuz-6.1.0-10-amd64
Found initrd image: /boot/initrd.img-6.1.0-10-amd64
Warning: os-prober will not be executed to detect other bootable partitions.
Systems on them will not be added to the GRUB boot configuration.
Check GRUB_DISABLE_OS_PROBER documentation entry.
Adding boot menu entry for UEFI Firmware Settings ...
done
```

testing in the current machine

```
hamza@FennecHOST:~/linux$ uname -ra
Linux FennecHOST 6.1.0-10-amd64 #1 SMP PREEMPT_DYNAMIC Debian 6.1.38-1 (2023-07-14) x86_64 GNU/Linux
```

testing in the current machine

```
hamza@FennecHOST:~$ uname -ar
Linux FennecHOST 6.12.0-rc7-00212-g4a5df3796467 #4 SMP PREEMPT_DYNAMIC Mon Nov 18 17:19:21 CET 2024
x86_64 GNU/Linux
hamza@FennecHOST:~$
```

testing in the current machine

```
hamza@FennecHOST: ~ 136x29
T:~$ sudo grep 'vmlinuz' /boot/grub/grub.cfg
/boot/vmlinuz-6.12.0-rc7-00212-g4a5df3796467 root=UUID=2a4202d0-feab-4a48-b96d-a97532070320 ro  quiet
linux   /boot/vmlinuz-6.12.0-rc7-00212-g4a5df3796467 root=UUID=2a4202d0-feab-4a48-b96d-a97532070320 ro  quiet
linux   /boot/vmlinuz-6.12.0-rc7-00212-g4a5df3796467 root=UUID=2a4202d0-feab-4a48-b96d-a97532070320 ro single
linux   /boot/vmlinuz-6.12.0-rc7-00212-g4a5df3796467.old root=UUID=2a4202d0-feab-4a48-b96d-a97532070320 ro  quiet
linux   /boot/vmlinuz-6.12.0-rc7-00212-g4a5df3796467.old root=UUID=2a4202d0-feab-4a48-b96d-a97532070320 ro single
linux   /boot/vmlinuz-6.1.0-10-amd64 root=UUID=2a4202d0-feab-4a48-b96d-a97532070320 ro  quiet
linux   /boot/vmlinuz-6.1.0-10-amd64 root=UUID=2a4202d0-feab-4a48-b96d-a97532070320 ro single
T:~$
```

minimal linux live

- getting and building linux, glibc, busybox
- Creating iso
- Generating Image
- testing it on QEMU

minimal linux live

```
#-----------minimal-------------
mkdir -p build/
tar xvf linux-5.18.3.tar.xz
cd linux-5.18.3
make defconfig
make --perfix=../build
cd ..

wget https://ftp.gnu.org/gnu/glibc/glibc-2.35.tar.bz2
tar xvf glibc-2.35.tar.bz2
cd xvf glibc-2.35
./configure --prefix=  --with-headers=../build/include \
    --without-gd --without-selinux\
    --disable-werror CFLAGS="$CFLAGS"
make -j16 && make install DESTDIR=../build/glibc
cd ..

mkdir -p ./{sysroot,rootfs}
cp -r ../build/glibc/* sysroot/
cp -r ../build/include sysroot/
SYSROOT=$(realpath sysroot/)
mkdir -p $SYSROOT/usr
```

minimal linux live

```
mkdir ../rootfs
ROOTFS=$(realpath ../rootfs)
cp -r busybox ../rootfs
cp -r $ROOTFS/bin/busybox
cp $SYSROOT/lib/ld-linux* $ROOTFS/lib64
cp $SYSROOT/lib/libm.so.6 $ROOTFS/lib
cp $SYSROOT/lib/libc.so.6 $ROOTFS/lib
cp $SYSROOT/lib/libresolv.so.2 $ROOTFS/lib
set +e
strip -g \
  $ROOTFS/bin/* \
  $ROOTFS/sbin/* \
  $ROOTFS/lib/* \
  2>/dev/null
set -e
find . | cpio -R root:root -H newc -o | xz -9 --check=crc32 > ../rootfs.cpio.xz

#------creating iso-------
xorriso -as mkisofs \
    -isohybrid-mbr ../syslinux/syslinux-*/bios/mbr/isohdpfx.bin \
    -c boot/syslinux/boot.cat \
    -b boot/syslinux/isolinux.bin \
```

minimal linux live

```
    #----------GENERATE IMAGE---------

cd $ROOTFS
mkdir image
cp -r $ROOTFS/*
cd image && tar -zcf image.tgz *

#-----runing the live distro------

qemu-system-x86_64 -m 128M -cdrom live.iso -boot d -vga std
```

minimal linux live

```
/hamza/KINGSTON$ qemu-system-x86_64 -m 128M -cdrom live.iso -boot d -vga std
```

QEMU - Press Ctrl+Alt+G to release grab

Machine View

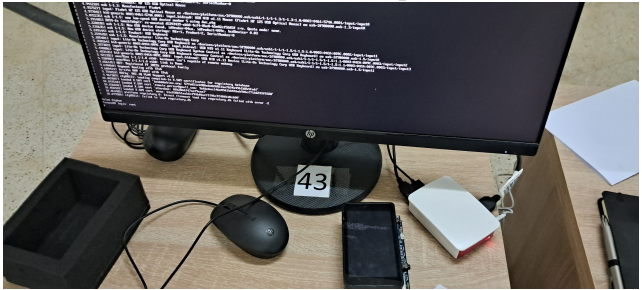
```
[    2.281974] PM:   Magic number: 0:630:997
[    2.282483] printk: console [netcon0] enabled
[    2.282537] netconsole: network logging started
[    2.284309] cfg80211: Loading compiled-in X.509 certificates for regulatory d
atabase
[    2.346629] cfg80211: Loaded X.509 cert 'sforshee: 00b28ddf47aef9cea7'
[    2.347634] platform regulatory.0: Direct firmware load for regulatory.db fai
led with error -2
[    2.347804] cfg80211: failed to load regulatory.db
[    2.348457] ALSA device list:
[    2.348529]   No soundcards found.
[    2.436256] Freeing unused kernel image memory: 1316K
[    2.436519] Write protecting the kernel read-only data: 20480k
[    2.438140] Freeing unused kernel image memory: 2004K
[    2.438736] Freeing unused kernel image memory: 900K
```

minimal linux live

```
/ # ls
README  dev     lib     proc    sbin    tmp     var
bin     etc     lib64   root    sys     usr
/ # pzd
/bin/sh: pzd: not found
/ # pwd
/
/ # whoami
whoami: unknown uid 0
/ # _
```

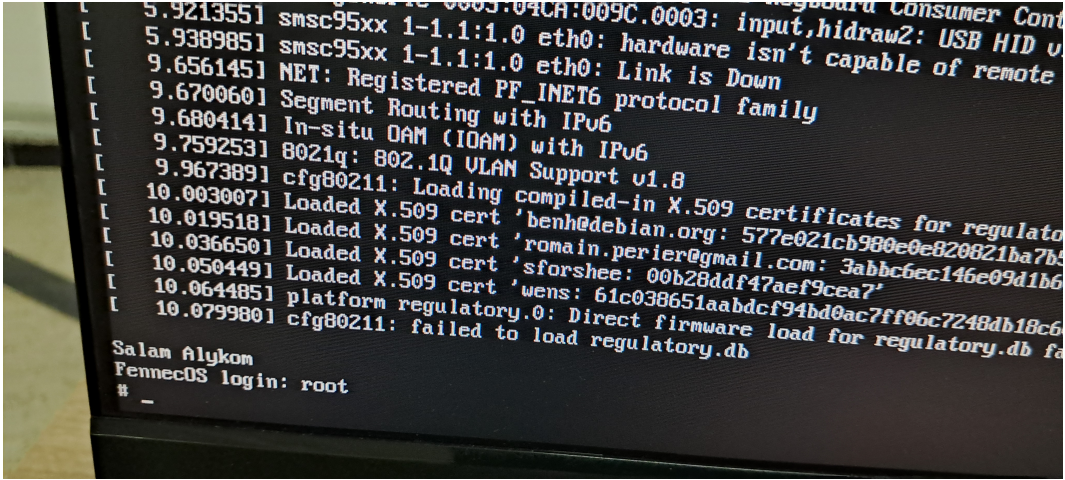
ARM Version on Pi3

Due to cross-compilation complications we choose to call for the help of other utilities that can provide cross-compile toolchain.



We have created an ARM OS using **Buildroot** (pre-built make files for cross-comp) and successfully booted it to a Pi3 device after converting the image with dd command to the SD card.

ARM Version on Pi3



NEW USB Driver

we choose to implement a very small driver that could be usufull in the future a driver that:

- identify a new usb
- identify devices containing LEDs (keybord as exemple)
- toogling thoos LEDs

NEW USB Driver

a basic exemple that interigate with the leds of the keybord

```
// Define the notifier block to register with the USB subsystem
static struct notifier_block usb_nb = {
    .notifier_call = usb_notify,
};

// Module initialization
static int __init usb_led_init(void)
{
    printk(KERN_INFO "USB LED Driver module loaded\n");

    // Register with the USB subsystem to receive device add/remove notifications
    usb_register_notify(&usb_nb);

    return 0;
}

// Module exit
```

NEW testing the driver

after building the driver we should insert the driver using insmod

```
sudo rmmod test.ko
sudo insmod test.ko
```

after inserting the module we could see diffrent prints on dmesg

```
[ 7520.573248] USB LED Driver module unloaded
[ 7523.605160] USB LED Driver module loaded
```

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LFS

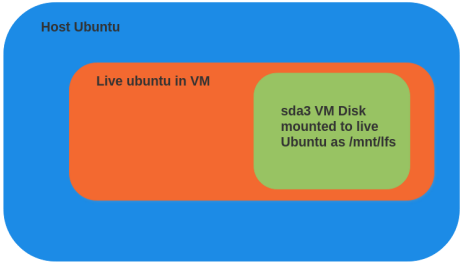
Linux From Scratch

Version 12.2-systemd

Published September 1st, 2024

We have used LFS book to make a our minimal linux distobution FennecOS which was used later on the rest of our VM's as a base system.

Method of building



- We boot via a live OS inside our VM.
- we create 3 partitons in our VM disk (boot,rootfs,swap)(ex2,ex4,swap-file).
- we install a list of required tools for building and compiling our LFS, these tools are installed on the live RAM disk and belong to the live distro.

Final minimal OS

```
-bash-5.2# name -r
-bash: name: command not found
-bash-5.2# cat /proc/version
Linux version 6.10.5 (root@ubuntu) (gcc (GCC) 14.2.0, GNU ld (GNU Binutils) 2.43
.1) #1 SMP PREEMPT_DYNAMIC Sun Nov 17 04:51:17 CET 2024
-bash-5.2#
```

After rebooting the vm and removing the ISO of our live Ubuntu, we are introduced to our final minimal OS using Linux from scratch.

Why use virtualization route

- Create multiple copies of our OS.
- Snapshots for recovery of failures.
- Network options like bridge interfaces and creation of separate network ranges.
- Using VM tools to export images.

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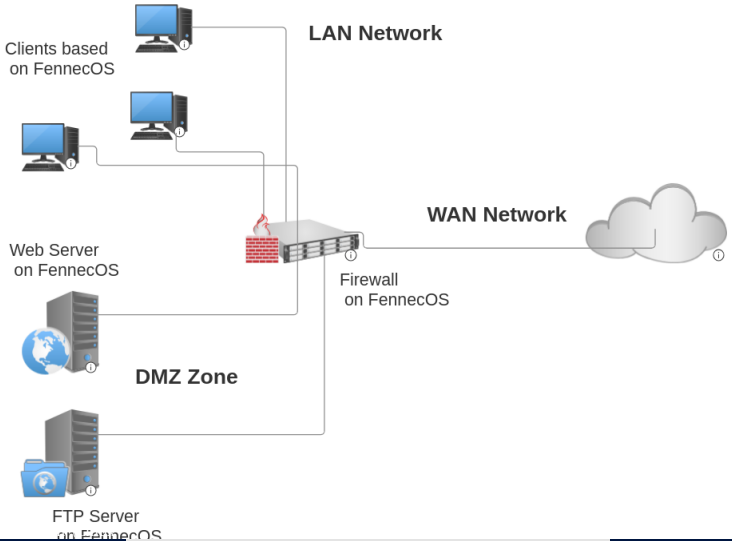
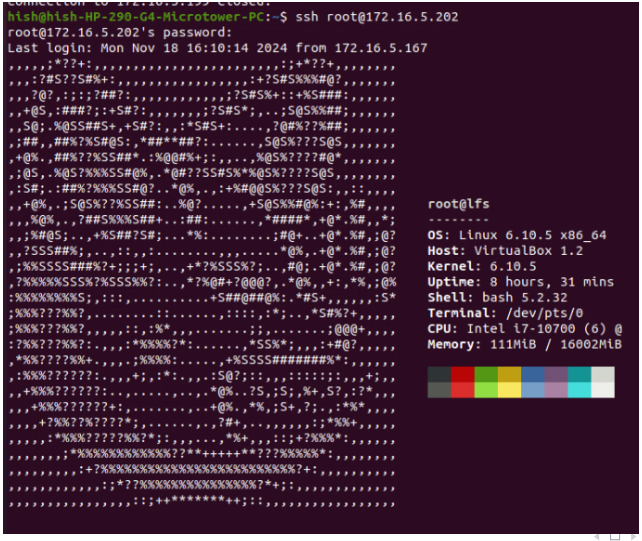
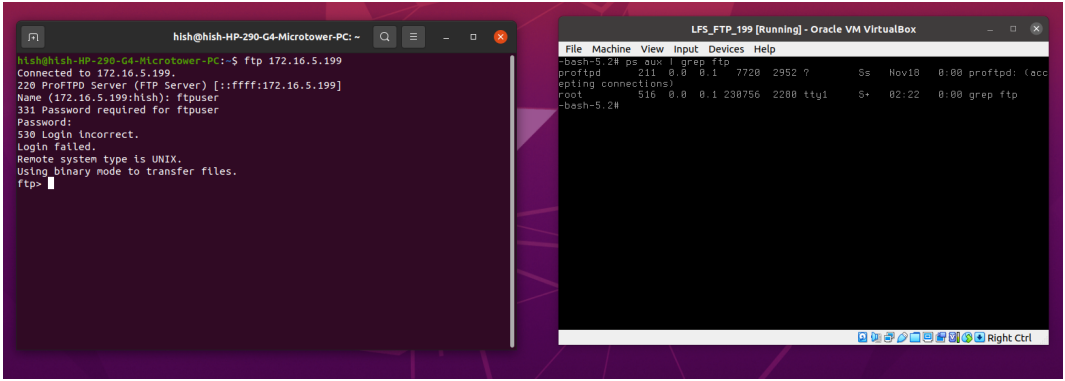
Network Topology



FennecOS clients

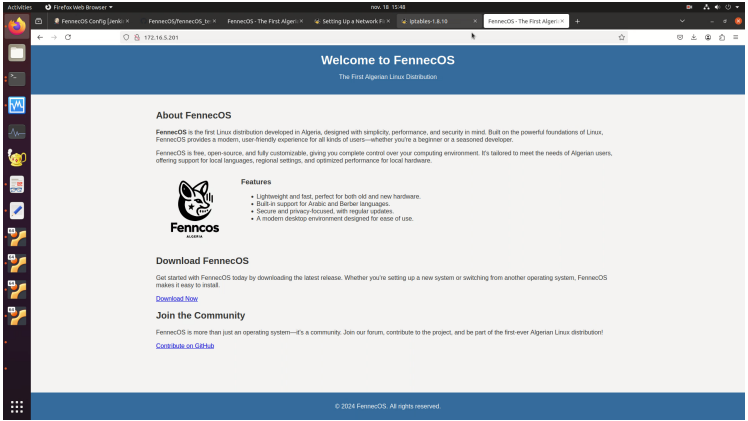


FTP Server



FTP Server using portftpd.

Web Server



A simple static landing page using Apache web server.

Firewall

- We used IPTables.
- Required Kernel modification to add NETFILTER.
- DMZ zone for FTP server and Web server.
- WAN network with bridged interface.
- LAN network on third interface.

IPtables

- LAN_IF="eth0"
- WAN_IF="enp0s"
- DMZ_IF="eth1"
- iptables -P INPUT DROP
- iptables -P FORWARD DROP
- iptables -P OUTPUT ACCEPT
- iptables -A INPUT -i lo -j ACCEPT
- iptables -A OUTPUT -o lo -j ACCEPT
- iptables -A INPUT -p tcp –dport 21 -j ACCEPT
- iptables -A OUTPUT -p tcp –sport 21 -j ACCEPT
- iptables -A INPUT -p tcp –dport 80 -j ACCEPT
- iptables -A OUTPUT -p tcp –sport 80 -j ACCEPT
- iptables -A INPUT -p tcp –dport 443 -j ACCEPT
- iptables -A OUTPUT -p tcp –sport 443 -j ACCEPT
- iptables -A INPUT -p tcp –dport 22 -j ACCEPT
- iptables -A OUTPUT -p tcp –sport 22 -j ACCEPT
- iptables -t nat -A POSTROUTING -o $WAN_IF -j MASQUERADE

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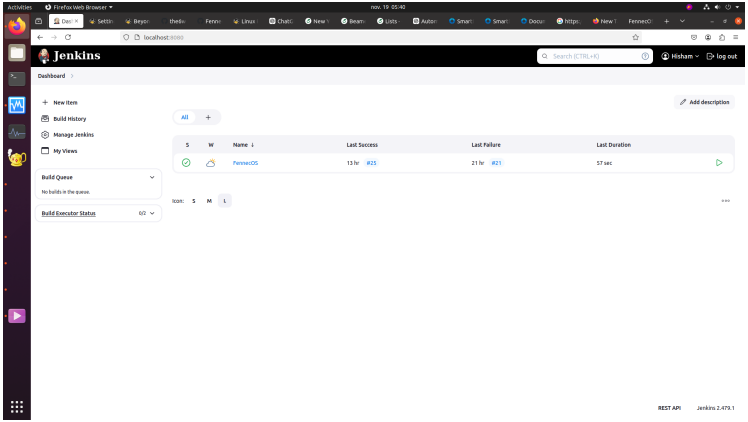
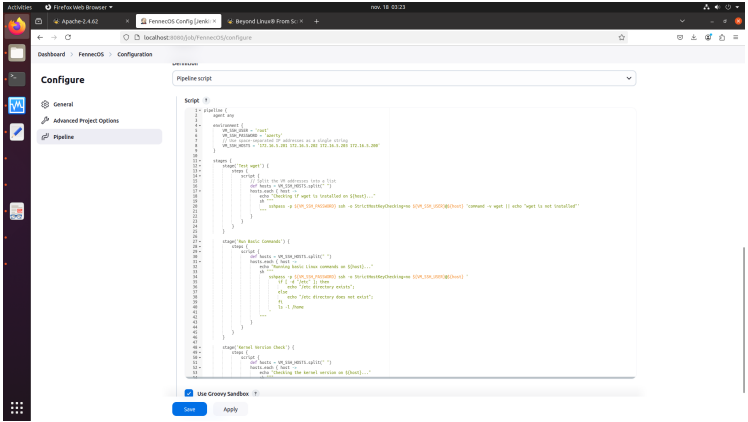
Jenkins new pipeline



We used Jenkins with sshpass and virualbox to automate the testing process of our machines.

Jenkins pipeline script



here we defined a list of tests that Jenkins will perform to test our machines.

Pipeline Features

- The pipeline loops over the **VM_SSH_HOSTS** list to perform tests on each specified host.
- The use of **sshpass** ensures password-based SSH authentication.
- Each stage checks a specific aspect of the system and reports the results.

Test wget

```
command -v wget || echo "wget is not installed"
```

Run Basic Commands

```
if [ -d "/etc" ]; then echo "/etc directory exists"; else
    echo "/etc directory does not exist"; fi
ls -l /home
```

Kernel Version Check

```
uname -r
```

Kernel Logs Check

```
dmesg | grep -i "error\|warn" || echo "No kernel errors
    or warnings"
```

CPU Info Check

```
cat /proc/cpuinfo
```

Memory Info Check

```
cat /proc/meminfo
```

Network Connectivity Test

```
ping -c 4 8.8.8.8 || echo "Network connectivity test
    failed"
```

Tests Finished successfully in Jenkins

localhost:8080/job/FennecOS/27/console

Dashboard > FennecOS > #27

```
64 bytes from 8.8.8.8: icmp_seq=3 ttl=113 time=36.123 ms
--- 8.8.8.8 ping statistics ---
4 packets transmitted, 4 packets received, 0% packet loss
round-trip min/avg/max/stddev = 35.145/35.593/36.123/0.368 ms
[Pipeline] echo (hide)
Testing network connectivity on 172.16.5.199...
[Pipeline] sh
+ sshpass -p azerty ssh -o StrictHostKeyChecking=no root@172.16.5.199 ping -c 4 8.8.8.8 || echo "Network connectivity test failed"
PING 8.8.8.8 (8.8.8.8): 56 data bytes
64 bytes from 8.8.8.8: icmp_seq=0 ttl=113 time=35.756 ms
64 bytes from 8.8.8.8: icmp_seq=1 ttl=113 time=35.718 ms
64 bytes from 8.8.8.8: icmp_seq=2 ttl=113 time=35.940 ms
64 bytes from 8.8.8.8: icmp_seq=3 ttl=113 time=35.629 ms
--- 8.8.8.8 ping statistics ---
4 packets transmitted, 4 packets received, 0% packet loss
round-trip min/avg/max/stddev = 35.629/35.761/35.940/0.113 ms
[Pipeline] }
[Pipeline] // script
[Pipeline] }
[Pipeline] // stage
[Pipeline] stage
[Pipeline] { (Declarative: Post Actions)
[Pipeline] echo
Pipeline finished
[Pipeline] echo
All tests passed!
[Pipeline] }
[Pipeline] // stage
[Pipeline] }
[Pipeline] // withEnv
[Pipeline] }
[Pipeline] // node
[Pipeline] End of Pipeline
Finished: SUCCESS
```

What are our perspectives ?

- scalable architecture with the due to the ease of containerizing and deploying our OS into Docker or kubernetes.
- very simple and helpful for educational purposes.
- Widely customizable and deployable on different machines with different architectures X86 and ARM.