Alpaquita Linux
Setting up Secure Boot

Alpaquita Linux
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bellsoft

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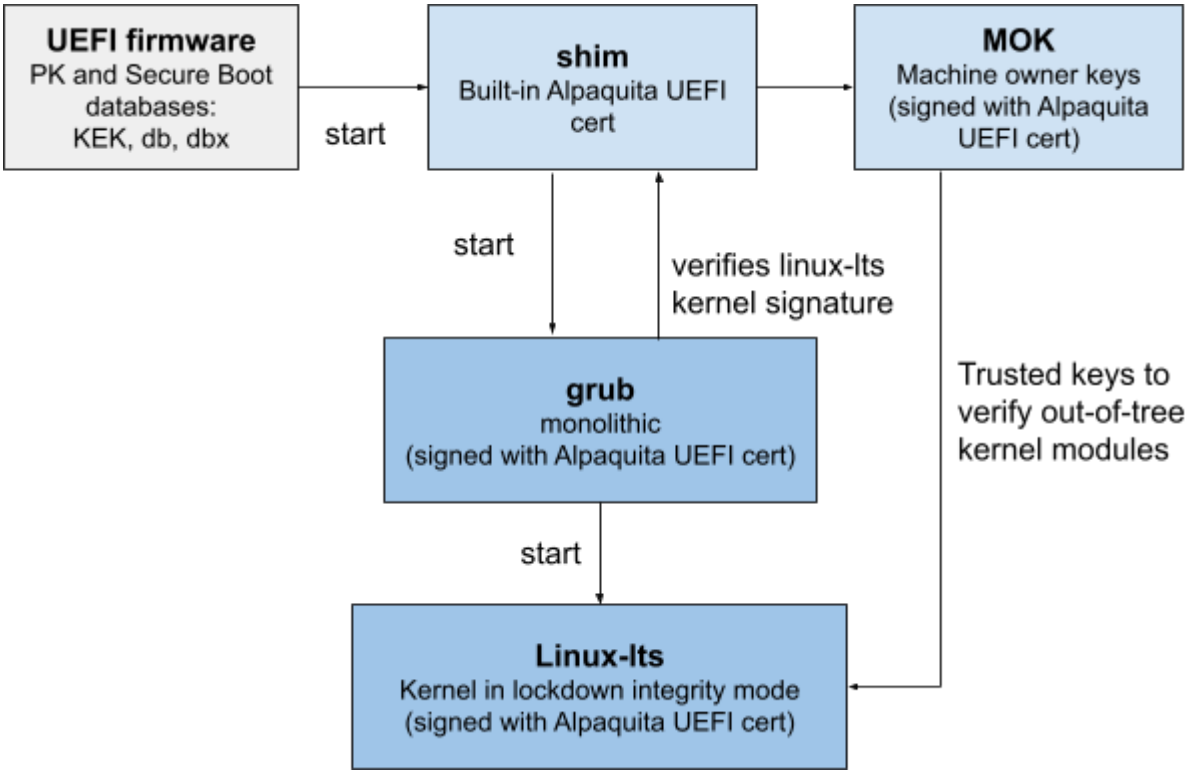
Contents

1. Overview

Secure Boot (SB) is a mechanism to boot only trusted software and protect the system from malicious code early in the boot process. Since the introduction of this feature in 2011 by Microsoft, most Unified Extensible Firmware Interface (UEFI) firmware now comes with preloaded Microsoft certificates that only boot what is signed with them when SB is enabled. Moreover, many SB systems today allow users to add their own trusted keys to SB databases, and Alpaquita SB currently relies on the latter.

How SB Works in Alpaquita Linux

Alpaquita Linux provides a trusted chain, which includes pre-bootloader "shim" with a built-in Alpaquita UEFI certificate, signed MOKManager utility, grub, and Linux kernel (automatically locked down if SB is enabled).



- **UEFI firmware** is a replacement for the Basic Input/Output System (BIOS) firmware interface. In the Secure Boot context, it has a platform key (PK) and several SB databases that include the signature database (db), revoked signatures database (dbx), and Key Enrollment Key database (KEK).

- **shim** is the first stage bootloader, a root of trust for all other booted components in Alpaquita Linux. It embeds the BellSoft Alpaquita UEFI certificate that is used to sign further booted software.
- **MOK** (Machine Owner Key) is an extra database of keys or hashes, similar to db, which can be easily managed by a user. There is a mockutil package that can be used to add or remove keys, but changes can only be confirmed and applied at boot time. This allows signing locally built kernel modules, bootloaders or kernels.

As demonstrated in the previous diagram, the shim, the first-stage bootloader, must be signed with the key you control from UEFI Signature Database (db) or the shim hash must be added to db in order to start Alpaquita Linux in Secure Boot mode. After the shim is signed and the key or hash is loaded to the UEFI db, secure boot can be enabled and used without any further setup, because the other components in the boot chain are trusted, signed by BellSoft.

To demonstrate signing of the shim and enrollment of new keys, we will use an x86 virtual machine using QEMU/KVM with UEFI support. Bare-metal machines have their own specific UEFI firmware implementations. Contact your hardware vendor (manufacturer) for details, such as the possibility of changing Secure Boot keys, assistance, and tools you may need.

2. Setting up Secure Boot

The following sections provide detailed information on how to set up Secure Boot for Alpaquita Linux.

Setting up Virtual Machine

To proceed, prepare an x86 Linux machine with QEMU/KVM installed and UEFI firmware for the demo VM.

OVMF is Open Virtual Machine Firmware that is a part of the Intel's EFI Development Kit II (edk2). It enables UEFI support for x86 Virtual Machines. To simplify the setup, use the edk2-ovmf or ovmf package that can be found in many distributions. Download Fedora edk2-ovmf package, which is available in official Fedora repositories and includes the already built UEFI firmware image with SB support.

1. Create a new directory for the new VM.

   ```
   mkdir alpaquita-sb-vm
   cd alpaquita-sb-vm
   ```

2. Unpack edk2-ovmf rpm to edk2-ovmf directory and copy two ovmf files from there.

   ```
   mkdir edk2-ovmf
   rpm2cpio edk2-ovmf-20210527gite1999b264f1f-3.fc36.noarch.rpm | cpio -i
   --make-directories
   cd ..
   cp edk2-ovmf/usr/share/edk2/ovmf/OVMF_CODE.secboot.fd OVMF_CODE.fd
   cp edk2-ovmf/usr/share/edk2/ovmf/OVMF_VARS.secboot.fd OVMF_VARS.fd
   ```

3. Create a QEMU disk image.

   ```
   qemu-img create -f qcow2 -o preallocation=off aplaca.qcow2 8G
   ```

4. Download official Alpaquita Linux ISO from https://bell-sw.com/pages/downloads/alpaquita/.

5. Start a VM with the following options.

   ```
   qemu-system-x86_64 -cpu host -enable-kvm -m 512 -smp 2 \
      -hda alpaquita.qcow2 \
      -machine q35,smm=on \
      -device e1000,netdev=net0 -netdev user,id=net0,hostfwd=tcp::5555-:22 \
   ```

```
   -global driver=cfi.pflash01,property=secure,value=on \
   -drive if=pflash,format=raw,unit=0,file=OVMF_CODE.fd,readonly=on \
   -drive if=pflash,format=raw,unit=1,file=OVMF_VARS.fd \
   -drive id=cd0,if=none,format=raw,readonly,file=alpaquita-virt-22.0-
x86_64.iso \
   -device ide-cd,bus=ide.1,drive=cd0,bootindex=1
```

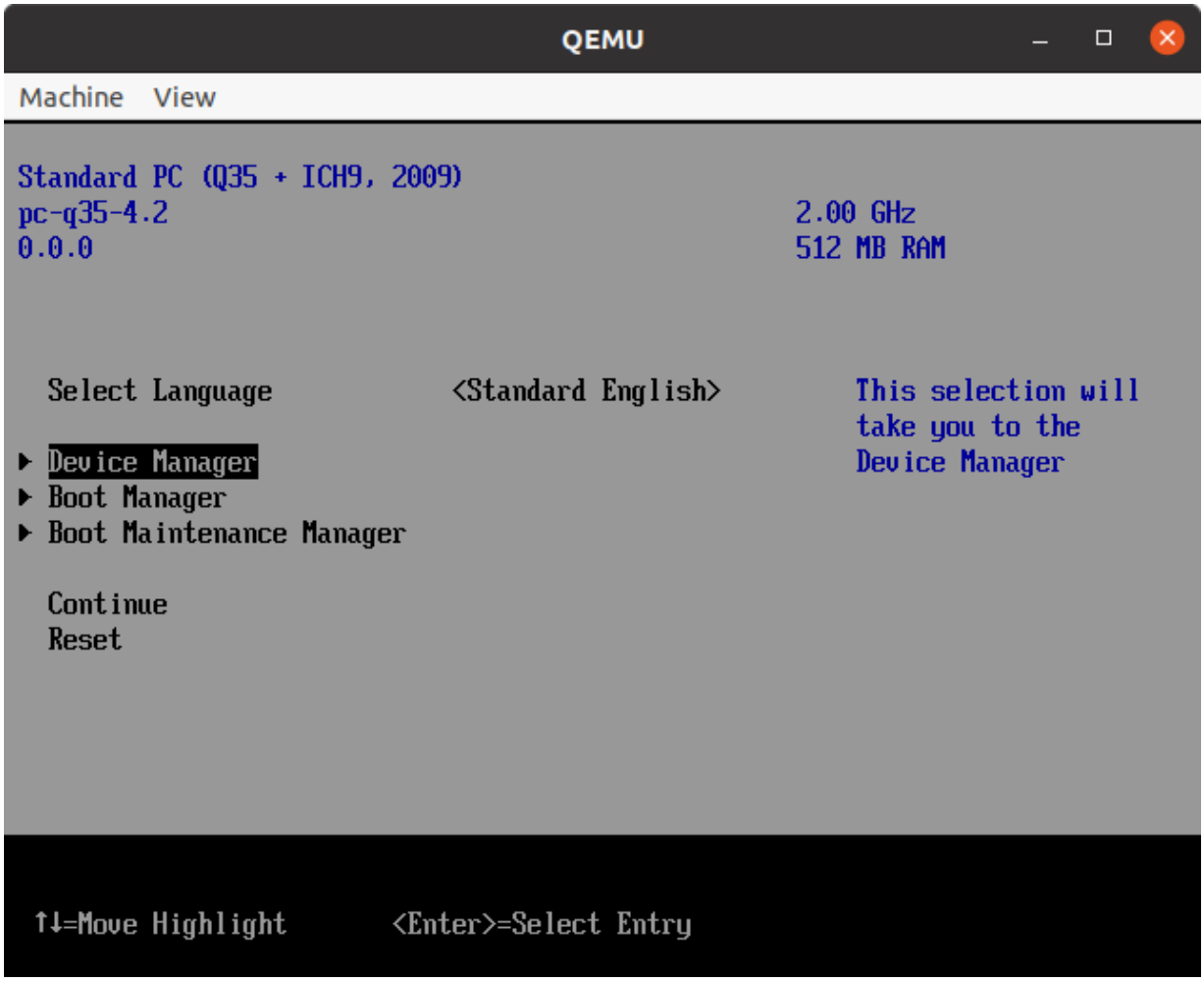
6. The `qemu` options also forward ssh port, so you can access the VM via ssh after the installation is complete.

   ```
   ssh -p 5555 alpaquita@localhost
   ```

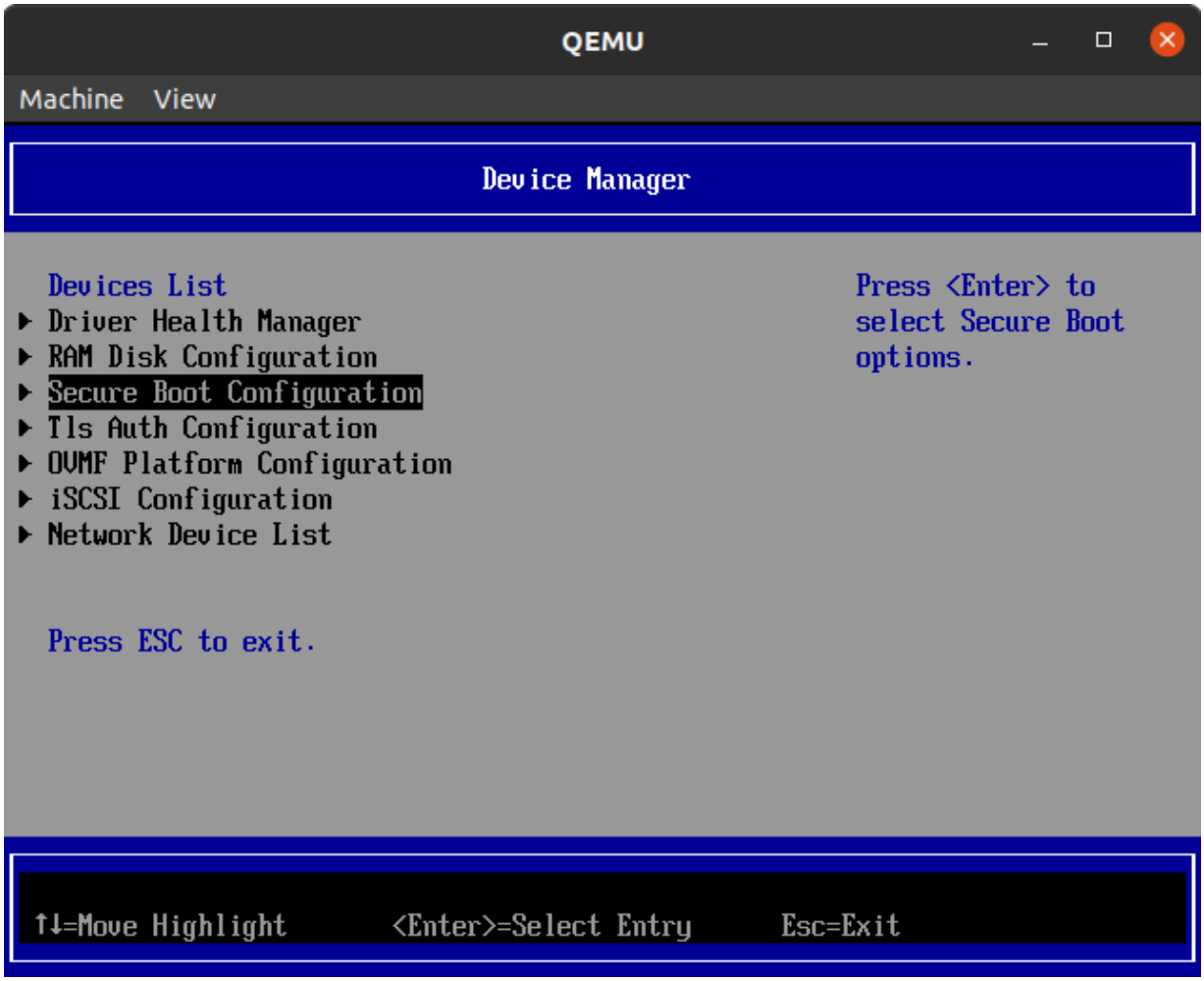
Disabling Secure Boot

After creating and starting the VM, disable Secure Boot in order to load Alpaquita Linux ISO. This is required because the UEFI Secure Boot database contains only Microsoft certificates and Alpaquita shim is not signed by them yet.

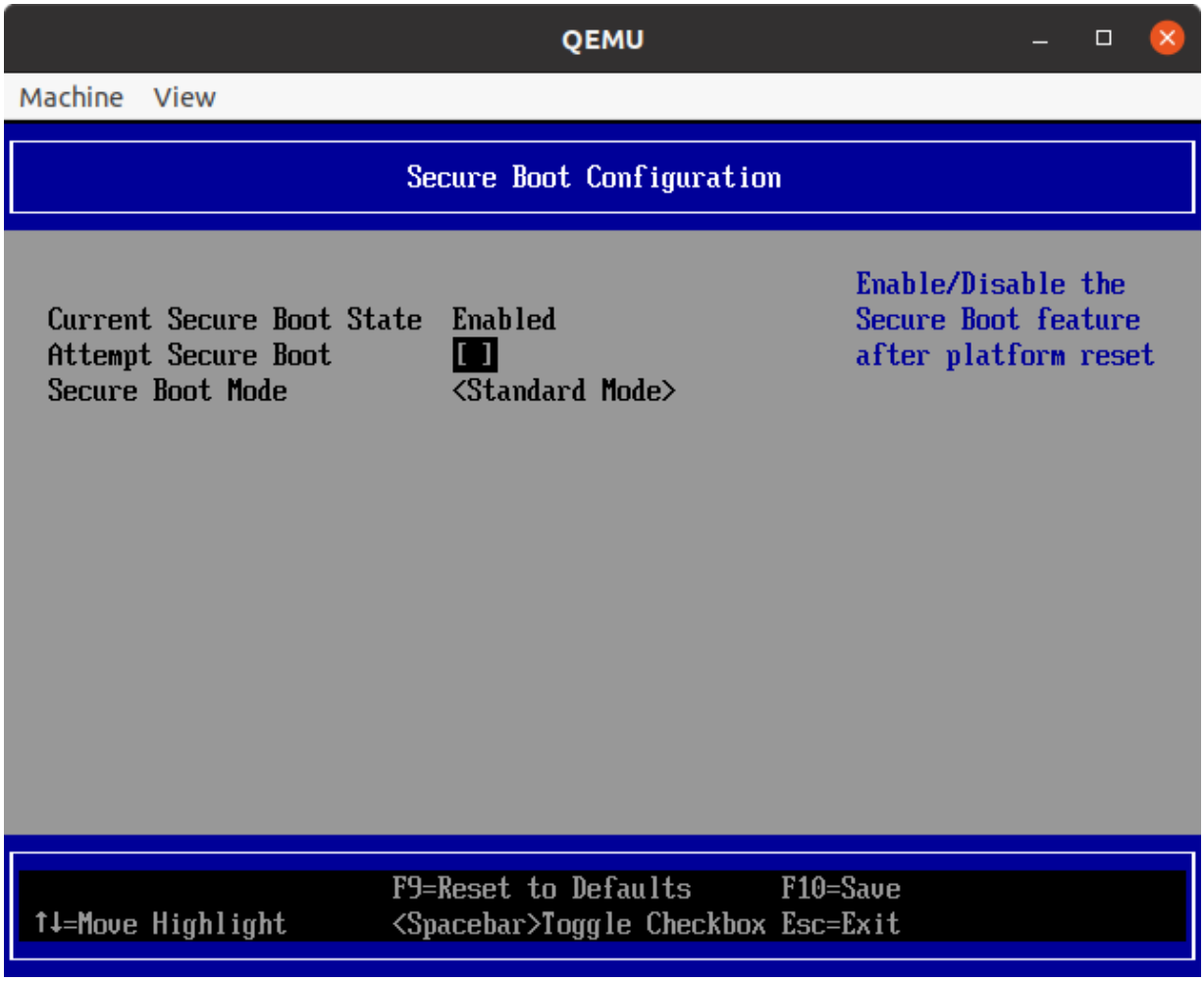
1. Press ESC during early start-up and the following menu appears. Navigate to "Device Manager."



2. On the "Device Manager" screen, select the "Secure Boot Configuration" entry.



3. Clear the "Attempt Secure Boot" option.



4. Save the settings and reboot.

Alpaquita Linux ISO loads grub and starts the kernel.

Setting up Alpaquita Linux

In the previous step we disabled Secure Boot and booted the VM with Alpaquita Linux ISO. Now we can set up Alpaquita Linux.

On the "Secure Boot" screen of the Alpaquita Linux Installation, select "Install Secure Boot required packages to sign with own keys." Complete the setup and reboot.

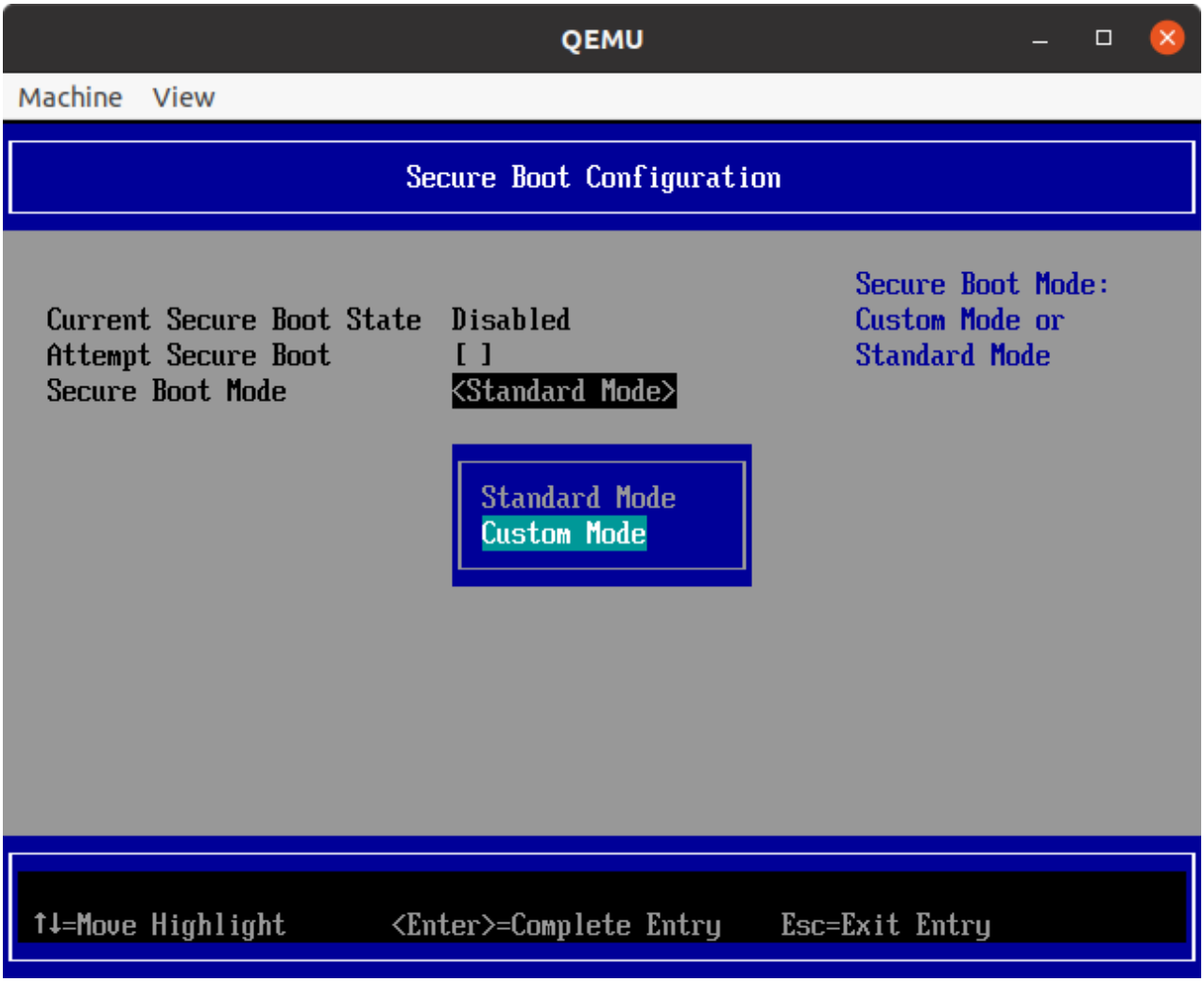
Disable booting from ISO. You can remove the lines below from the options of the previous `qemu-system-x86_64` command:

```
-drive id=cd0,if=none,format=raw,readonly,file=alpaquita-virt-22.0-x86_64.iso \
```

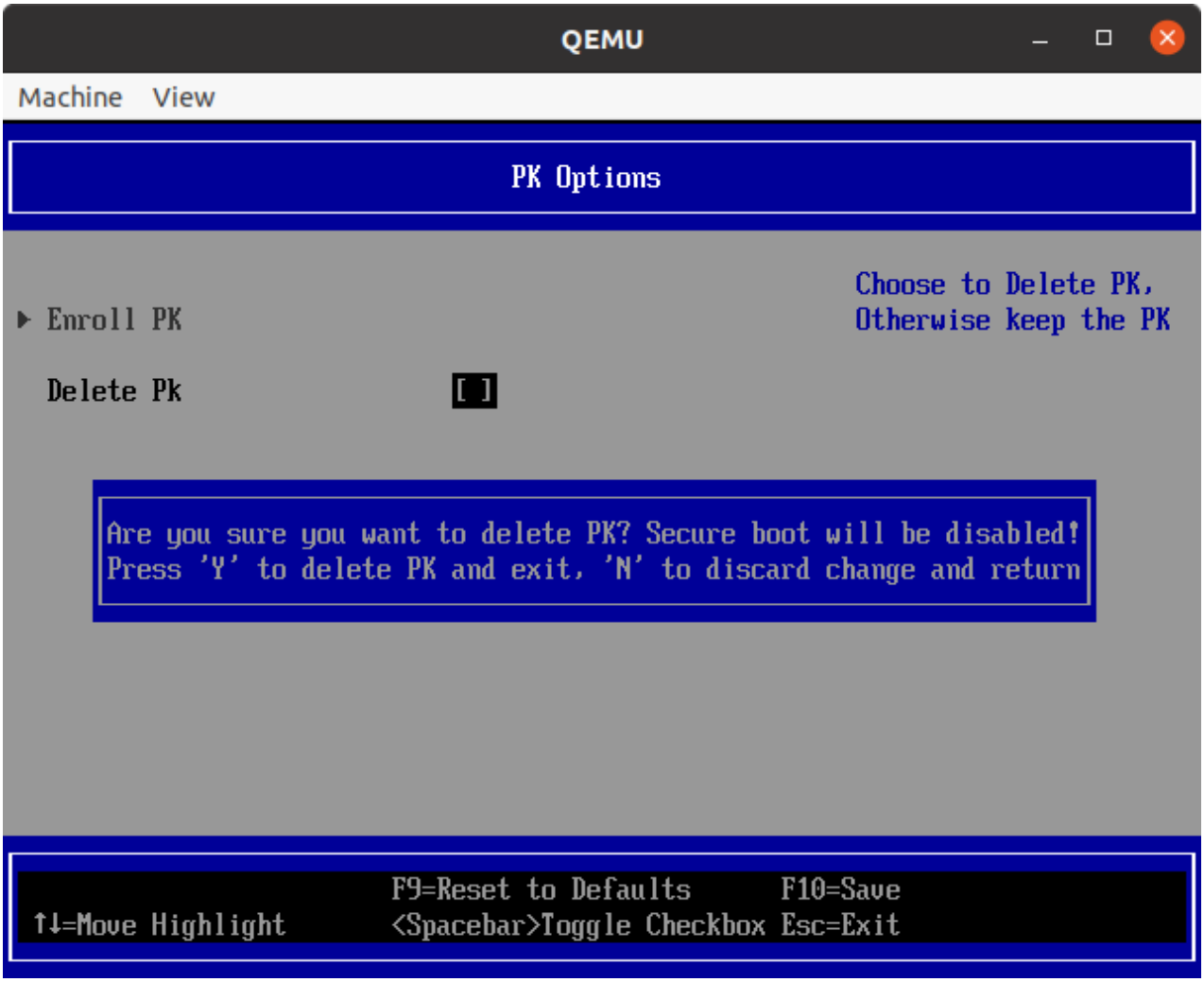
```
-device ide-cd,bus=ide.1,drive=cd0,bootindex=1 \
```

Switching Secure Boot to Setup Mode

Reboot the machine, interrupt the normal booting process by pressing the ESC button. Navigate to "Secure Boot Mode" and select "Custom Mode," then "Custom Secure Boot Options." Delete db, KEK, and PK keys.



Confirm the deletion of PK.



After deleting the PK key, Secure Boot turns on "Setup Mode."

Reboot the machine to complete this step.

Create PK, KEK, db keys

Installing required packages

Install the following packages.

```
sudo apk add openssl efitools sbsigntool uuidgen util-linux-misc
```

Creating the keys

Use the following script to create the keys.

```
#!/bin/sh

create_key()
{
  local name="$1"
  local subj="$2"

  openssl req -new -x509 -newkey rsa:2048 -sha256 -days 3650 \
    -keyout $name.key -subj "/CN=$subj" -out $name.pem
}

gen_keys()
{
  create_key PK "My Platform Key"
  create_key KEK "My Key Exchange Key"
  create_key SSK "My Shim Signing Key"

  local owner="$(uuidgen)"

  cert-to-efi-sig-list -g "$owner" PK.pem PK.esl
  cert-to-efi-sig-list -g "$owner" KEK.pem KEK.esl
  cert-to-efi-sig-list -g "$owner" SSK.pem SSK.esl

  cp SSK.esl db.esl

  # Uncomment to add Microsoft certificates to db
  # Dual boot, for Windows:
  #wget https://www.microsoft.com/pkiops/certs/MicWinProPCA2011_2011-10-19.crt
  # Third-party binaries signed by Microsoft (boot other Linux distros):
  #wget https://www.microsoft.com/pkiops/certs/MicCorUEFCA2011_2011-06-27.crt
  #openssl x509 -in MicWinProPCA2011_2011-10-19.crt -inform DER -out MicWin.pem
-outform PEM
  #openssl x509 -in MicCorUEFCA2011_2011-06-27.crt -inform DER -out MicCor.pem
-outform PEM
  #local mic=”77fa9abd-0359-4d32-bd60-28f4e78f784b”
  #cert-to-efi-sig-list -g "$mic" MicCor.pem MicCor.esl
  #cert-to-efi-sig-list -g "$mic" MicWin.pem MicWin.esl
  #cat SSK.esl MicWin.esl MicCor.esl > db.esl

  sign-efi-sig-list -k PK.key -c PK.pem PK PK.esl PK.auth
```

```
  sign-efi-sig-list -k PK.key -c PK.pem KEK KEK.esl KEK.auth
  sign-efi-sig-list -k KEK.key -c KEK.pem db db.esl db.auth
}

gen_keys
```

After completion, the script should produce the following keys: SSK.key, SSK.pem, PK.auth, KEK.auth, db.auth. Note that "SSK" key is used to sign shim; and it is included in db.auth.

> **Important:**
>
> Keep the private keys (*.key) secure and store them on an encrypted external device.

Signing shim

Perform the following commands with the created keys to sign shim.

```
sudo su
sbsign --key SSK.key --cert SSK.pem /boot/efi/EFI/alpaquita/shimx64.efi
cd /boot/efi/EFI/alpaquita/
mv shimx64.efi.signed shimx64.efi
cp shimx64.efi ../BOOT/BOOTX64.EFI
exit
```

Installing Keys to Secure Boot database

You can now Install new keys to UEFI Firmware using `KeyTool.efi` from the `efitools` package or `efi-updatevar` as follows.

1. We recommend backing up UEFI variables before changing them.

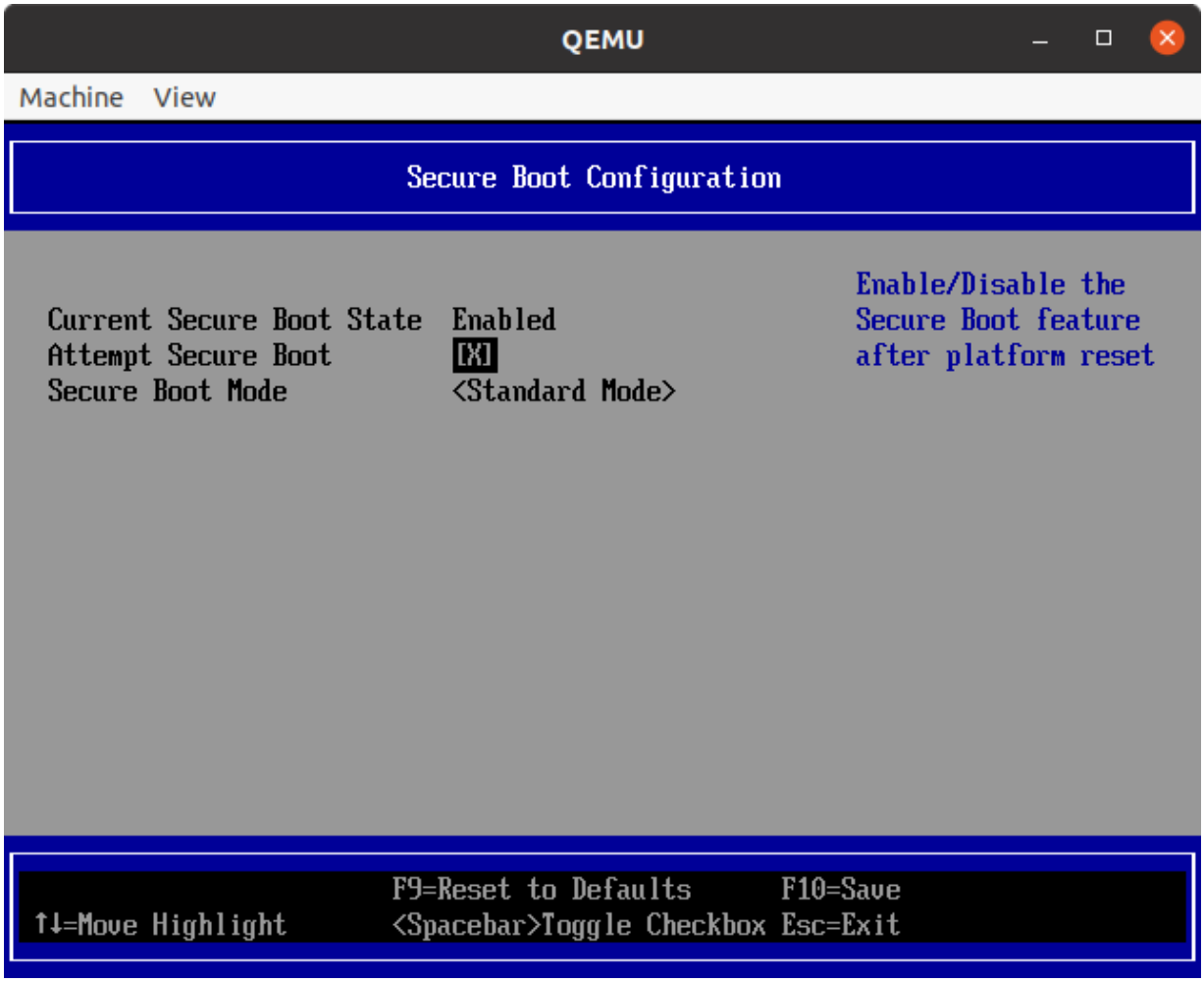
   ```
   efi-readvar -v PK -o PK_old.auth
   efi-readvar -v KEK -o KEK_old.auth
   efi-readvar -v db -o db_old.auth
   ```

2. Update with new ones.

   ```
   sudo efi-updatevar -f db.auth db
   sudo efi-updatevar -f KEK.auth KEK
   ```

```
sudo efi-updatevar -f PK.auth PK
```

3. Reboot the machine and enable Secure Boot in the UEFI firmware.



At this step, the Secure Boot is activated and Alpaquita Linux boots in lockdown mode.

Verifying Secure Boot

Enter the following command to verify that Secure Boot is enabled.

```
$ mokutil --sb-state
SecureBoot enabled
```

`dmesg` should contain the following lines indicating that secure boot is enabled and the kernel is locked down.

```
$ sudo dmesg | grep Secure
```

```
[    0.000000] Kernel is locked down from EFI Secure Boot; see man
kernel_lockdown.7
[    0.000000] secureboot: Secure boot enabled
[    0.207058] integrity: Loaded X.509 cert 'BellSoft: Alpaquita Secure Boot
CA: 3a793ac1906e33e9e12f28ca97c0f5b9652eae24'
```

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