# Moxa Industrial Linux 3.0 (Debian 11) Manual for Arm-based Computers

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**www.moxa.com/products**

# Moxa Industrial Linux 3.0 (Debian 11) Manual for Arm-based Computers

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# Table of Contents

# 1. Introduction

## Moxa Industrial Linux 3.0

Moxa Industrial Linux 3 (MIL3) is an industrial-grade Linux distribution developed and maintained by Moxa to address the security, reliability, and long-term support needs of industrial automation systems such as transportation, energy, oil and gas, and manufacturing.

MIL3 is based on Debian 11 with kernel 5.10 and integrated with several feature sets designed to strengthen and accelerate user application development as well as ensure system reliability and security.

## Secure and Standard Models

MIL3 provides two security levels in the form of standard and secure models. The standard models come with the default Debian 11 security configuration and is for users who prefer the flexibility to build their own security solutions. The secure models of Moxa's Arm-based computers are secure-by-default and certified for IEC 62443-4-2 SL2 (security level 2). They come with Secure Boot, pre-defined security configuration, and additional security tools/utilities preinstalled

To identify the security model that you have, use the mx-interface-mgmt deviceinfo command to display the information. Only the secure models will have SECUREBOOT enabled.

```
moxa@moxa-tbzkb1090923: ~# mx-interface-mgmt deviceinfo
SERIALNUMBER=TBBBB1182827
MODELNAME=UC-8220-T-LX-US-S
SECUREBOOT=Enabled
```

The following table compares the main features in the standard and secure models.

| | Standard Model | Secured Model |
|---|---|---|
| IEC 62443-4-2 SL2 Host Device Certified | N/A | ✓ |
| Security Configuration | Default Debian configuration | IEC 62443-4-2 SL-2 Certified |
| Secure Boot | N/A | ✓ |
| Boot from SD or USB | ✓ | N/A (*1) |
| Disk Encryption | N/A | ✓ |
| Install Image via TFTP | ✓ | N/A (*2) |
| Secure Image Installation | N/A | ✓ |
| Secure Update | ✓ | ✓ |
| Intrusion Detection | ✓ (AIDE preinstalled without pre-defined monitoring database) | ✓ (AIDE with security monitoring database pre-defined) |
| Intrusion Prevention | ✓ (Fail2ban) | ✓ (Fail2ban) |
| Network Security Monitoring | ✓ (Zeek) | ✓ (Zeek) |
| Firewall | ✓ (nftable disabled by default) | ✓ (nftable with pre-configured security policy) |
| Security Diagnosis Tool (Moxa Guardian) | N/A | ✓ |
| Security Event Audit Log | ✓ (Audit service disabled by default) | ✓ (Audit service configured and running) |
| TPM 2.0 | ✓ | ✓ |
| Backup, Decommission and Recovery | ✓ (Moxa System Management) | ✓ (Moxa System Management) |
| Network Management | ✓ (Moxa Connection Management) | ✓ (Moxa Connection Management) |
| Computer Interface Management | ✓ (Moxa Computer Interface Manager) | ✓ (Moxa Computer Interface Manager) |

*1: SD/USB is not secure as a boot source; *2: TFTP is not a secure protocol

# Eligible Computing Platforms

This user manual is applicable to Moxa's Arm-based computers listed below and covers the complete set of instructions applicable to all the supported models. Detailed instructions on configuring advanced settings are covered in Chapter 3 to Chapter 6 of the manual.

You can order Moxa Arm-based computers with MIL3 preinstalled via the Moxa Computer Configuration System (CCS) using following model names:

| Arm-based Computer Series | CTO Model Name |
|---|---|
| UC-8200 Series | UC-8210-T-LX-S (CTO) |
| | UC-8220-T-LX (CTO) |
| | UC-8220-T-LX-US-S (CTO) |
| | UC-8220-T-LX-EU-S (CTO) |
| | UC-8220-T-LX-AP-S (CTO) |

# 2. Getting Started

## Connecting to the Arm-based Computer

You will need another computer to connect to the Arm-based computer and log on to the command line interface. There are two ways to connect: locally through serial console or ethernet cable, or remotely via Secure Shell (SSH). Refer to the Hardware Manual to see how to set up the physical connections.

For default login username and password, please reference the Default Credentials and Password Strength.

The username and password are the same for all serial console and SSH remote log in actions. Root account login is disabled until you manually create a password for the account. The user **moxa** is in the **sudo** group so you can operate system level commands with this user using the **sudo** command. For additional details, see the Sudo Mechanism section in Chapter 7.

⚠ **ATTENTION**

For security reasons, we highly recommend that you disable the default user account and create your own user accounts.

### Connecting through the Serial Console

This method is particularly useful when using the computer for the first time. The signal is transmitted over a direct serial connection, so you do not need to know either of its two IP addresses in order to connect to the Arm-based computer. To connect through the serial console, configure your PC's terminal software using the following settings.

| Serial Console Port Settings | |
|---|---|
| **Baudrate** | 115200 bps |
| **Parity** | None |
| **Data bits** | 8 |
| **Stop bits** | 1 |
| **Flow Control** | None |
| **Terminal** | VT100 |

Below we show how to use the terminal software to connect to the Arm-based computer in a Linux environment and in a Windows environment.

## Linux Users

**NOTE**

These steps apply to the Linux PC you are using to connect to the Arm-based computer. Do NOT apply these steps to the Arm-based computer itself.

Take the following steps to connect to the Arm-based computer from your Linux PC.

1. Install **minicom** from the package repository of your operating system.

   For Centos and Fedora:

   ```
   user@PC1:~# yum -y install minicom
   ```

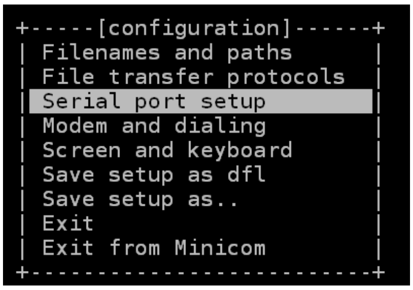
   For Ubuntu and Debian:

   ```
   user@PC2:~# apt install minicom
   ```

2. Use the **`minicom -s`** command to enter the configuration menu and set up the serial port settings.

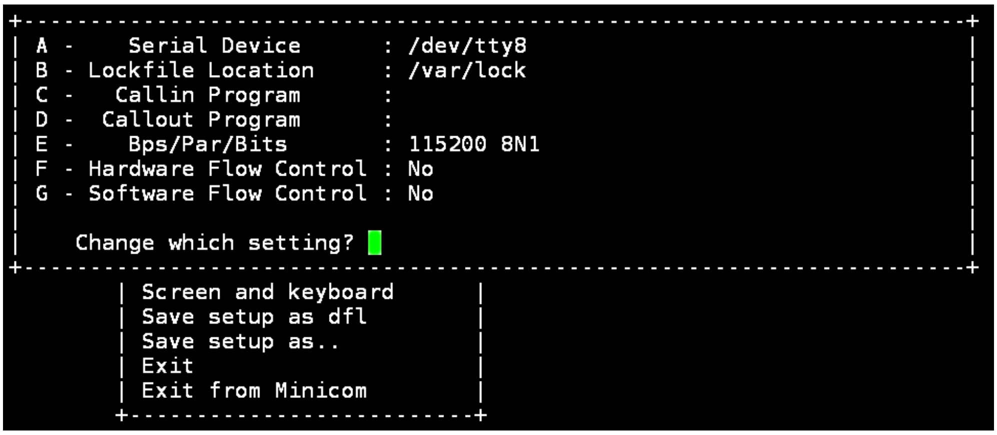
   ```
   user@PC1:~# minicom -s
   ```

3. Select **Serial port setup**.



```
+-----[configuration]------+
| Filenames and paths      |
| File transfer protocols  |
| Serial port setup        |
| Modem and dialing        |
| Screen and keyboard      |
| Save setup as dfl        |
| Save setup as..          |
| Exit                     |
| Exit from Minicom        |
+--------------------------+
```

4. Select **A** to change the serial device. Note that you need to know which device node is connected to the Arm-based computer.



```
+-----------------------------------------------------------------------+
| A -    Serial Device      : /dev/tty8                                 |
| B - Lockfile Location     : /var/lock                                 |
| C -   Callin Program      :                                           |
| D -  Callout Program      :                                           |
| E -    Bps/Par/Bits       : 115200 8N1                                |
| F - Hardware Flow Control : No                                        |
| G - Software Flow Control : No                                        |
|                                                                       |
|    Change which setting?                                              |
+-----------------------------------------------------------------------+
        | Screen and keyboard      |
        | Save setup as dfl        |
        | Save setup as..          |
        | Exit                     |
        | Exit from Minicom        |
        +--------------------------+
```

5. Select **E** to configure the port settings according to the **Serial Console Port Settings** table provided.
6. Select **Save setup as dfl** (from the main configuration menu) to use default values.
7. Select **Exit from minicom** (from the configuration menu) to leave the configuration menu.
8. Execute **minicom** after completing the above configurations.

   ```
   user@PC1:~# minicom
   ```

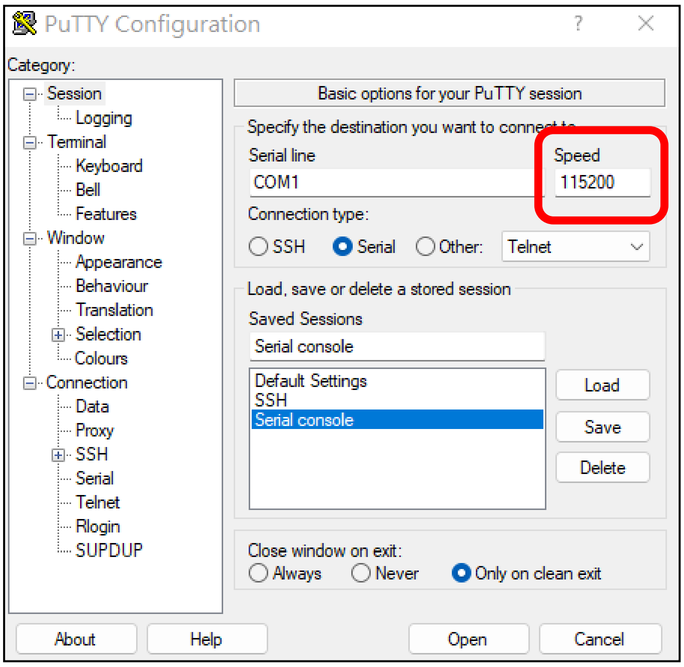
## Windows Users

### NOTE

These steps apply to the Windows PC you are using to connect to the Arm-based computer. Do NOT apply these steps to the Arm-based computer itself.

Take the following steps to connect to the Arm-based computer from your Windows PC.

1. Download PuTTY http://www.chiark.greenend.org.uk/~sgtatham/putty/download.html to set up a serial connection with the Arm-based computer in a Windows environment. The figure below shows a simple example of the configuration that is required.
2. Once the connection is established, the following window will open.



Specify the destination you want to connect to

Serial line: COM1

Speed: 115200

Connection type: ○ SSH ● Serial ○ Other: Telnet

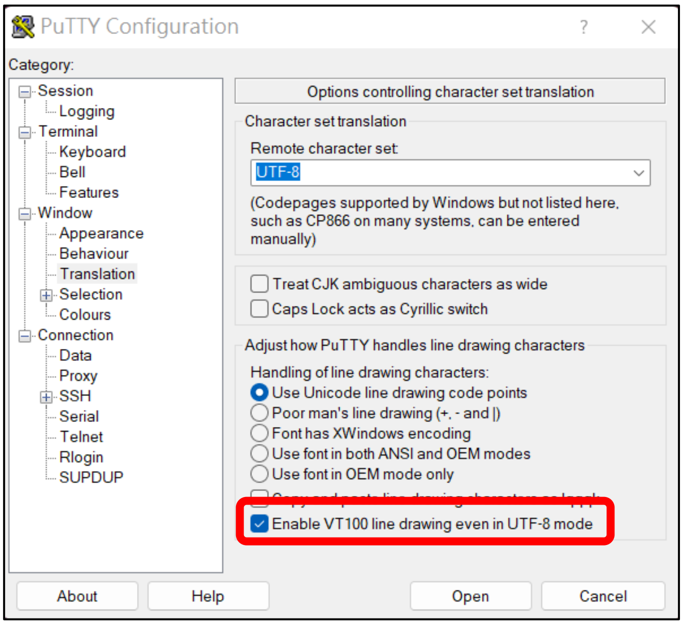
Load, save or delete a stored session

Saved Sessions: Serial console

Default Settings
SSH
Serial console

Close window on exit: ○ Always ○ Never ● Only on clean exit

3. Select the **Serial** connection type and choose settings that are similar to the Minicom settings.
4. Enable **VT100 line drawing** option for the MCM GUI configurator to show correctly.



Character set translation

Remote character set: UTF-8

(Codepages supported by Windows but not listed here, such as CP866 on many systems, can be entered manually)

□ Treat CJK ambiguous characters as wide

□ Caps Lock acts as Cyrillic switch

Adjust how PuTTY handles line drawing characters

Handling of line drawing characters:

● Use Unicode line drawing code points

○ Poor man's line drawing (+, - and |)

○ Font has XWindows encoding

○ Use font in both ANSI and OEM modes

○ Use font in OEM mode only

☑ Enable VT100 line drawing even in UTF-8 mode

# Connecting via the SSH

The Arm-based computer supports SSH connections remotely or over an Ethernet network. If you are connecting the computer using an Ethernet cable, refer to the following IP addresses information

| Ethernet Port | Configuration | IP Address |
|---|---|---|
| LAN 1 (*) | DHCP (DHCP client) | Assigned by DHCP server. Link-local IP addresses will be assigned when DHCP server is not available |
| LAN 2 | Static IP | 192.168.4.127 |

*LAN 1 is by default for DHCP/link-local IP configuration and is managed by Moxa Connection Manger (MCM).

### NOTE

Be sure to configure the IP address of your notebook/PC's Ethernet interface on the same subnet as the LAN port of Arm-based computer you plan to connect to. For example, 192.168.4.**126** for LAN2.

## Linux Users

### NOTE

These steps apply to the Linux PC you are using to connect to the Arm-based computer. Do NOT apply these steps to the Arm-based computer itself.

Use the **ssh** command from a Linux computer to access the computer’s LAN2 port.

```
user@PC1:~ ssh moxa@192.168.4.127
```

Type **yes** to complete the connection.

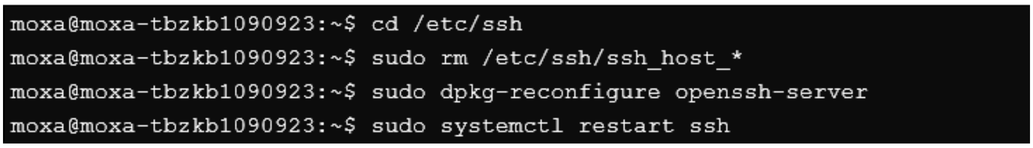
```
The authenticity of host ‘192.168.3.127’ can’t be established.
RSA key fingerprint is 8b:ee:ff:84:41:25:fc:cd:2a:f2:92:8f:cb:1f:6b:2f.
Are you sure you want to continue connection (yes/no)? yes_
```

To connect using LAN1, you need to know the IP address.

## ATTENTION

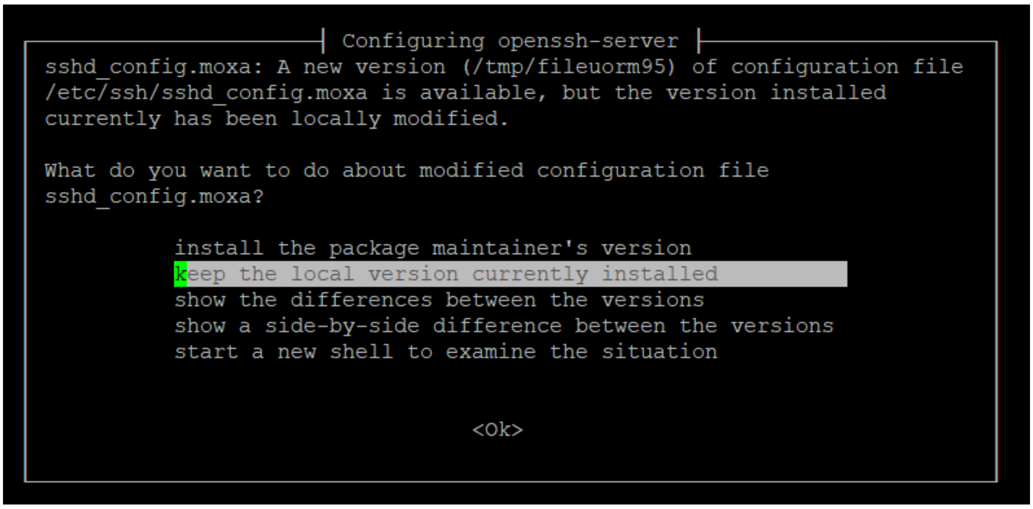
**Regenerate SSH key regularly**

In order to secure your system, we suggest doing a regular SSH-rekey, as shown in the following steps:



```
moxa@moxa-tbzkb1090923:~$ cd /etc/ssh
moxa@moxa-tbzkb1090923:~$ sudo rm /etc/ssh/ssh_host_*
moxa@moxa-tbzkb1090923:~$ sudo dpkg-reconfigure openssh-server
moxa@moxa-tbzkb1090923:~$ sudo systemctl restart ssh
```

Select "**keep the local version currently installed**" following is prompt during rekey process



```
┌───────────────────────┤ Configuring openssh-server ├──────────────────────┐
│ sshd_config.moxa: A new version (/tmp/fileuorm95) of configuration file    │
│ /etc/ssh/sshd_config.moxa is available, but the version installed          │
│ currently has been locally modified.                                       │
│                                                                            │
│ What do you want to do about modified configuration file                   │
│ sshd_config.moxa?                                                          │
│                                                                            │
│           install the package maintainer's version                         │
│           keep the local version currently installed                       │
│           show the differences between the versions                        │
│           show a side-by-side difference between the versions              │
│           start a new shell to examine the situation                       │
│                                                                            │
│                                                                            │
│                                  <Ok>                                      │
│                                                                            │
└────────────────────────────────────────────────────────────────────────────┘
```

For more information about SSH, refer to the following link.

https://wiki.debian.org/SSH

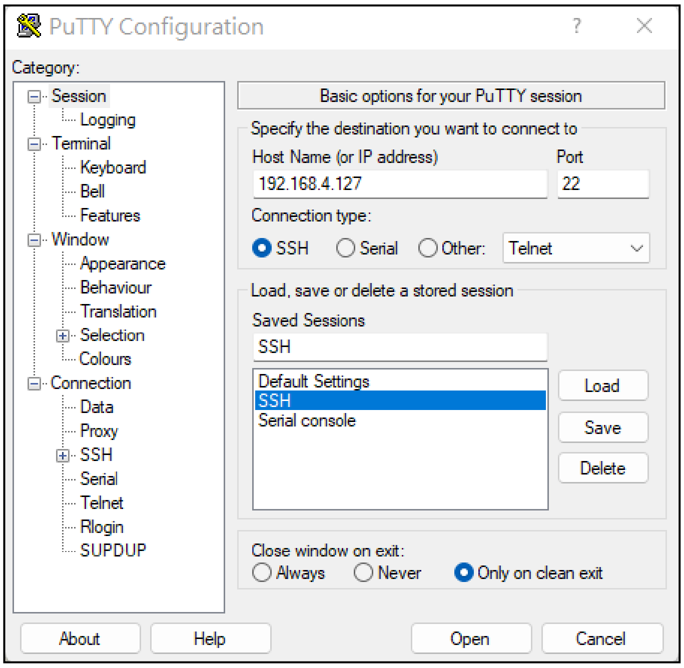
## Windows Users

### NOTE

These steps apply to the Windows PC you are using to connect to the Arm-based computer. Do NOT apply these steps to the Arm-based computer itself.

Take the following steps from your Windows PC.

Click on the link http://www.chiark.greenend.org.uk/~sgtatham/putty/download.html to download PuTTY (free software) to set up an SSH console for the Arm-based computer in a Windows environment. The following figure shows a simple example of the configuration that is required.



Basic options for your PuTTY session

Specify the destination you want to connect to

Host Name (or IP address): 192.168.4.127

Port: 22

Connection type: ● SSH ○ Serial ○ Other: Telnet

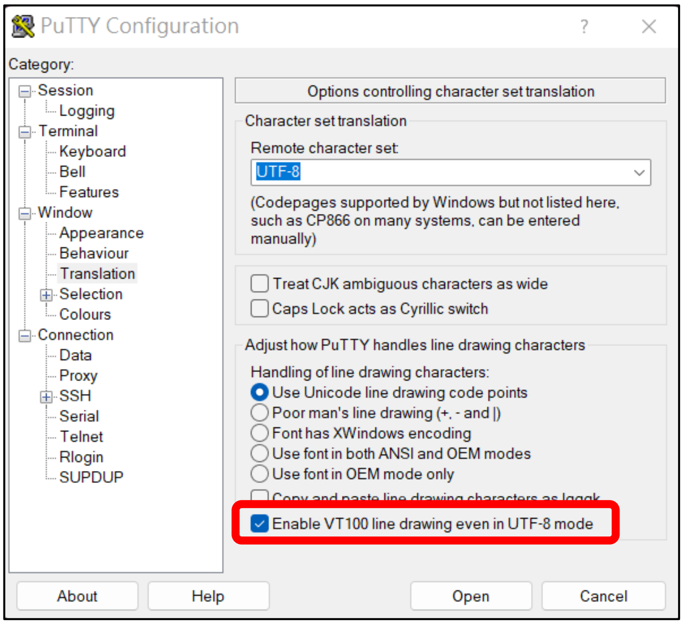
Load, save or delete a stored session

Saved Sessions: SSH

Default Settings
SSH
Serial console

Close window on exit: ○ Always ○ Never ● Only on clean exit

Enable **VT100 line drawing** option for the MCM GUI configurator to show correctly



Options controlling character set translation

Character set translation

Remote character set: UTF-8

(Codepages supported by Windows but not listed here, such as CP866 on many systems, can be entered manually)

□ Treat CJK ambiguous characters as wide

□ Caps Lock acts as Cyrillic switch

Adjust how PuTTY handles line drawing characters

Handling of line drawing characters:

● Use Unicode line drawing code points

○ Poor man's line drawing (+, - and |)

○ Font has XWindows encoding

○ Use font in both ANSI and OEM modes

○ Use font in OEM mode only

□ Copy and paste line drawing characters as lqqqk

☑ Enable VT100 line drawing even in UTF-8 mode

# Managing User Accounts

## Default User Account and Password Policy

The default login username and password of Moxa Industrial Linux are both **moxa** for the first-time login. You will be prompted to set a new password before you can continue to login.

- Default Username: **moxa**
- Default Password: **moxa**

**Password Strength Requirements:**

- At least 8 characters in length
- Dictionary checking is enabled to prevent the use of common passwords

To modify the password strength policy, edit the **/etc/security/pwquality.conf.d/00-moxa-standard-pwquality.conf** file to configure the policy.

### NOTE

Click the following link for more information on the password strength configuration.

https://manpages.debian.org/bullseye/libpwquality-common/pwquality.conf.5.en.html

For bootloader administrator password configuration, refers to the bootloader configuration section.

## Creating and Deleting User Accounts

### ATTENTION

DO NOT disable the default account before creating an alternative user account.

You can use the **useradd** and **userdel** commands to create and delete user accounts. Be sure to reference the main page of these commands to set relevant access privileges for the account. Following example shows how to create a **test1** user in the **sudo** group whose default login shell is **bash** and has home directory at **/home/test1**:

```
moxa@ moxa-tbzkb1090923:~# sudo useradd -m -G sudo -s /bin/bash test1
```

To change the password for test1, use the **passwd** option along with the new password. Retype the password to confirm the change.

```
moxa@moxa-tbzkb1090923:~# sudo passwd test1
New password:
Retype new password:
passwd: password updated successfully
```

To delete the user **test1**, use the **userdel** command.

```
moxa@ moxa-tbzkb1090923:# sudo userdel test1
```

## Modifying User Accounts

You can use the **`usermod`** commands to create and modify the user account settings. Some examples of commonly used settings are listed here, including adding a user to a group, locking an account, activating an account and setting the password expiration date for the account.

1. Adding user test1 to the user group Moxa

```
moxa@ moxa-tbzkb1090923:# sudo usermod -a -G Moxa test1
```

2. Disabling or locking the user account test1

```
moxa@ moxa-tbzkb1090923:# sudo usermod -L test1
```

3. Activating the user account test1

```
moxa@ moxa-tbzkb1090923:# sudo usermod -U test1
```

4. Set a password expire date of 2023-11-01 for the user account test1.

```
moxa@ moxa-tbzkb1090923:# sudo usermod -e 2023-11-01 test1
```

### NOTE

Refers to below link for complete usage of **`usermod`**

https://linux.die.net/man/8/usermod

## Changing the Password

You can use the **`passwd`** commands to change the password of a user account. Changing the password will not have any impact on other functionalities.

An example of changing the password for user account **test1**.

```
moxa@ moxa-tbzkb1090923:# sudo passwd test1
New password:
Retype new password:
passwd: password updated successfully
```

# Querying the System Image Version

Use the **`mx-ver`** command to check the system **image version** on your Arm-based computer.

```
moxa@moxa-tbzkb1090923:# mx-ver
UC-8220-T-LX-US-S MIL3 version 1.0 Build 22052300
```

```
moxa@moxa-tbzkb1090923:# mx-ver -h

Usage: mx-ver [OPTION]
       -a: show product information inline
       -b: show the build time
       -m: show the model name
       -v: show the image version
       -A: show all information
       -M: show the MIL version
       -o: show the image option code
       -h: show the help menu
```

# Querying the Device Information

Use the **# mx-interface-mgmt deviceinfo** command to retrieve general information for your Moxa Arm-based Computer

| Command and Usage | Description |
|---|---|
| deviceinfo | Shows the following device information:<br>• Serial number (S/N)<br>• Model name<br>• SECUREBOOT (Enabled/Disabled) |

```
moxa@moxa-tbbbb1182827:~$ mx-interface-mgmt deviceinfo
SERIALNUMBER=TBBBB1182827
MODELNAME=UC-8220-T-LX-US-S
SECUREBOOT=Enabled
```

# Determining Available Drive Space

To determine the amount of available drive space, use the **df** command with the **–h** option. The system will return the amount of drive space broken down by file system. Here is an example:

```
moxa@moxa-tbzkb1090923:~$ sudo df -h

Filesystem       Size  Used  Avail   Use%  Mounted on
devtmpfs         485M     0   485M     0%  /dev
tmpfs            497M  7.1M   490M     2%  /run
/dev/mmcblk0p2   984M  150M   780M    17%  /boot_device/p2
/dev/mmcblk0p3   5.9G   39M   5.5G     1%  /boot_device/p3
/dev/mmcblk0p4   240M  2.8M   221M     2%  /var/log
/dev/loop0       147M  147M      0   100%  /boot_device/p2/lower
overlay          5.9G   39M   5.5G     1%  /
/dev/mmcblk0p1    54M   15M    36M    30%  /boot_device/p1
tmpfs            497M     0   497M     0%  /dev/shm
tmpfs            5.0M     0   5.0M     0%  /run/lock
tmpfs            497M     0   497M     0%  /sys/fs/cgroup
tmpfs            100M     0   100M     0%  /run/user/1000
```

# Shutting Down the Device

To shut down the computer, first disconnect the power source. When the computer is powered off, main components such as the CPU, RAM, and storage devices are powered off, although an internal clock may retain battery power.

You can use the Linux command **shutdown** to close all software running on the device and halt the system. However, main components such as the CPU, RAM, and storage devices will continue to be powered after you run this command.

```
moxa@moxa-tbzkb1090923: ~# sudo shutdown -h now
```

# 3. Device Configuration

In this chapter, we describe how to configure the basic settings of Moxa Arm-based computers, including using the bootloader menu, configuring the network connections and power-saving settings, and localizing the computer. The instructions in this chapter cover all functions supported in Moxa Arm-based computers. Before referring to the sections in this chapter, ensure that they are applicable to and are supported by the hardware specification of your Arm-based computer.

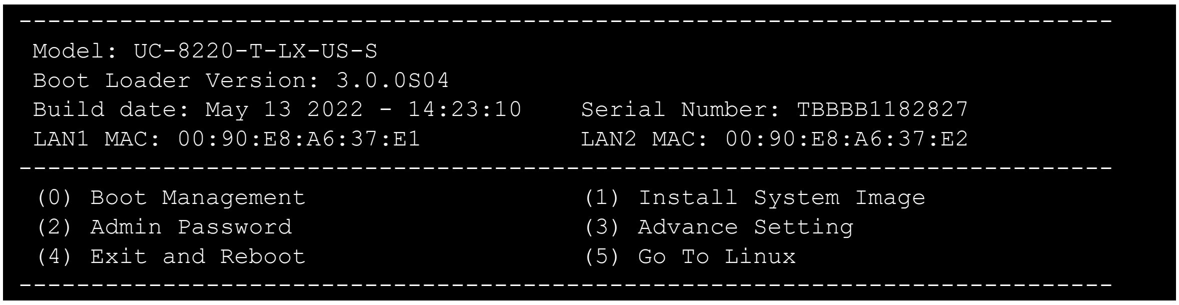
# Bootloader Configuration

## Accessing the Bootloader Configuration Menu

To access bootloader menu, you must first connect to Moxa Arm-based computer via its serial console port. After powering on the Arm-based computer, press **Ctrl + Backspace** or **DEL** to enter the bootloader configuration menu

### NOTE

If you cannot enter the bootloader menu by pressing <DEL>, replace the PuTTy tool with the Tera Term terminal console tool (detailed information is available at: https://ttssh2.osdn.jp/index.html.en.)



```
---------------------------------------------------------------------------
 Model: UC-8220-T-LX-US-S
 Boot Loader Version: 3.0.0S04
 Build date: May 13 2022 - 14:23:10    Serial Number: TBBBB1182827
 LAN1 MAC: 00:90:E8:A6:37:E1           LAN2 MAC: 00:90:E8:A6:37:E2
---------------------------------------------------------------------------
 (0) Boot Management                   (1) Install System Image
 (2) Admin Password                    (3) Advance Setting
 (4) Exit and Reboot                   (5) Go To Linux
---------------------------------------------------------------------------
```

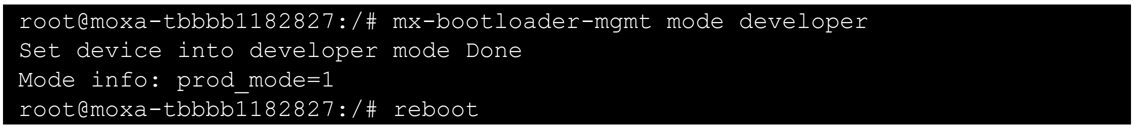
## Production and Developer Mode

The configurable options and operations in bootloader menu of Standard and Secure model are different for security consideration. Below is an overview of configuration options provided in Bootloader.

The Secure Model's bootloader menu has two modes (**Production** and **Developer mode**) where the **Production Mode** is the default mode with security configuration configured to comply with IEC 62443-4-2 security level 2 standard. **Developer Mode** provides addition operation and configuration that should only be used during development stage or maintenance.

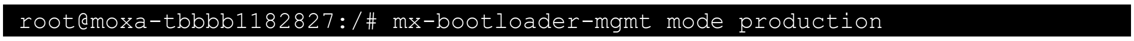
For **Secure Model**, the administrator password to access bootloader menu is set by default. The Default Administrator Password is the **unique Serial Number(S/N)** printed on the sticker of Moxa Arm-based computer

1. To switch to Developer Mode, run **`mx-bootloader-mgmt mode developer`**



```
root@moxa-tbbbb1182827:/# mx-bootloader-mgmt mode developer
Set device into developer mode Done
Mode info: prod_mode=1
root@moxa-tbbbb1182827:/# reboot
```

2. To switch to Production Mode, use **`mx-bootloader-mgmt mode -production`**



```
root@moxa-tbbbb1182827:/# mx-bootloader-mgmt mode production
```

```
Set device into production mode Done
Mode info: prod_mode=0
root@moxa-tbbbb1182827:/# reboot
```

3. Reboot computer for setting to take effect
4. To check the current mode, run **`mx-bootloader-mgmt mode info`**

An overview of bootloader configuration options is listed in the following table:

| Main Menu | Sub Menu | Secure Model | | Standard Model |
|---|---|---|---|---|
| Main Menu | Sub Menu | Production Mode | Developer Mode | Production Mode |
| (0) Boot Management | (0) Set to Default | N/A | N/A | ✓ |
| | (1) Boot Option | N/A | N/A | ✓ |
| | (2) Advance Boot Option | N/A | N/A | ✓ |
| | (3) View Current Setting | N/A | N/A | ✓ |
| (1) Install System Image | (0) Install System Image from TFTP | N/A | ✓ | ✓ |
| | (1) Install System Image from SD | ✓ | ✓ | ✓ |
| | (2) Install System Image from USB | ✓ | ✓ | ✓ |
| | (3) TFTP Settings | N/A | ✓ | ✓ |
| (2) Admin Password | (0) Set to Default | ✓ | ✓ | ✓ |
| | (1) Enable/Disable Admin Password | ✓ (enabled) | ✓ (enabled) | ✓ (disabled by default) |
| | (2) Configure Admin Password | ✓ | ✓ | ✓ |
| | (3) Configure Admin Password Policy | ✓ | ✓ | ✓ |
| (3) Advance Setting | (0) Set to Default | ✓ | ✓ | ✓ |
| | (1) Configure Auto Reboot | ✓ (enabled) | ✓ (enabled) | ✓ (disabled) |
| | (2) Configure Login Message | ✓ | ✓ | ✓ |
| | (3) Configure Invalid Login Attempts | ✓ | ✓ | ✓ |
| | (4) Clear TPM | N/A | ✓ | ✓ |
| | (5) View Bootloader log | ✓ | ✓ | ✓ |
| (3) Exit & Reboot | – | ✓ | ✓ | ✓ |
| (4) Go to Linux | – | N/A | N/A | ✓ |

# Boot Management

## Boot Option

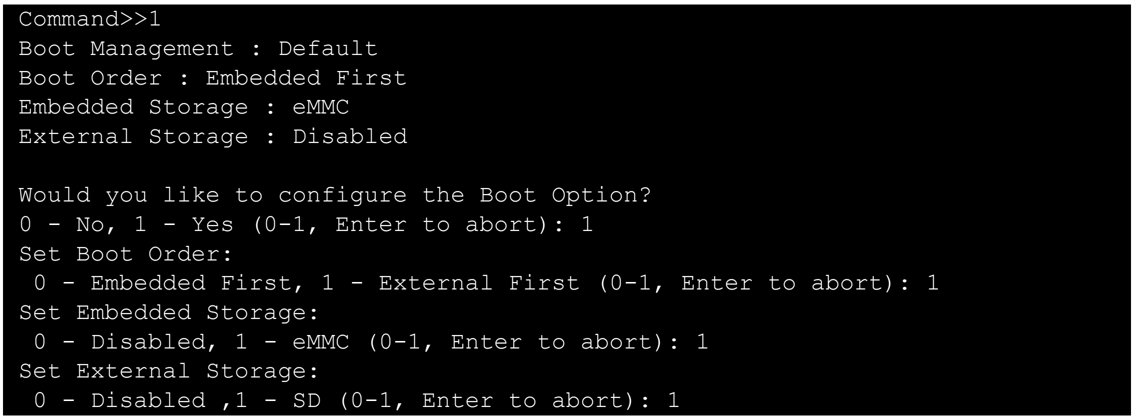
By default, Moxa Arm-based computers boot up from the embedded eMMC flash. Some models also provide an option to boot up from an external SD or USB.

The following is an example of changing first boot priority to SD card and setting the secondary boot option to SD card if the first option fails to boot.

1. Select **(0) Boot Management > (1) Boot Option**
2. Choose to first boot from an external storage.
3. Choose if the embedded storage should be disabled.

   If the embedded storage is disabled, Moxa Arm-based computers will only attempt to boot from the SD card. If embedded storage is set to eMMC, the computers will try to boot from SD; if that fails, they will boot from eMMC.
4. Set the External Storage to the SD card

```
----------------------------------------------------------------------------
 Model: UC-8220-T-LX-US-S
 Boot Loader Version: 3.0.0S04
 Build date: May 13 2022 - 14:23:10     Serial Number: TBBBB1182827
 LAN1 MAC: 00:90:E8:A6:37:E1            LAN2 MAC: 00:90:E8:A6:37:E2
----------------------------------------------------------------------------
  (0) Boot Management                    (1) Install System Image
  (2) Admin Password                     (3) Advance Setting
  (4) Exit and Reboot                    (5) Go To Linux
----------------------------------------------------------------------------
```



```
Command>>1
Boot Management : Default
Boot Order : Embedded First
Embedded Storage : eMMC
External Storage : Disabled

Would you like to configure the Boot Option?
0 - No, 1 - Yes (0-1, Enter to abort): 1
Set Boot Order:
 0 - Embedded First, 1 - External First (0-1, Enter to abort): 1
Set Embedded Storage:
 0 - Disabled, 1 - eMMC (0-1, Enter to abort): 1
Set External Storage:
 0 - Disabled ,1 - SD (0-1, Enter to abort): 1
```

The table below lists all possible combinations of boot options configuration and the corresponding boot action

| Set Boot Order | Set Embedded Storage | Set External Storage | Boot Action |
|---|---|---|---|
| 0 – Embedded First | 1 – eMMC | 0 – Disabled | Boot from eMMC |
| 1 – External First | 0 – Disabled | 1 – SD or 2 – USB | Boot from the external storage |
| 0 – Embedded First | 1 – eMMC | 1 – SD or 2 – USB | First boot from eMMC; if it fails, boot from the external storage |
| 1 – External First | 1 – eMMC | 1 – SD or 2 – USB | Boot from the external storage; if this fails, boot from eMMC |

## Advance Boot Option

Allow advanced users to edit the **bootargs** and **bootcmd** parameters to customize the boot process.

- **bootargs:** Used to tell the kernel how to configure various device drivers and where to find the root filesystem.
- **bootcmd:** Bootloader will execute the commands listed sequentially. Commands should be separated by semicolons.

# Installing the System Image

## Installing System Image From TFTP

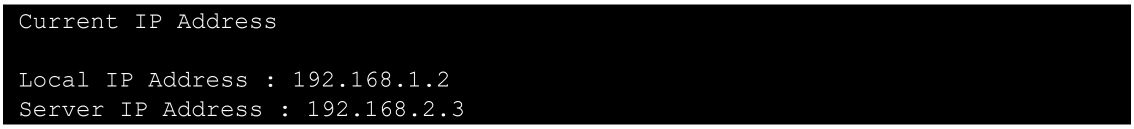
1. Prepare a TFTP server
2. Set up a TFTP server.
3. Make sure the image (*.img) file is in your TFTP server directory.

### IMPORTANT!

Use this method to install a system image on your computer if the size of the image file is less than 2 GB. If the file size is larger than 2 GB, use the SD card or USB to install the system image.

4. Select **Install System Image > TFTP Settings** and configure the following:
   - ➢ The LAN port to be used for TFTP transfer
   - ➢ Local IP address of LAN port
   - ➢ TFTP server IP
5. Press **ESC** to exit and select **Install System Image from TFTP**.

   If you want to change the TFTP IP address, enter 1 to set up the local LAN port IP address and the TFTP server IP address, and then choose an image (*.img) file.



```
Current IP Address

Local IP Address : 192.168.1.2
Server IP Address : 192.168.2.3
```

```
Using LAN2 to download data.
Do you want to change the ip address?
0 - No, 1 - Yes(0-1, Enter to abort):1
Local IP Address : 192.168.31.134
Server IP Address : 192.168.31.132
Saving Environment to SPI Flash...
Erasing SPI flash...Writing to SPI flash...done
Valid environment: 2
System Image File Name (system image.img): IMG_UC-8200_MIL3_V1.0.img
```

6. After the system image installation process is complete, unplug the power supply and reboot the system.
7. After rebooting the system, you can use the following command to check if the system image is up-to-date.

```
moxa@moxa-tbzkb1090923:# sudo mx-ver
UC-8220-T-LX-US-S MIL3 version 1.0 Build 22052300
```

## Installing the System Image From SD or USB

The system image on the Moxa Arm-based computers can be installed through an external SD or USB disk. Prepare a USB or SD disk in the FAT32 or ext4 format with the system image and plug it into the USB or SD port of the computer.

1. Select **Install System Image > Install System Image from SD** or **Install System Image from USB**
2. Type in the system image file name.

```
---------------------------------------------------------------------------
Model: UC-8220-T-LX-US-S
Boot Loader Version: 3.0.0S04
Build date: May 13 2022 - 14:23:10   Serial Number: TBBBB1182827
LAN1 MAC: 00:90:E8:A6:37:E1           LAN2 MAC: 00:90:E8:A6:37:E2
---------------------------------------------------------------------------
 (0) Install System Image from TFTP    (1) Install System Image from SD
 (2) Install System Image from USB     (3) TFTP Settings
---------------------------------------------------------------------------
Command>>2

System Image File Name (system image.img): IMG_UC-8200_MIL3_V1.0.img
```

### NOTE

Make sure to put **the hash file of the system image** in the same folder as image as integrity validation is required

3. After the system image installation process is complete, unplug the power supply and reboot the system.
4. After rebooting the system, you can use the following command to check if the system image is up-to-date.

```
moxa@moxa-tbzkb1090923:# sudo mx-ver
UC-8220-T-LX-US-S MIL3 version 1.0 Build 22052300
```

# Administrator Password

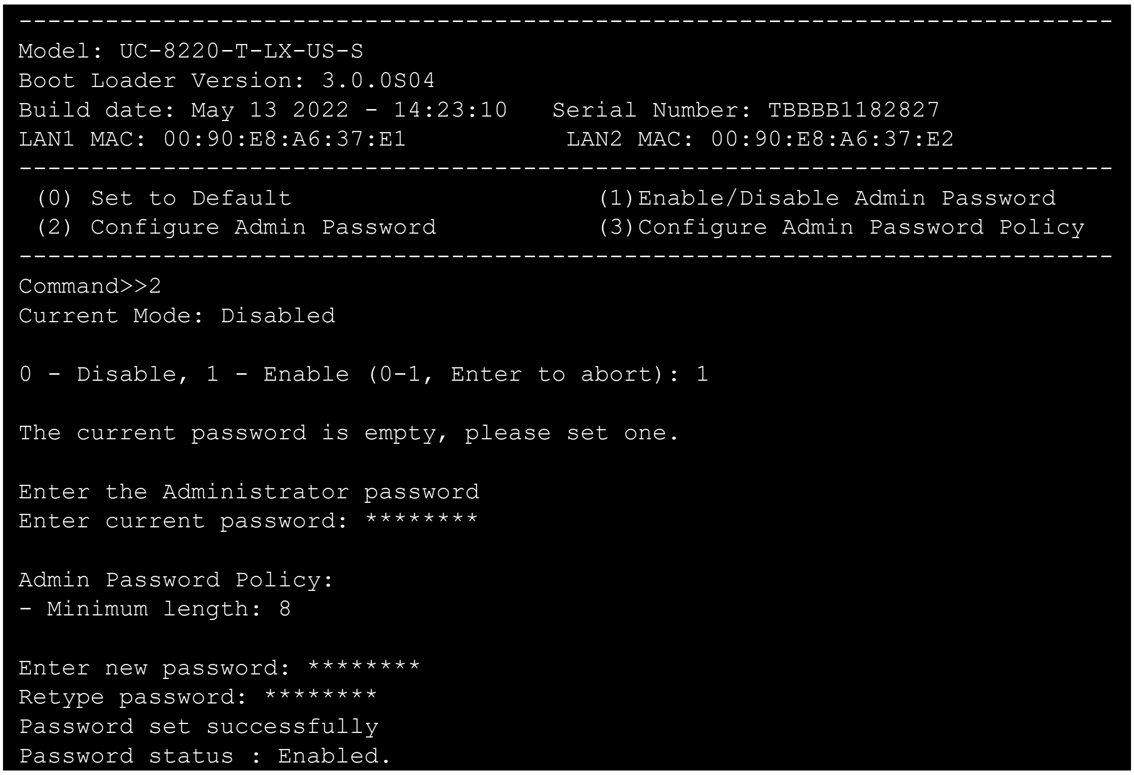
## Enabling/Disabling Admin Password

For the **Secure Model**, the administrator password to access bootloader menu is set by default. The

Default Administrator Password is the **unique Serial Number(S/N)** printed on the sticker of Moxa Arm-based computer.

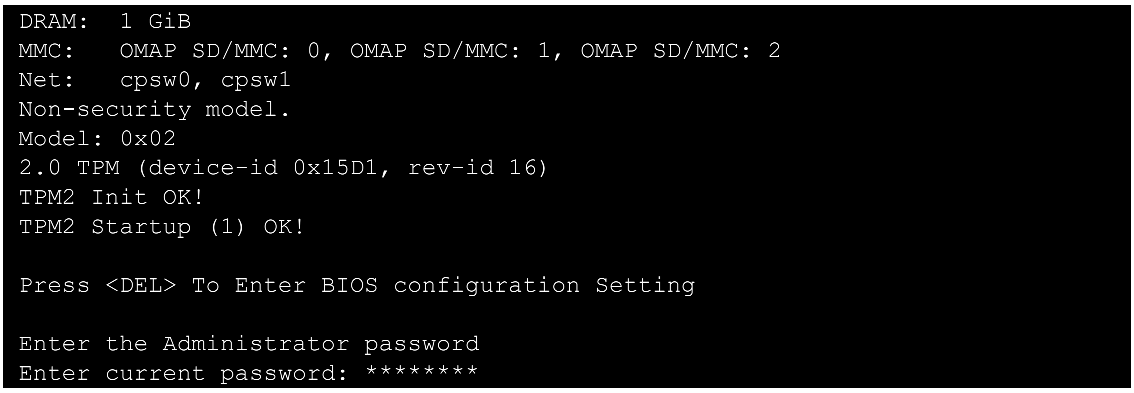
For **Standard Model**, the bootloader menu is not protected by password by default. To enhance the security of your Moxa Arm-based computer, it is strongly recommended to setup an administrator password if there is physical unauthorized access is possible. To setup an administrator password, follow the below procedures:

1. Select **Admin Password > Enable/Disable Admin Password**.
2. Select **1** to setup an administrator password. If **0** (disable) is selected, the currently set password will be cleared.
3. Enter the password you would like to set twice; the password strength requirement is at least 8 characters in length.



```
----------------------------------------------------------------------------
Model: UC-8220-T-LX-US-S
Boot Loader Version: 3.0.0S04
Build date: May 13 2022 - 14:23:10   Serial Number: TBBBB1182827
LAN1 MAC: 00:90:E8:A6:37:E1           LAN2 MAC: 00:90:E8:A6:37:E2
----------------------------------------------------------------------------
 (0) Set to Default                     (1)Enable/Disable Admin Password
 (2) Configure Admin Password           (3)Configure Admin Password Policy
----------------------------------------------------------------------------
Command>>2
Current Mode: Disabled

0 - Disable, 1 - Enable (0-1, Enter to abort): 1

The current password is empty, please set one.

Enter the Administrator password
Enter current password: ********

Admin Password Policy:
- Minimum length: 8

Enter new password: ********
Retype password: ********
Password set successfully
Password status : Enabled.
```

4. Once Administrator password is set, password authentication is required when accessing bootloader menu.



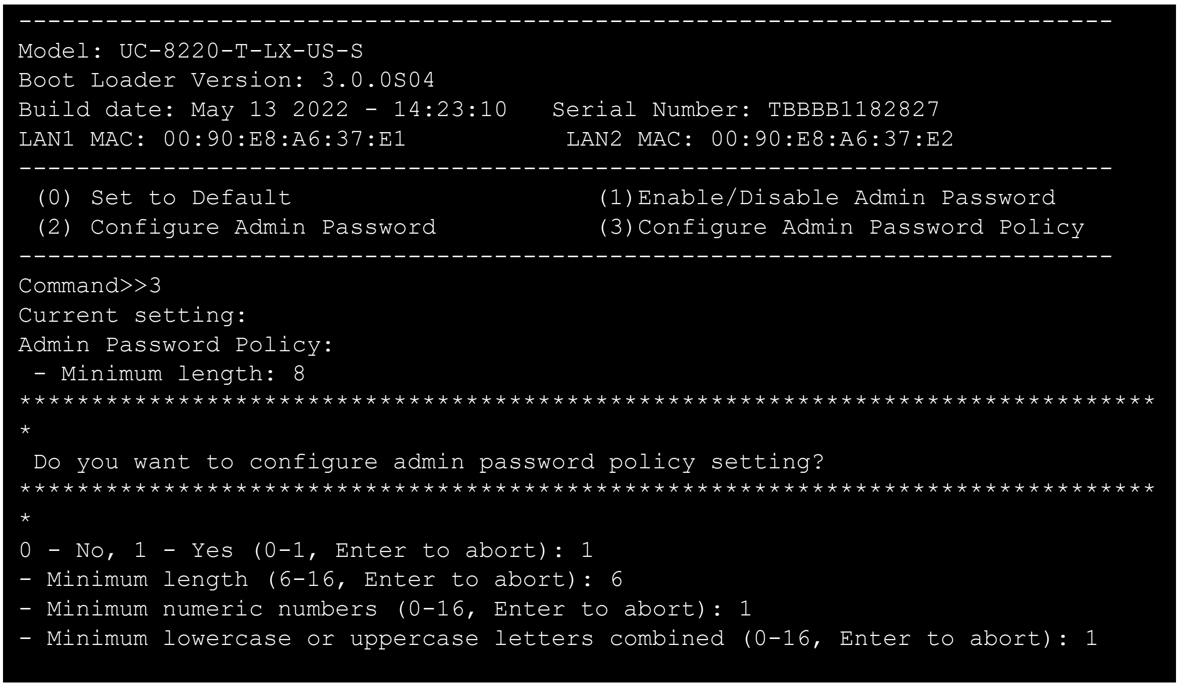
```
DRAM:  1 GiB
MMC:   OMAP SD/MMC: 0, OMAP SD/MMC: 1, OMAP SD/MMC: 2
Net:   cpsw0, cpsw1
Non-security model.
Model: 0x02
2.0 TPM (device-id 0x15D1, rev-id 16)
TPM2 Init OK!
TPM2 Startup (1) OK!

Press <DEL> To Enter BIOS configuration Setting

Enter the Administrator password
Enter current password: ********
```

## WARNING

It is important to save the password in a secure location. If the password is lost and access to bootloader menu is needed, you will have to contact Moxa technical support to send your Arm-based computer to Moxa for password reset.

## Configuring the Admin Password Policy

To change the administrator password, select **Admin Password > Configure Admin Password** and follows the on-screen instructions. Changing the password will not have any impact on functionalities.



```
-----------------------------------------------------------------------------
Model: UC-8220-T-LX-US-S
Boot Loader Version: 3.0.0S04
Build date: May 13 2022 - 14:23:10   Serial Number: TBBBB1182827
LAN1 MAC: 00:90:E8:A6:37:E1           LAN2 MAC: 00:90:E8:A6:37:E2
-----------------------------------------------------------------------------
 (0) Set to Default                     (1)Enable/Disable Admin Password
 (2) Configure Admin Password           (3)Configure Admin Password Policy
-----------------------------------------------------------------------------
Command>>3
Current setting:
Admin Password Policy:
 - Minimum length: 8
********************************************************************************
*
 Do you want to configure admin password policy setting?
********************************************************************************
*
0 - No, 1 - Yes (0-1, Enter to abort): 1
- Minimum length (6-16, Enter to abort): 6
- Minimum numeric numbers (0-16, Enter to abort): 1
- Minimum lowercase or uppercase letters combined (0-16, Enter to abort): 1
```

### Minimum Length

| Setting | Description | Factory Default |
|---|---|---|
| Input from 6 to 16 | It allows users to decide the minimum length of the password. | 8 |

### Minimum Numeric Numbers

| Setting | Description | Factory Default |
|---|---|---|
| Input from 0 to 16 | It allows users to decide the minimum of numeric number that the password must contain | 0 |

### Minimum Lowercase or Uppercase Letters Combined

| Setting | Description | Factory Default |
|---|---|---|
| Input from 0 to 16 | It allows users to decide the minimum letters (lowercase or uppercase combined) that the password must contain. | 0 |

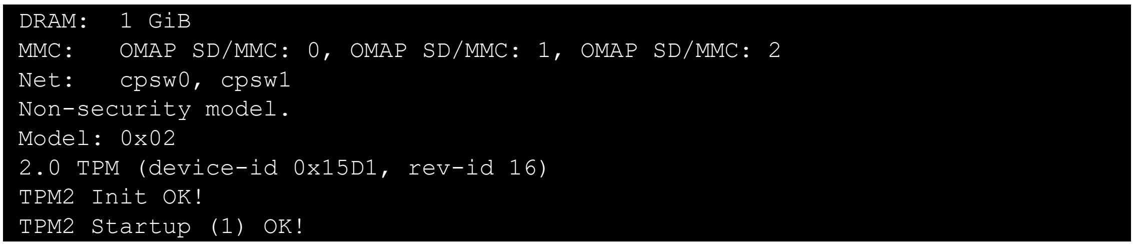
## Configuring Admin Password

To change the administrator password, select **Admin Password > Configure Admin Password** and follows the on-screen instructions

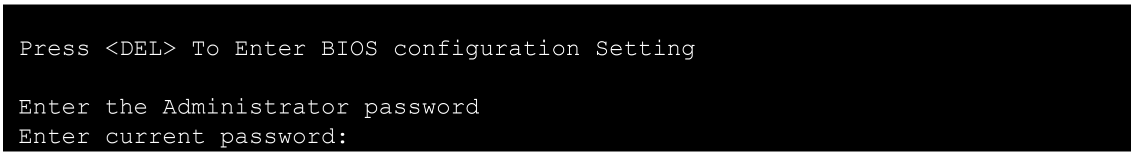
## Resetting the Admin Password to Default

If you lost your password, follow the below steps to reset the password to the factory default

1. After powering on the Arm-based computer, press **Ctrl + Backspace** or **DEL** to enter the Bootloader configuration menu that prompts for a password.



```
DRAM:  1 GiB
MMC:   OMAP SD/MMC: 0, OMAP SD/MMC: 1, OMAP SD/MMC: 2
Net:   cpsw0, cpsw1
Non-security model.
Model: 0x02
2.0 TPM (device-id 0x15D1, rev-id 16)
TPM2 Init OK!
TPM2 Startup (1) OK!
```



```
Press <DEL> To Enter BIOS configuration Setting

Enter the Administrator password
Enter current password:
```

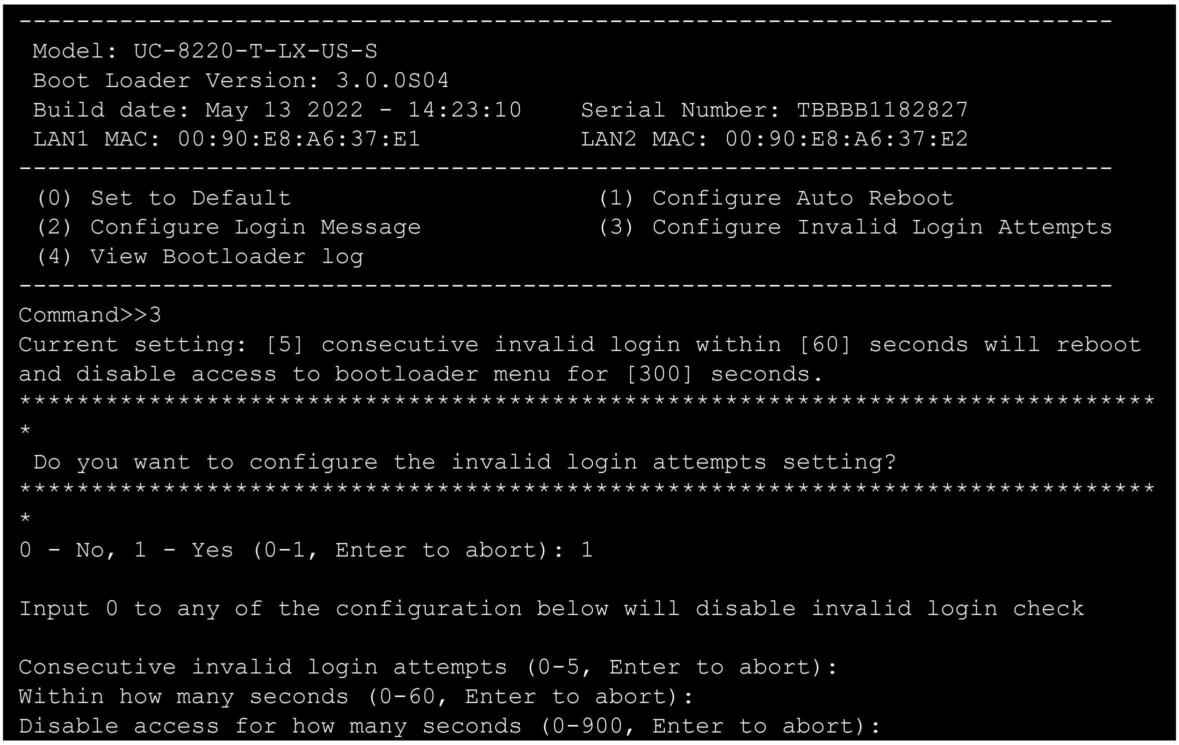
2. Immediately press and hold the **FN** button on the Moxa Arm-based computer for over 5 seconds will trigger the password reset process. You must complete this step within **10 seconds** after step one for the reset process to initiate.

# Login Policy

## Invalid Login Attempts

This determines the **maximum consecutive failure login attempts** allowed during the specified **time period** and the duration to block users from accessing bootloader configuration menu when failure login attempts and time period is over the defined threshold.

To configure this policy, select **Advance Setting > Configure Invalid Login Attempts** and follow the on-screen instructions.



```
----------------------------------------------------------------------------
 Model: UC-8220-T-LX-US-S
 Boot Loader Version: 3.0.0S04
 Build date: May 13 2022 - 14:23:10    Serial Number: TBBBB1182827
 LAN1 MAC: 00:90:E8:A6:37:E1           LAN2 MAC: 00:90:E8:A6:37:E2
----------------------------------------------------------------------------
 (0) Set to Default                      (1) Configure Auto Reboot
 (2) Configure Login Message             (3) Configure Invalid Login Attempts
 (4) View Bootloader log
----------------------------------------------------------------------------
Command>>3
Current setting: [5] consecutive invalid login within [60] seconds will reboot
and disable access to bootloader menu for [300] seconds.
*******************************************************************************
*
 Do you want to configure the invalid login attempts setting?
*******************************************************************************
*
0 - No, 1 - Yes (0-1, Enter to abort): 1

Input 0 to any of the configuration below will disable invalid login check

Consecutive invalid login attempts (0-5, Enter to abort):
Within how many seconds (0-60, Enter to abort):
Disable access for how many seconds (0-900, Enter to abort):
```

### Consecutive Invalid Login Attempts

| Configuration | Setting | Factory Default |
|---|---|---|
| Consecutive invalid login attempts | Input from 0 to 5 | 0 (Standard model)<br>5 (Secure model) |
| Within how many Seconds | Input from 0 to 60 | 0 (Standard model)<br>60 (Secure model) |
| Disable access for how many seconds | Input from 0 to 900 | 0 (Standard model)<br>300 (Secure model) |

**NOTE**

Input 0 to any of the above configuration will disable the invalid login check.

### Auto Reboot After Inactivity

This determines the time period for auto reboot when users do not do any action.

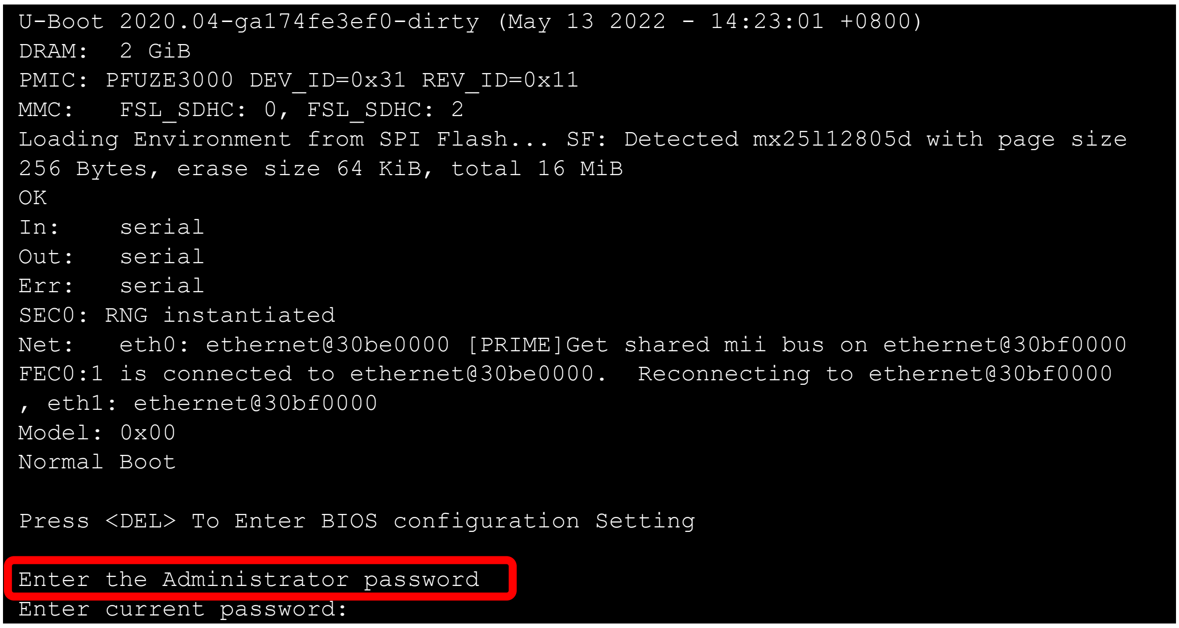
To set the time period, select **(2) Advance Setting > (1) Configure Auto Reboot** and follow the on-screen instructions.

| Setting | Description | Factory Default |
|---|---|---|
| Input from 0 to 900 (seconds) | This determines the time period for auto reboot when users do not do any action | 0 (Standard model)<br>900 (Secure model) |

### Login Banner Message

This allows users to customize the login message before prompting the administrator password.

To configure the message, select **Advance Setting > Configure Login Message** and follow the on-screen instructions.



```
U-Boot 2020.04-ga174fe3ef0-dirty (May 13 2022 - 14:23:01 +0800)
DRAM:  2 GiB
PMIC: PFUZE3000 DEV_ID=0x31 REV_ID=0x11
MMC:   FSL_SDHC: 0, FSL_SDHC: 2
Loading Environment from SPI Flash... SF: Detected mx25l12805d with page size
256 Bytes, erase size 64 KiB, total 16 MiB
OK
In:    serial
Out:   serial
Err:   serial
SEC0: RNG instantiated
Net:   eth0: ethernet@30be0000 [PRIME]Get shared mii bus on ethernet@30bf0000
FEC0:1 is connected to ethernet@30be0000.  Reconnecting to ethernet@30bf0000
, eth1: ethernet@30bf0000
Model: 0x00
Normal Boot

Press <DEL> To Enter BIOS configuration Setting

Enter the Administrator password
Enter current password:
```

## Clearing the TPM Module

Clearing the TPM will erases information stored on the TPM. You will lose all created keys and access to data encrypted by these keys.

To clear the TPM, select **Advance Setting > Clear TPM** and follow the directions.

# Localizing Your Arm-based Computer

## Adjusting the Time

The Arm-based computer has two time settings. One is the system time, and the other is the RTC (Real Time Clock) time kept by the Arm-based computer's hardware. Use the **`date`** command to query the current system time or set a new system time. Use the **`hwclock`** command to query the current RTC time or set a new RTC time.

Use the **`date MMDDhhmmYYYY`** command to set the system time:

**MM** = Month
**DD** = Date
**hhmm** = hour and minute

```
moxa@moxa-tbzkb1090923:# sudo date 102900282021
Fri 29 Oct 2021 12:28:00 AM GMT
```

Use the following command to set the RTC time to system time:

```
moxa@moxa-tbzkb1090923:# sudo hwclock -w
moxa@moxa-tbzkb1090923:# sudo hwclock
2021-10-28 16:25:04.077432+00:00
```

### NOTE

Click the following links for more information on date and time:

https://www.debian.org/doc/manuals/system-administrator/ch-sysadmin-time.html

https://wiki.debian.org/DateTime

## NTP Time Synchronization

The Moxa Industrial Linux (MIL) uses Network Time Security (NTS) to secure NTP, which provides a handshake (TLS) before using a NTP server and authentication of the NTP time synchronization packets using the results of the TLS handshake.

The default NTP client in MIL is `Chrony`. MIL disabled NTP server without NTS support by default and uses the following public NTP servers that support NTS.

- Cloudflare
- Netnod
- System76
- PTB

The default server list is configured in the **/etc/chrony/sources.d/moxa-nts.sources** file.

```
# prefer nts over ntp server
server time.cloudflare.com nts iburst prefer
server sth1.nts.netnod.se nts iburst prefer
server sth2.nts.netnod.se nts iburst prefer
server virginia.time.system76.com nts iburst prefer
server ohio.time.system76.com nts iburst prefer
server oregon.time.system76.com nts iburst prefer
server ptbtime1.ptb.de nts iburst prefer
server ptbtime2.ptb.de nts iburst prefer
server ptbtime3.ptb.de nts iburst prefer
```

The configuration file for Chrony is at **/etc/chrony/chrony.conf**.

The following example show some basic functions to monitor the current status of the Chrony's chronyc tool and make changes if necessary.

1. Check the time synchronization status between the local system and reference server using the command:

   **`# chronyc tracking`**

   ```
   moxa@moxa-tbbbb1182827:~$ chronyc tracking
   Reference ID    : A29FC801 (time.cloudflare.com)
   Stratum         : 4
   Ref time (UTC)  : Sun Jul 31 18:27:42 2022
   System time     : 0.000334575 seconds slow of NTP time
   Last offset     : +0.000226902 seconds
   RMS offset      : 0.005672113 seconds
   Frequency       : 27.766 ppm fast
   Residual freq   : -0.065 ppm
   Skew            : 3.403 ppm
   Root delay      : 0.203054637 seconds
   Root dispersion : 0.006750254 seconds
   ```

```
Update interval : 517.4 seconds
Leap status     : Normal
```

2. Check the time source configured in the **/etc/chrony/chrony.conf** file using the **`# chronyc sources`** command.

```
moxa@moxa-tbbbb1182827:~$ chronyc sources

MS Name/IP address         Stratum Poll Reach LastRx Last sample
=============================================================================
===
^+ ohio.time.system76.com     2   9   377   147    +18ms[  +18ms] +/-  141ms
^+ oregon.time.system76.com   2   9   377   203    +14ms[  +14ms] +/-  137ms
^- ptbtime1.ptb.de            1   9    21   682  -2780us[-2417us] +/-  166ms
^- ptbtime2.ptb.de            1   9    21   674  -5243us[-4882us] +/-  169ms
^- ptbtime3.ptb.de            1   9    21   687    +17ms[  +17ms] +/-  192ms
^+ sth1-ts.nts.netnod.se      1   9   377   220    -12ms[  -12ms] +/-  162ms
^- sth2-ts.nts.netnod.se      1   8   377    91  -3843us[-3843us] +/-  171ms
^* time.cloudflare.com        3   9   377   230    +13ms[  +13ms] +/-  129ms
^+ virginia.time.system76.c>  2   9   377   226  -8753us[-8753us] +/-  116ms
```

3. Manually synchronize the time using the **`# chronyc makestep`** command.

**NOTE**

For additional details on Chrony, check the following links:
https://linux.die.net/man/8/chronyd
https://linux.die.net/man/1/chronyc

# Setting the Time Zone

There are two ways to configure the Moxa Arm-based computer's time zone. One is using the **TZ** variable. The other is using the **/etc/localtime** file.

## Using the TZ Variable

The format of the TZ environment variable looks like this:

TZ=*<Value>HH[:MM[:SS]][daylight[HH[:MM[:SS]]][,start date[/starttime], enddate[/endtime]]]*

Here are some possible settings for the North American Eastern time zone:

1. **`TZ=EST5EDT`**
2. **`TZ=EST0EDT`**
3. **`TZ=EST0`**

In the first case, the reference time is GMT and the stored time values are correct worldwide. A simple change of the TZ variable can print the local time correctly in any time zone.

In the second case, the reference time is Eastern Standard Time and the only conversion performed is for Daylight Saving Time. Therefore, there is no need to adjust the hardware clock for Daylight Saving Time twice per year.

In the third case, the reference time is always the time reported. You can use this option if the hardware clock on your machine automatically adjusts for Daylight Saving Time or you would like to manually adjust the hardware time twice a year.

```
moxa@Moxa-tbzkb1090923:~$ TZ=EST5EDT
moxa@Moxa-tbzkb1090923:~$ export TZ
```

You must include the TZ setting in the **/etc/rc.local** file. The time zone setting will be activated when you restart the computer.

The following table lists other possible values for the TZ environment variable:

| Hours From Greenwich Mean Time (GMT) | Value | Description |
|---|---|---|
| 0 | GMT | Greenwich Mean Time |
| +1 | ECT | European Central Time |
| +2 | EET | European Eastern Time |
| +2 | ART | |
| +3 | EAT | Saudi Arabia |
| +3.5 | MET | Iran |
| +4 | NET | |
| +5 | PLT | West Asia |
| +5.5 | IST | India |
| +6 | BST | Central Asia |
| +7 | VST | Bangkok |
| +8 | CTT | China |
| +9 | JST | Japan |
| +9.5 | ACT | Central Australia |
| +10 | AET | Eastern Australia |
| +11 | SST | Central Pacific |
| +12 | NST | New Zealand |
| -11 | MIT | Samoa |
| -10 | HST | Hawaii |
| -9 | AST | Alaska |
| -8 | PST | Pacific Standard Time |
| -7 | PNT | Arizona |
| -7 | MST | Mountain Standard Time |
| -6 | CST | Central Standard Time |
| -5 | EST | Eastern Standard Time |
| -5 | IET | Indiana East |
| -4 | PRT | Atlantic Standard Time |
| -3.5 | CNT | Newfoundland |
| -3 | AGT | Eastern South America |
| -3 | BET | Eastern South America |
| -1 | CAT | Azores |

## Using the localtime File

The local time zone is stored in the **/etc/localtime** and is used by GNU Library for C (glibc) if no value has been set for the TZ environment variable. This file is either a copy of the **/usr/share/zoneinfo/** file or a symbolic link to it. The Arm-based computer does not provide **/usr/share/zoneinfo/** files. You should find a suitable time zone information file and write over the original local time file in the Arm-based computer.

# 4. Using and Managing Computer Interfaces

In this chapter, we include more information on the Arm-based computer's interfaces, such as the serial interface, storage, diagnostic LEDs, and the wireless module. The instructions in this chapter cover all functions supported in Moxa's Arm-based computers. Before referring to the sections in this chapter, make sure that they are applicable to and are supported by the hardware specification of your Arm-based computer.

## Moxa Computer Interface Manager (MCIM)

On many occasions, there isn't one standard method to access and configure specific interfaces on Moxa Arm-based computers because the hardware varies. Hence, programing across different Moxa Arm-based computer models can be difficult and time consuming. The goal of MCIM is to provide a unified software interface to access and configure non-standard computer interfaces. For example, MCIM can change the serial port interface mode (e.g., RS-232, RS-485-2W,RS-422). However, configuring the serial port baud rate is not possible in MCIM because Linux provides a standard method to set the baud rate

MCIM is a command-line interface (CLI) Moxa utility designed to access and manage Moxa Arm-based computers' interfaces. Use the **`# mx-interface-mgmt`** command to display the menu page.

### Configuring the Log Level

To set the log level of MCIM, edit the configuration file **`/etc/moxa/MoxaComputerInterfaceManager/MoxaComputerInterfaceManager.con`**

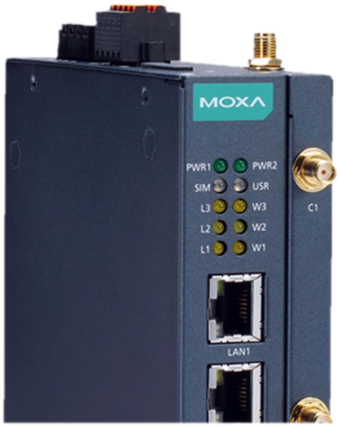
| Key | Value | Description |
|---|---|---|
| LOG_LEVEL | debug/info/warn/error | The log-level settings for the logs generated by MCIM for debugging and troubleshooting. The default level is "info" |

## Device Information

Use the **`# mx-interface-mgmt deviceinfo`** command to get information on your Moxa Arm-based computer.

| Command and Usage | Description |
|---|---|
| deviceinfo | Show the following information:<br>• Serial number (S/N)<br>• Model name<br>• SECUREBOOT (Enabled / Disabled) |

# LED Indicators



Use **# mx-interface-mgmt led** command to get the list of controllable LEDs on your Arm-based computer. In the following example, the returned NAME "L1" refers to the yellow LED for cellular signal, labeled "L1" on the device. For **LEDs** with **multiple colors** such as USR (yellow and green), 2 LED names will appears (USR_Yellow and USR_Green). For this type of LEDs, you must set the state of a color to "off" before setting another color to "on" or "blinking".

```
moxa@moxa-tbzkb1090923:~$ mx-interface-mgmt led

NAME          LABEL                        STATE
W3             W3:yellow:signal            off
USR_Yellow     USR:yellow:programmable     off
USR_Green      USR:green:programmable      off
L1             L1:yellow:signal            off
W1             W1:yellow:signal            off
L2             L2:yellow:signal            off
W2             W2:yellow:signal            off
L3             L3:yellow:signal            off
```

The MCIM commands for LED indicator controls are listed in the following table:

| **Command and Usage** | **Description** |
|---|---|
| **led** | Shows the following information for all controllable LEDs<br>• Name (as labeled on the device)<br>• Model series of the device<br>• Color of the LED<br>• Description of the LED<br>• LED state (on/off/heartbeat) |
| **led *<led_name>*** | Show the above information of a **specified** LED |
| **led *<led_name>* get_state** | Get the current state (on/off/heartbeat) of a **specified** LED |
| **led *<led_name>* set_state *<led_state>*** | Set the state of a **specified** LED. Value of <state> can be **on**, **off**, or **heartbeat** |

An example of changing the current state of USR LED from **yellow** (steady) to **yellow** (blinking) is given below:

```
moxa@moxa-tbzkb1090923:~# sudo mx-interface-mgmt led USR_Yellow
NAME=SYS
LABEL= USR_Yellow
STATE=on
moxa@moxa-tbzkb1090923:~# sudo mx-interface-mgmt led USR_Yellow set_state
heartbeat
moxa@moxa-tbzkb1090923:~# sudo mx-interface-mgmt led USR_Yellow get_state
heartbeat
```

# Storage and Partitions

Use **# mx-interface-mgmt disk and # mx-interface-mgmt partition** commands for managing the storage device and partitions.

| Command and Usage | Description |
|---|---|
| **disk** | Show the following information of **all** embedded and external storage<br>• Name (e.g., eMMC, USB, SD)<br>• Device node (e.g., /dev/mmcblk0)<br>• System disk (Y/N), if 'Y', it is the disk with MIL installed.<br>• Number of partitions<br>• Automount enabled/disabled (Y/N) |
| **disk *<disk_name>*** | Show the following information of a **specified** storage device<br>• Name (e.g., eMMC, USB, SD)<br>• Device node (e.g., /dev/mmcblk0)<br>• System disk (Y/N), if 'Y', it is the disk with MIL installed.<br>• Partition name and device node<br>• Automount enabled/disabled (Y/N) |
| **disk *<disk_name>* set_automount *<value>*** | Set a **specified** external storage device (e.g., USB, SD) to automount when attach to device; <value> is true/false |
| **partition** | Show the following information for partitions on **all** embedded and external storage devices:<br>• Name (e.g., eMMC_p1, eMMC_p2, USB_p1)<br>• Device node (e.g., /dev/mmcblk0p1)<br>• Partition mounted (Y/N)<br>• Partition mount point (e.g., /boot_device/p1)<br>• Filesystem (e.g., ext4, FAT32) |
| **partition *<partition_name>*** | Show the above information of a **specified** partition |
| **partition *<partition_name>* mount** | Mount a **specified** partition |
| **partition *<partition_name>* unmount** | Unmount a **specified** partition |

For example, to query available storage device and set USB storage drive to automount, use the following command:

```
moxa@moxa-tbzkb1090923:~$ mx-interface-mgmt disk
NAME  DEVICE         SYSTEM_DISK  NUMBER_OF_PARTITIONS  AUTOMOUNT_SETTING
USB   /dev/sdb       N              1                         false
eMMC  /dev/mmcblk0  Y              4                         false
moxa@moxa-tbzkb1090923:~$ sudo mx-interface-mgmt disk USB set_automount true
```

To query available partitions and mount the partition 1 of the USB storage drive, use the following command:

```
moxa@moxa-tbzkb1090923:~# mx-interface-mgmt partition
NAME       DEVICE           IS_MOUNTED  FS_TYPE  MOUNTPOINT
eMMC_p1   /dev/mmcblk0p1  Y             ext4     /boot_device/p1
eMMC_p2   /dev/mmcblk0p2  Y             ext4     /boot_device/p2
eMMC_p3   /dev/mmcblk0p3  Y             ext4     /boot_device/p3
eMMC_p4   /dev/mmcblk0p4  Y             ext4     /boot_device/p4
USB_p1    /dev/sdb1        N             N/A       N/A

moxa@moxa-tbzkb1090923:~# sudo mx-interface-mgmt partition USB_p1 mount
moxa@moxa-tbzkb1090923:~$ mx-interface-mgmt partition USB_p1
NAME=USB_p1
DEVICE=/dev/sdb1
IS_MOUNTED=Y
FS_TYPE=vfat
MOUNTPOINT=/media/USB_p1
```

**WARNING**

Setting external storage device to automount may expose your device to cybersecurity risks. It is strongly recommended that you not automount storage device unless your device is placed is in a highly secure environment.

# Serial Port

The serial ports support RS-232, RS-422, and RS-485 2-wire operation modes with flexible baudrate settings. The default operation mode is RS-232.

Use the **`# mx-interface-mgmt serialport`** command to query and configure the operation mode for the serial ports.

| Command and Usage | Description |
|---|---|
| **`serialport`** | Shows the following information for **all** serial ports on the device:<br>• Name (as labeled on device)<br>• Device node (e.g., /dev/ttyM0) |
| **`serialport <serialport_name>`** | Shows the following information for a **specified** serial port:<br>• Name (as labeled on device)<br>• Device node (e.g., /dev/ttyM0)<br>• Supported operation modes (e.g., RS-232, RS-485-2W, RS-422)<br>• Supported baudrates<br>• Current operation mode configured |
| **`serialport <serialport_name> get_interface`** | Gets the current operation mode for a **specified** serial port |
| **`serialport <serialport_name> set_interface <serial_interface>`** | Sets the operation mode for a **specified** serial port. |

## Changing the Serial Port Operation Mode

For example, to change the mode of COM1 serial port from default RS-232 mode to the RS-422 mode, use the following command:

```
moxa@moxa-tbzkb1090923:~# mx-interface-mgmt serialport
NAME  DEVICE
COM1  /dev/ttyM0
COM2  /dev/ttyM1
moxa@moxa-tbzkb1090923:~# mx-interface-mgmt serialport COM1
NAME=COM1
DEVICE=/dev/ttyM0
SUPPORTED_INTERFACES=RS-232,RS-485-2W,RS-422
SUPPORTED_BAUDRATES=50,300,600,1200,1800,2400,4800,9600,19200,38400,57600,11520
0,230400,460800,921600
INTERFACE=RS-232
moxa@moxa-tbzkb1090923:~# sudo mx-interface-mgmt serialport COM1 set_interface
RS-422
moxa@moxa-tbzkb1090923:~# mx-interface-mgmt serialport COM1 get_interface
RS-422
root@moxa-tbzkb1090923:~#
```

## Changing Other Serial Interface Settings with STTY

The **stty** command is used to view and modify the serial terminal settings.

### Displaying All Settings

Use the following example to display all serial terminal settings of COM1 serial port.

```
moxa@moxa-tbzkb1090923:/# mx-interface-mgmt serialport
NAME  DEVICE
COM1  /dev/ttyM0
COM2  /dev/ttyM1

moxa@moxa-tbzkb1090923:/#  sudo stty -a -F /dev/ttyM0
speed 9600 baud; rows 0; columns 0; line = 0;
intr = ^C; quit = ^\; erase = ^?; kill = ^U; eof = ^D; eol = <undef>;
eol2 = <undef>; swtch = <undef>; start = ^Q; stop = ^S; susp = ^Z; rprnt = ^R;
werase = ^W; lnext = ^V; flush = ^O; min = 1; time = 0;
-parenb -parodd cs8 hupcl -cstopb cread clocal -crtscts
-ignbrk -brkint -ignpar -parmrk -inpck -istrip -inlcr -igncr icrnl ixon -ixoff
-iuclc -ixany -imaxbel -iutf8
opost -olcuc -ocrnl onlcr -onocr -onlret -ofill -ofdel nl0 cr0 tab0 bs0 vt0 ff0
isig icanon iexten echo echoe echok -echonl -noflsh -xcase -tostop -echoprt
echoctl echoke
```

### Configuring Serial Settings

The following example changes the baudrate to 115200.

```
moxa@moxa-tbzkb1090923:~$ sudo stty 115200 -F /dev/ttyM0
```

Check the settings to confirm that the baudrate has changed to 115200.

```
moxa@moxa-tbzkb1090923:~$ sudo stty -a -F /dev/ttyM0
speed 115200 baud; rows 0; columns 0; line = 0;
intr = ^C; quit = ^\; erase = ^?; kill = ^U; eof = ^D; eol = <undef>;
eol2 = <undef>; swtch = <undef>; start = ^Q; stop = ^S; susp = ^Z; rprnt = ^R;
werase = ^W; lnext = ^V; flush = ^O; min = 1; time = 0;
-parenb -parodd cs8 hupcl -cstopb cread clocal -crtscts
-ignbrk -brkint -ignpar -parmrk -inpck -istrip -inlcr -igncr icrnl ixon -ixoff
-iuclc -ixany -imaxbel -iutf8
opost -olcuc -ocrnl onlcr -onocr -onlret -ofill -ofdel nl0 cr0 tab0 bs0 vt0 ff0
isig icanon iexten echo echoe echok -echonl -noflsh -xcase -tostop -echoprt
echoctl echoke
```

### NOTE

Detailed information on the **stty** utility is available at the following link:

https://manpages.debian.org/bullseye/coreutils/stty.1.en.html

# Ethernet Interface

Use **# mx-interface-mgmt ethernet** command to display information on the Ethernet ports.

| Command and Usage | Description |
|---|---|
| **ethernet** | Show the following information of **all** ethernet ports on the device.<br>• Name (as labeled on device)<br>• Network interface name (eth0, eth1, etc.) |
| **ethernet <ethernet_name>** | Show the above information of a **specified** ethernet port |

```
moxa@moxa-tbzkb1090923:~$ mx-interface-mgmt ethernet
NAME  DEVICE_NAME
LAN1  eth0
LAN2  eth1
moxa@moxa-tbzkb1090923:~$ mx-interface-mgmt ethernet LAN1
NAME=LAN1
DEVICE_NAME=eth0
moxa@moxa-tbzkb1090923:~$
```

# Serial Console Interface

Use the **# mx-interface-mgmt console** command to display the serial console port information.

| Command and Usage | Description |
|---|---|
| **console** | Show the following information for the console port.<br>• Name (as labeled on the device)<br>• Device node (e.g., /dev/ttyS0) |
| **Console <console_name>** | Show the above information of a specified serial console interface |

Following is an example of showing the console port device node

```
root@moxa-tbzkb1090923:~# mx-interface-mgmt console
NAME     DEVICE
Console  /dev/ttyS0
root@moxa-tbzkb1090923:~#
```

# Digital Input/Output (DIO)

Use the **# mx-interface-mgmt dio** command to query and configure the state for each digital input/output (DIO) interface, and also configure the hook script.

The predetermined state of the digital output interface is high (open circuit).

| Command and Usage | Description |
|---|---|
| **dio** | Shows the following information of **all** DIO interfaces:<br>• Name (as labeled on device)<br>• State (high/low)<br>• Event<br>• Path of falling edge script<br>• Path of rising edge script |
| **dio <dio_name>** | Shows the above information of a **specified** DI or DO interface |
| **dio <dio_name> get_state** | Gets the current state (high/low) of a **specified** DI or DO interface |
| **dio <dio_name> set_state <dio_state>** | Sets the state (high/low) of a **specified** DO interface |
| **dio <dio_name> add_hook <edge> <path>** | Adds an edge script (rising/falling) from a **specified** path to an interface |
| **dio <dio_name> remove_hook <edge>** | Removes the edge script (rising/falling) of an interface |

# Buzzer

Use the **# mx-interface-mgmt buzzer** command to query and set the state for buzzer alarm in Moxa Arm-based computers with a buzzer.

| Command and Usage | Description |
|---|---|
| **buzzer** | Show the following information of **all** buzzers<br>• Name<br>• State (on/off) |
| **buzzer <buzzer_name>** | Show the following information of a **specified** buzzer<br>• Name<br>• State (on/off) |
| **buzzer <buzzer_name> get_state** | Get the current state (on/off) of a **specified** buzzer |
| **buzzer <buzzer_name> set_state** | Set the state (on/off) of a **specified** buzzer |

# Cellular Module Interface

Use **# mx-interface-mgmt cellular** command to query and manage cellular module(s)

| Command and Usage | Description |
|---|---|
| **cellular** | Show the following information for **all** cellular modules.<br>• Name (e.g., Cellular1)<br>• Network interface name (wwan0, wwan1, etc.)<br>• Cellular module detected (true/false) |
| **cellular <name>** | Show the detail information of a **specified** cellular module<br>• Name (e.g., Cellular1)<br>• Network interface name (wwan0, wwan1)<br>• Cellular module detected (true/false)<br>• QMI Port (e.g., /dev/cdc-wdm0)<br>• AT Port (e.g., /dev/ttyUSB4)<br>• GPS Port (e.g., /dev/ttyUSB3) if GPS is supported<br>• Cellular module power status (on/off)<br>• Number of available SIM slots on the device<br>• The SIM slot # that is currently used by the cellular module<br>*Note: SIM slot # correspond to the labeled slot # on the device* |
| **cellular <name> get_power** | Get the cellular module power status (on/off). |
| **cellular <name> set_power <power_state>** | Set the cellular module power status (on/off).<br>*Note: Module will power-on when device reboot* |
| **cellular <name> get_sim_slot** | Get the SIM slot # that is currently used by the cellular module |
| **cellular <name> set_sim_slot <sim_slot>** | Set the SIM slot # used by cellular module. Module power off/on is required for SIM slot changed to take effect.<br>*Note: SIM slot # will be set to default (slot 1) when the device reboot* |

## NOTE

1. Some cellular modules may not support power on/off or SIM slot control.
2. If you are using Moxa Connection Manager (MCM) to manage the cellular connection, do not use set_power or sim_slot commands as they might interrupt MCM's network failover/failback operations.

An example of using MCIM to query the cellular module information and changing the SIM slot # use by the module from slot 1 to 2 is given below:

```
moxa@moxa-tbzkb1090923:~$ mx-interface-mgmt cellular
NAME         DEVICE_NAME   DEVICE_DETECTED
Cellular1   wwan0          true
moxa@moxa-tbzkb1090923:~$ mx-interface-mgmt cellular Cellular1
NAME=Cellular1
DEVICE_NAME=wwan0
QMI_PORT=/dev/cdc-wdm0
```

```
AT_PORT=/dev/ttyUSB4
GPS_PORT=/dev/ttyUSB3
DEVICE_DETECTED=true
POWER=on
SIM_SLOT_NUMBER=2
SIM_SLOT=1
moxa@moxa-tbzkb1090923:~$ mx-interface-mgmt cellular Cellular1 set_sim_slot 2
moxa@moxa-tbzkb1090923:~$ mx-interface-mgmt cellular Cellular1 get_sim_slot 2
```

# Wi-Fi Module Interface

Use the **`# mx-interface-mgmt wifi`** command to query and manage Wi-Fi modules.

| Command and Usage | Description |
|---|---|
| **`wifi`** | Shows the following information of **all** Wi-Fi modules.<br>• Name (e.g., WiFi1)<br>• Network interface name (wlan0, wlan1)<br>• Wi-Fi module detected (true/false) |
| **`wifi <name>`** | Shows the above information for a **specified** Wi-Fi module |
| **`wifi <name> get_power`** | Gets the Wi-Fi module power status (on/off). |
| **`wifi <name> set_power <power_state>`** | Set the Wi-Fi module power status (on/off).<br>*Note: The module will power-on when the device reboots.* |

**NOTE**

Some Wi-Fi modules may not support power on/off control.

# Socket Interface

Use the **`# mx-interface-mgmt socket`** command manage the Mini PCI-E sockets on the Moxa Arm-based Computer

| Command and Usage | Description |
|---|---|
| **`socket`** | List all the available sockets' name (e.g., Socket1, Socket2) |
| **`socket <socket_name>`** | Shows the following information for a **specified** Mini PCI-E socket<br>• Name (e.g., Socket1, Socket2)<br>• Power status (on/off)<br>• Number of available SIM slots if a cellular module is insert to this Mini PCI-E socket<br>• Get the SIM slot # that is currently used by the cellular module on this Mini PCI-E socket<br>*Note: SIM slot # correspond to the labeled slot # on the device.* |
| **`socket < socket_name> get_power`** | Gets the power status (on/off) for a **specified** Mini PCI-E socket |
| **`socket <name> set_power <power_state>`** | Set the power status (on/off) for a **specified** Mini PCI-E socket.<br>*Note: The socket will power-on when the device reboots.* |

# CAN Port

The CAN ports on Moxa's Arm-based computers support CAN 2.0A/B standard.

## Configuring the Socket CAN Interface

The CAN ports are initialized by default. If any additional configuration is needed, use the **`ip link`** command to check the CAN device.

To check the CAN device status, use the **`ip link`** command.

```
# ip link
can0: <NOARP,UP,LOWER_UP,ECHO> mtu 16 qdisc pfifo_fast state UNKNOWN mode
DEFAULT group default qlen 10 link/can
```

To configure the CAN device, use **`# ip link set can0 down`** to turn off the device first

```
# ip link set can0 down
# ip link
can0: <NOARP,ECHO> mtu 16 qdisc pfifo_fast state DOWN mode DEFAULT group
default qlen 10 link/can
```

Here’s an example with bitrate 12500:

```
# ip link set can0 up type can bitrate 12500
```

# CAN Bus Programming Guide

The following code is an example of the SocketCAN API, which sends packets using the raw interface.

## CAN Write

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <string.h>
#include <net/if.h>
#include <sys/types.h>
#include <sys/socket.h>
#include <sys/ioctl.h>
#include <linux/can.h>
#include <linux/can/raw.h>
int main(void)
{
    int s;
    int nbytes;
    struct sockaddr_can addr;
    struct can_frame frame;
    struct ifreq ifr;
    char *ifname = "can1";
    if((s = socket(PF_CAN, SOCK_RAW, CAN_RAW)) < 0) {
        perror("Error while opening socket");
        return -1;
    }
    strcpy(ifr.ifr_name, ifname);
    ioctl(s, SIOCGIFINDEX, &ifr);
    addr.can_family = AF_CAN;
    addr.can_ifindex = ifr.ifr_ifindex;
    printf("%s at index %d\n", ifname, ifr.ifr_ifindex);
    if(bind(s, (struct sockaddr *)&addr, sizeof(addr)) < 0) {
        perror("Error in socket bind");
        return -2;
    }
    frame.can_id = 0x123;
    frame.can_dlc = 2;
    frame.data[0] = 0x11;
    frame.data[1] = 0x22;
    nbytes = write(s, &frame, sizeof(struct can_frame));
    printf("Wrote %d bytes\n", nbytes);
    return 0;
}
```

## CAN Read

The following sample code illustrates how to read the data.

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <string.h>
#include <net/if.h>
#include <sys/types.h>
#include <sys/socket.h>
#include <sys/ioctl.h>
#include <linux/can.h>
#include <linux/can/raw.h>
Int main(void)
{
    int i;
    int s;
    int nbytes;
    struct sockaddr_can addr;
    struct can_frame frame;
    struct ifreq ifr;
    char *ifname = "can0";
    if((s = socket(PF_CAN, SOCK_RAW, CAN_RAW)) < 0) {
        perror("Error while opening socket");
        return -1;
    }
    strcpy(ifr.ifr_name, ifname);
    ioctl(s, SIOCGIFINDEX, &ifr);
    addr.can_family = AF_CAN;
    addr.can_ifindex = ifr.ifr_ifindex;
    printf("%s at index %d\n", ifname, ifr.ifr_ifindex);
    if(bind(s, (struct sockaddr *)&addr, sizeof(addr)) < 0) {
        perror("Error in socket bind");
        return -2;
    }
    nbytes = read(s, &frame, sizeof(struct can_frame));
    if (nbytes < 0) {
        perror("Error in can raw socket read");
        return 1;
    }
    if (nbytes < sizeof(struct can_frame)) {
        fprintf(stderr, "read: incomplete CAN frame\n");
        return 1;
    }
    printf(" %5s %03x [%d] ", ifname, frame.can_id, frame.can_dlc);
    for (i = 0; i < frame.can_dlc; i++)
        printf(" %02x", frame.data[i]);
    printf("\n");
    return 0;
}
```

After you use the SocketCAN API, the SocketCAN information is written to the paths: ***/proc/sys/net/ipv4/conf/can**** and ***/proc/sys/net/ipv4/neigh/can****

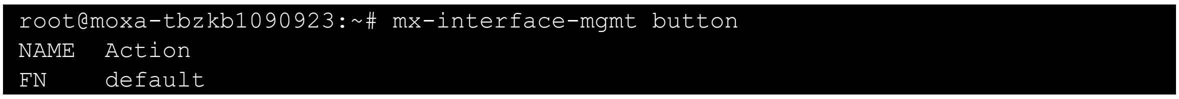
# Push-button

## Getting the Button List and Status

Use **# mx-interface-mgmt button** command to display the available buttons and the button-configured actions.

| Command and Usage | Description |
|---|---|
| **button** | Show the following information for **all** buttons on the device:<br>• Name (as labeled on device)<br>• Action (default/user-defined/disabled)<br>➢ Default: Button behavior is default<br>➢ User-defined: The button behavior has been customized by the user<br>➢ Disabled: The button has no function when pushed |
| **button <name>** | Show the above information for a **specified** button |

Following is an example of using MCIM to query an available button (FN button) of the UC-8200 series.



```
root@moxa-tbzkb1090923:~# mx-interface-mgmt button
NAME  Action
FN    default
```

## Customize the Button Action

You can use the two scripts (default and custom) available in the following path to customize button actions: **/etc/moxa/MoxaComputerInterfaceManager/button-scripts/**. For example, in the UC-8200 series, the default script is "**uc8200-default.script**" and custom script is "**custom.script**".

By default, the FN button will load the default script when pressed. The default script will perform designed tasks based on the actions on the FN button. The following table gives a detailed description of the default script:

| FN button Action | LED Indicator Status | Resulting Action |
|---|---|---|
| Press and hold FN button and release within 1s | SYS LED blinks | Device reboot |
| Press and hold FN button and release between 7s to 9s | • SYS LED blinks for 1s to 6s<br>• SYS LED is ON for 7s to 9s | Reset to factory default |
| Press and hold FN button and release after 9s | • SYS LED blinks for 1s to 6s<br>• SYS LED is ON for 7s to 9s<br>• SYS LED is OFF after 9s | Do nothing; cancel action |

To customize the **FN** button action, a configuration file at **/etc/moxa/MoxaComputerInterfaceManager/peripheral-settings.conf** could be modified. The device needs to rebooted for the settings to take effect.

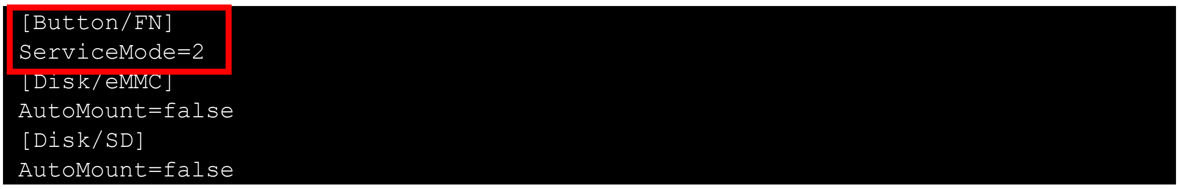
The **ServiceMode** parameter in the configuration file can have the following three values:

- 0: Disable the button (no action when pressed)
- 1: Run the default script
- 2: Run the custom script

### NOTE

You must reboot the system for the settings to take effect.

An example of the settings in the **peripheral-settings.conf** file is shown below:



```
[Button/FN]
ServiceMode=2
[Disk/eMMC]
AutoMount=false
[Disk/SD]
AutoMount=false
```

```
[Disk/USB]
AutoMount=true
[SerialPort/COM1]
Interface=1
[SerialPort/COM2]
Interface=0
```

If **ServiceMode** is set to 2 (custom script), **/etc/moxa/MoxaComputerInterfaceManager/button-scripts/custom.script** should be edited to add the desired actions. To make it easier to configure the actions in the script file, copy the content of the default script to custom script file and then make the required changes.

```
root@moxa-tbzkb1090923:/etc/moxa/MoxaComputerInterfaceManager/button-scripts#
cp uc3100-default.script custom.script
```

# Configuring the Real COM Mode

You can use Moxa's NPort series serial device drivers to extend the number of serial interfaces (ports) on your V2406C computer. The NPort comes equipped with COM drivers that work with Windows systems and TTY drivers for Linux systems. The driver establishes a transparent connection between the host and serial device by mapping the IP Port of the NPort's serial port to a local COM/TTY port on the host computer.

Real COM Mode also supports up to 4 simultaneous connections, so that multiple hosts can collect data from the same serial device at the same time.

One of the major conveniences of using Real COM Mode is that Real COM Mode allows users to continue using RS-232/422/485 serial communications software that was written for pure serial communications applications. The driver intercepts data sent to the host's COM port, packs it into a TCP/IP packet, and then redirects it through the host's Ethernet card. At the other end of the connection, the NPort accepts the Ethernet frame, unpacks the TCP/IP packet, and then sends it transparently to the appropriate serial device attached to one of the NPort's serial ports.

The Real COM driver is installed on the V2406C computer by default. You will be able to view the driver related files in the **/usr/lib/npreal2/driver** folder.

```
> mxaddsvr (Add Server, mapping tty port) > mxdelsvr (Delete Server, unmapping tty port)

> mxloadsvr (Reload Server) > mxmknod (Create device node/tty port)

> mxrmnod (Remove device node/tty port)

> mxuninst (Remove tty port and driver files)
```

At this point, you will be ready to map the NPort serial port to the system **tty** port. For a list of supported NPort devices and their revision history, click https://www.moxa.com/en/support/search?psid=50278.

## Mapping TTY Ports

Make sure that you set the operation mode of the desired NPort serial port to Real COM mode. After logging in as a super user, enter the directory /usr/lib/npreal2/driver and then execute mxaddsvr to map the target NPort serial port to the host tty ports. The syntax of **mxaddsvr** command is as follows:

```
mxaddsvr [NPort IP Address] [Total Ports] ([Data port] [Cmd port])
```

The **mxaddsvr** command performs the following actions:

1. Modifies the npreal2d.cf.
2. Creates tty ports in the /dev directory with major & minor number configured in npreal2d.cf.
3. Restarts the driver.

1.

## Mapping TTY Ports (automatic)

To map tty ports automatically, execute the **mxaddsvr** command with just the IP address and the number of ports, as shown in the following example:

```
# cd /usr/lib/npreal2/driver
# ./mxaddsvr 192.168.3.4 16
```

In this example, 16 tty ports will be added, all with IP 192.168.3.4 consisting of data ports from 950 to 965 and command ports from 966 to 981.

### ATTENTION

You must reboot the system after mapping tty ports with **mxaddsvr**.

## Mapping TTY Ports (manual)

To map tty ports manually, execute the **mxaddsvr** command and specify the data and command ports as shown in the following example:

```
 # cd /usr/lib/npreal2/driver
# ./mxaddsvr 192.168.3.4 16 4001 966
```

In this example, 16 tty ports will be added, all with IP 192.168.3.4, with data ports from 4001 to 4016 and command ports from 966 to 981.

### ATTENTION

You must reboot the system after mapping tty ports with **mxaddsvr**.

## Removing Mapped TTY Ports

After logging in as root, enter the directory /usr/lib/npreal2/driver and then execute the **mxdelsvr** command to delete a server. The syntax of **mxdelsvr** is:

**mxdelsvr [IP Address]**

Example:

```
# cd /usr/lib/npreal2/driver
# ./mxdelsvr 192.168.3.4
```

The following actions are performed when the **mxdelsvr** command is executed:

1. Modify npreal2d.cf.
2. Remove the relevant tty ports from the /dev directory.
3. Restart the driver.

If the IP address is not provided in the command line, the program will list the installed servers and total ports on the screen. You will need to choose a server from the list for deletion.

# 5. Configuring and Managing Networks

## Moxa Connection Manager (MCM)

MCM is a network management utility developed by Moxa to manage the LAN and WAN network on your Moxa Arm-based computer, including Wi-Fi, cellular, and ethernet interfaces. With MCM, you can easily fill in the connection profile and priority in the configuration file; then MCM will automatically connect and keep the connection alive. Following are the major features of MCM:

- Cellular, Ethernet and Wi-fi connection
- Connection auto keep-alive, failover, and failback
- DHCP server
- Data usage monitoring
- Cellular connection diagnosis tool
- Cellular modem and network information
- Cellular modem firmware upgrade with failback

| Interface | Default Managed by MCM | Network Configuration |
|---|---|---|
| LAN1 | Yes | • Set as DHCP WAN by default.<br>• After boot up, if LAN1 cannot obtain IP from DHCP server for 20 seconds, then link-local IP addresses is automatically assigned. |
| LAN2 | No | Static IPv4, 192.168.4.127 |
| Cellular/ Wi-Fi | No | Not configured |

To run **MCM**, you must use root permission to run **# mx-connect-mgmt**

```
MOXA Connection Management Command-line Utility

USAGE:
    mx-connect-mgmt [SUBCOMMAND]

FLAGS:
    -h, --help      Prints help information
    -V, --version   Prints version information

SUBCOMMANDS:
    configure       MOXA Connection Management via GUI dialog
    datausage       Show interface data usage information and related functions
    debug           and diagnose cellular connection
    help            Show the help menu
    ls              List available network interfaces
    modem           Upgrade cellular modem firmware
    nwk_status      Show network and modem’s information and connection status
    reload          configuration files and restart interfaces
    start           to control interfaces
    stop            to control interfaces
    unlock_pin      Unlock SIM PIN for the specified interface
    unlock_puk      Unlock PUK and reset SIM PIN for the specified interface
    wifi            Search Wi-Fi AP
```

**NOTE**

By default, only LAN1 port is managed by MCM.

There are 2 types of configuration files for MCM. One is main configuration file to manage the interrelationship between each interface, and one configuration files per each network interfaces available on Moxa Arm-based computer

| Config Type | Description | File Location |
|---|---|---|
| Main Config. | Main configuration file which is to configure which network interface you would like MCM to manage and set the priority during failover/failback | /etc/moxa/MoxaConnectionManager/**`MoxaConnectionManager.conf`** |
| Interface Config. | Per interface configuration file which is to configure properties of individual interfaces. Such as APN, PIN code of cellular connection or SSID and password of Wi-Fi. | /etc/moxa/MoxaConnectionManager /interfaces/**`[interface name].conf`** |

**NOTE**

When modification is made to configuration file, you must use **`# mx-connect-mgmt reload`** to make the change effective.

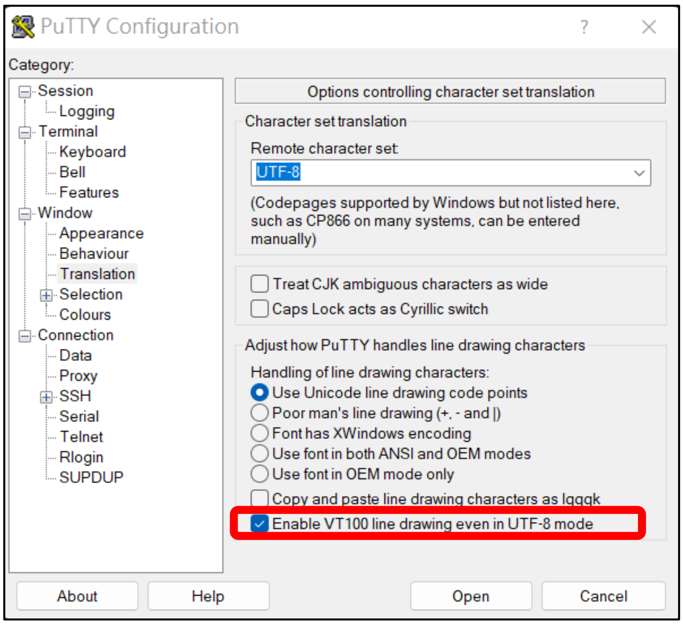
Instead of modifying the configuration file directly, we highly recommend you use the **GUI Configurator** described in next section to configure MCM.

# Setting Up MCM with GUI Configurator

## GUI Configurator Overview

To configure the WAN network through ethernet, Wi-Fi or cellular interface on the V2406C computer, you can use the simple GUI dialog provided by using **`# mx-connect-mgmt configure`** command.

If you are using PuTTY, enable **VT100 line drawing** option under **Windows > Translation** for the GUI to show correctly



Options controlling character set translation

Character set translation

Remote character set: UTF-8

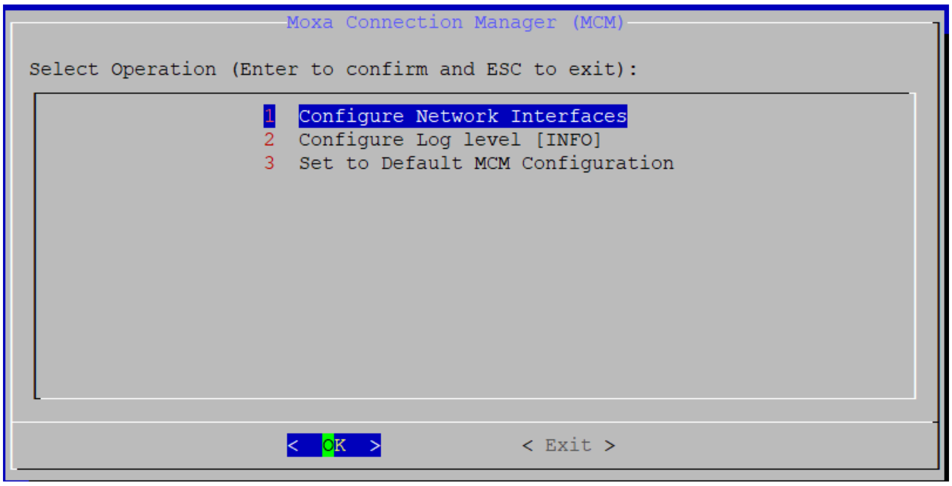
(Codepages supported by Windows but not listed here, such as CP866 on many systems, can be entered manually)

□ Treat CJK ambiguous characters as wide
□ Caps Lock acts as Cyrillic switch

Adjust how PuTTY handles line drawing characters

Handling of line drawing characters:
● Use Unicode line drawing code points
○ Poor man's line drawing (+, - and |)
○ Font has XWindows encoding
○ Use font in both ANSI and OEM modes
○ Use font in OEM mode only
□ Copy and paste line drawing characters as lqqqk
☑ Enable VT100 line drawing even in UTF-8 mode

1. Go to the main page.

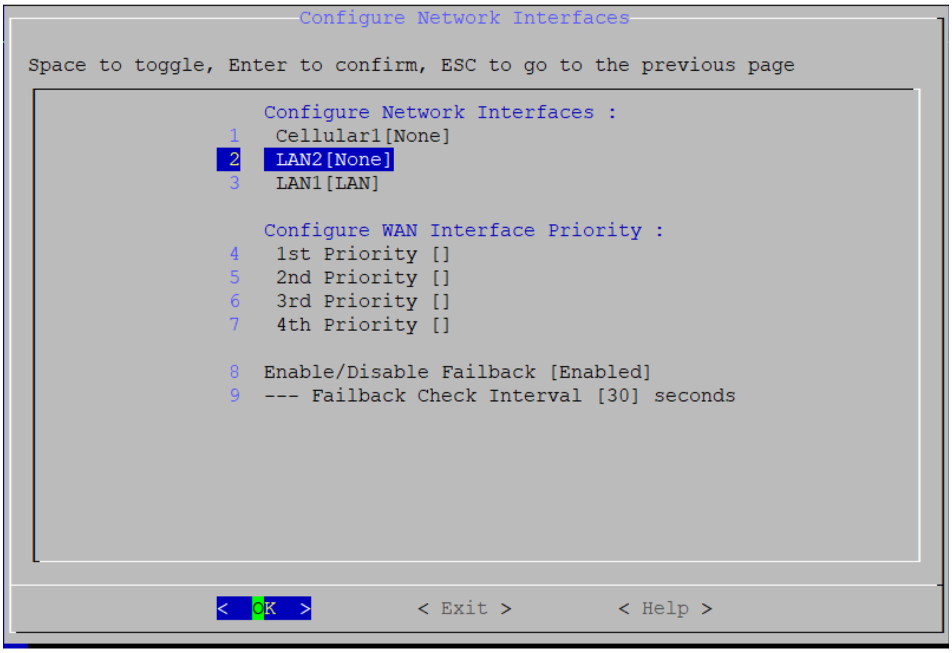


```
Moxa Connection Manager (MCM)

Select Operation (Enter to confirm and ESC to exit):

            1  Configure Network Interfaces
            2  Configure Log level [INFO]
            3  Set to Default MCM Configuration

            <  OK  >            < Exit >
```

*Figure 5.1 – Main page*

| Option Name | Description |
|---|---|
| Configure Network Interface | Configure network setting for |
| Configure Log Level | • Available syslog levels are ERR, WARN, INFO, DEBUG, TRACE<br>• MCM log is save in /var/log/syslog |
| Set to Default MCM Configuration | Set all configuration to default |

2. Configure network type for each interface and set the WAN connection priority for failover/failback.

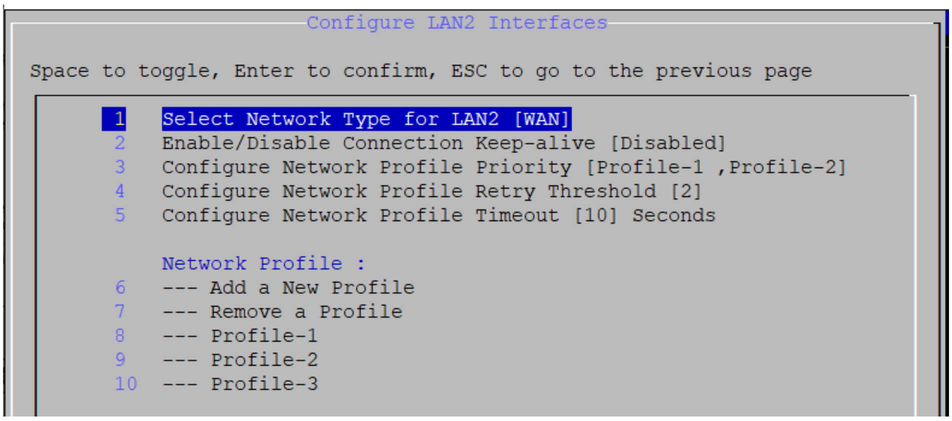


```
Configure Network Interfaces

Space to toggle, Enter to confirm, ESC to go to the previous page

            Configure Network Interfaces :
         1   Cellular1[None]
         2   LAN2[None]
         3   LAN1[LAN]

            Configure WAN Interface Priority :
         4   1st Priority []
         5   2nd Priority []
         6   3rd Priority []
         7   4th Priority []

         8  Enable/Disable Failback [Enabled]
         9  --- Failback Check Interval [30] seconds

        <  OK  >        < Exit >        < Help >
```

*Figure 5.2 –Configure network interface*

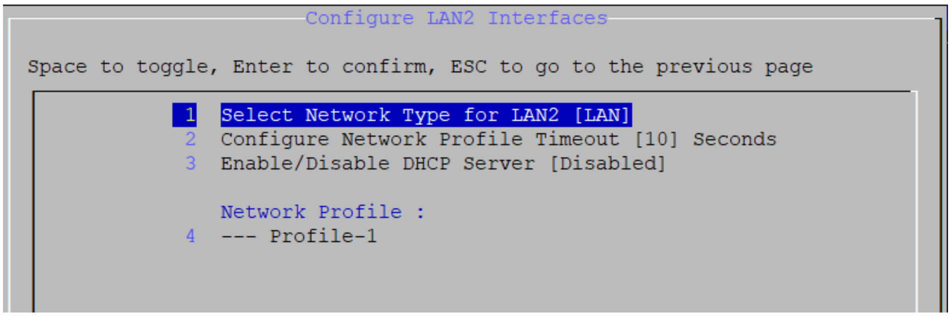
| Option Name | Description |
|---|---|
| Configure Network Interfaces | A list of available network interfaces will show, where you can set the network type for each interface. The options are:<br>• **WAN** - When set to WAN, this interface will be added to the default gateway list and allow MCM to apply automatic keep-alive and failover/failback control over it<br>• **LAN** - When set to LAN, MCM will connect this interface using the network attributes defined in Profile-1 and DHCP server can be enabled for this interface<br>• **LAN Bridge** - Bridge two or more LAN interfaces to construct a larger LAN<br>• **Manual** - When set to Manual, it allows the user to have total control over this interface. MCM will connect this interface one-time only network attributes defined in Profile-1. MCM will not set these interfaces as the default gateway nor apply connection keep-alive and failover/failback control over it.<br>• **None** - MCM will not manage this interface |
| Configure WAN Interface Priority | MCM will use the WAN interface set as 1st Priority as the default gateway. When the 1st priority interface becomes unavailable, MCM will automatically failover to the next priority interface. |
| Enable/Disable Failback | When enabled, the backup connection will automatically failback to the higher priority connection when it became available again |
| Failback Check Interval | This value determines how long (in seconds) the higher priority connection should maintain stability before MCM trigger the failback. The purpose is to avoid unstable connections causing frequent failover and failback |

3. Configure individual network interface.



```
                    Configure LAN2 Interfaces

 Space to toggle, Enter to confirm, ESC to go to the previous page

        1   Select Network Type for LAN2 [WAN]
        2   Enable/Disable Connection Keep-alive [Disabled]
        3   Configure Network Profile Priority [Profile-1 ,Profile-2]
        4   Configure Network Profile Retry Threshold [2]
        5   Configure Network Profile Timeout [10] Seconds

            Network Profile :
        6   --- Add a New Profile
        7   --- Remove a Profile
        8   --- Profile-1
        9   --- Profile-2
        10  --- Profile-3
```

*Figure 5.3 –Configurable options for WAN interface*



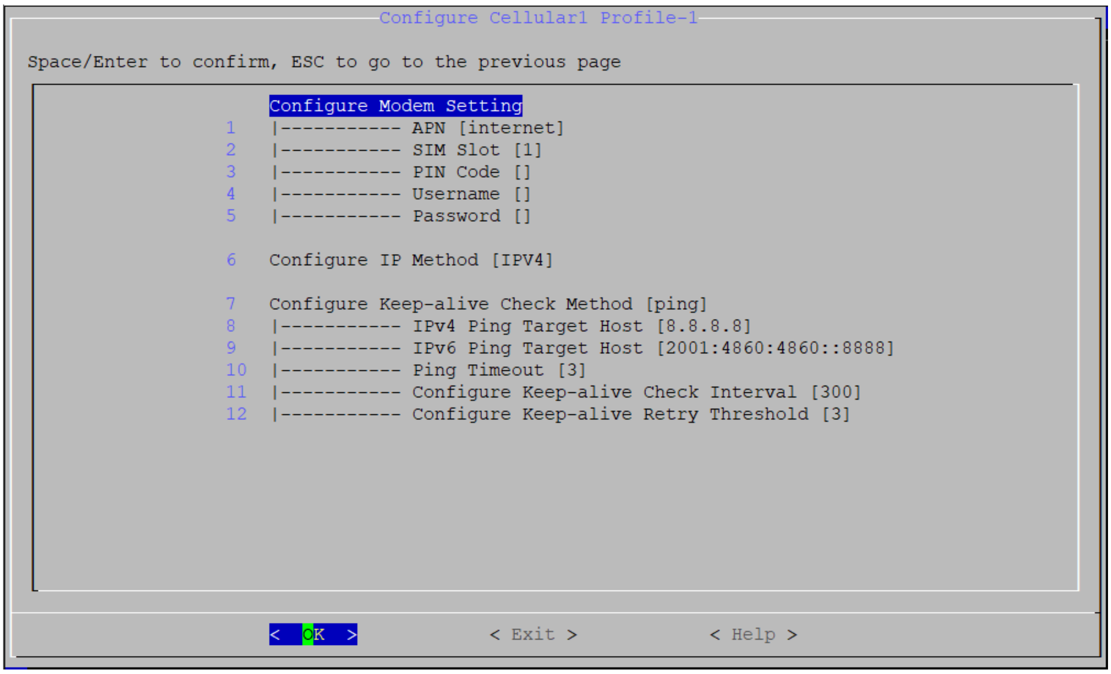
```
                    Configure LAN2 Interfaces

 Space to toggle, Enter to confirm, ESC to go to the previous page

             1   Select Network Type for LAN2 [LAN]
             2   Configure Network Profile Timeout [10] Seconds
             3   Enable/Disable DHCP Server [Disabled]

                 Network Profile :
             4   --- Profile-1
```

*Figure 5.4 –Configurable options for LAN interface*

| Option Name | Network Type | Description |
|---|---|---|
| Select Network Type | All | Available options are WAN/LAN/LAN Bridge/Manual/None |
| Enable/Disable Connection Keep-alive | WAN | You can enable this setting if a seamless failover experience is required, meaning if a backup interface is set to always keep-alive, then MCM can failover to a ready-to-use backup connection without the initialization downtime. |

| Option Name | Network Type | Description |
|---|---|---|
| Configure Network Profile Priority | WAN | When the 1st priority WAN network's profile cannot connect or becomes unavailable, MCM will automatically failover to the next profile in this priority list<br>*Note: network profile failback is currently not supported* |
| Configure Network Profile Retry Threshold | WAN | This value determines the maximum attempts MCM will try to connect using the current WAN network profile before failover to the next profile in the priority list. |
| Configure Network Profile Timeout | All | This value (in seconds) determines the maximum time MCM will try to connect using the current network profile before determining the connection is unavailable |
| Bridge IPv4 Address | LAN-bridge | Assign a static IPv4 address for the bridged LAN interfaces |
| Bridge IPv4 Subnet Mask | LAN-bridge | Assign a static IPv4 subnet mask for the bridged LAN interfaces |
| Enable/Disable DHCP Server | LAN, LAN-bridge | Configure a specific LAN or bridged LAN interfaces as DHCP server |
| Network Profile | WAN, LAN, Manual | • This section displays all network profile in a list with option to add, modify or remove a profile.<br>• If network type is set to LAN or Manual, only profile-1 will be used because network profile failover is only available for WAN |

4. Configure network profile of an interface.



```
Configure Cellular1 Profile-1

Space/Enter to confirm, ESC to go to the previous page

                      Configure Modem Setting
                  1   |----------- APN [internet]
                  2   |----------- SIM Slot [1]
                  3   |----------- PIN Code []
                  4   |----------- Username []
                  5   |----------- Password []

                  6   Configure IP Method [IPV4]

                  7   Configure Keep-alive Check Method [ping]
                  8   |----------- IPv4 Ping Target Host [8.8.8.8]
                  9   |----------- IPv6 Ping Target Host [2001:4860:4860::8888]
                  10  |----------- Ping Timeout [3]
                  11  |----------- Configure Keep-alive Check Interval [300]
                  12  |----------- Configure Keep-alive Retry Threshold [3]


                      <  OK  >           < Exit >           < Help >
```

*Figure 5.5 –Network profile setting (cellular interface as an example)*

| Option Name | Interface | Description |
|---|---|---|
| Configure Modem Setting | Cellular (WAN) | Configure cellular connection parameters including **APN, SIM slot** (which SIM slot number to use), **PIN Code, Username, Password** |
| | Wi-Fi (WAN) | Configure Wi-Fi connection parameters including **Mode** (only Wi-Fi client mode is supported), **SSID**, and **Password**<br>*Note: make sure to leave the password field empty if you are connecting to a public Wi-Fi without password* |
| Configure IP Method | All interfaces | Configure IP related parameters including protocol version (IPv4, IPv6 or IPv4v6) and IP assignment method (DHCP, auto*, static IP or Link-local) |

| Option Name | Interface | Description |
|---|---|---|
| Configure Keep-alive Check Method | All interfaces | Select the method to check connection is alive<br>• **Ping:** Connection is only considered alive if pinging the target server specified is successful<br>• **Check-ip-exist:** As long as an IP is assigned to the interface (e.g., the base station assigns IP to the cellular modem or DHCP server assigns IP to LAN port), are considered connection is alive |

* IP assignment method "auto" is for IPv6 only, which support Stateless Address Auto-Configuration (SLACC) and Stateless for DHCPv6.

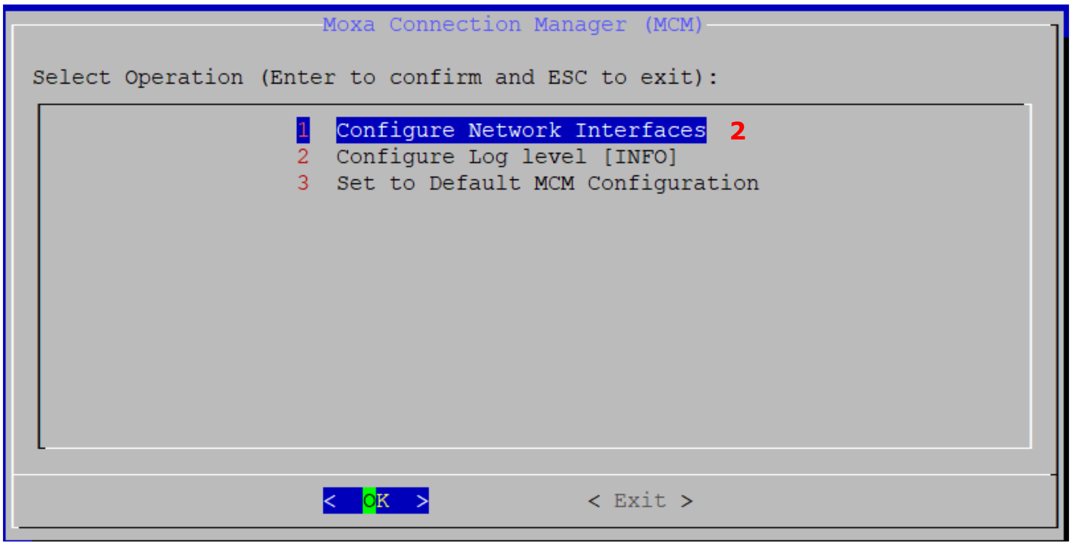
# Cellular and Wi-Fi Failover/Failback

One of the key features in MCM is WAN connection auto-failover, where you can configure multiple backup WAN networks. When the primary connection becomes unavailable, MCM will automatically fail over to the backup network depending on the priority you set. You can even configure the connection to fall back to the primary one when it is back online.

In below example, we will set Wi-Fi interface as the primary WAN network and Cellular(4G/LTE) as the backup. MCM will automatically switch to using Cellular(4G/LTE) when Wi-Fi is down and back to Wi-Fi when it is back online.

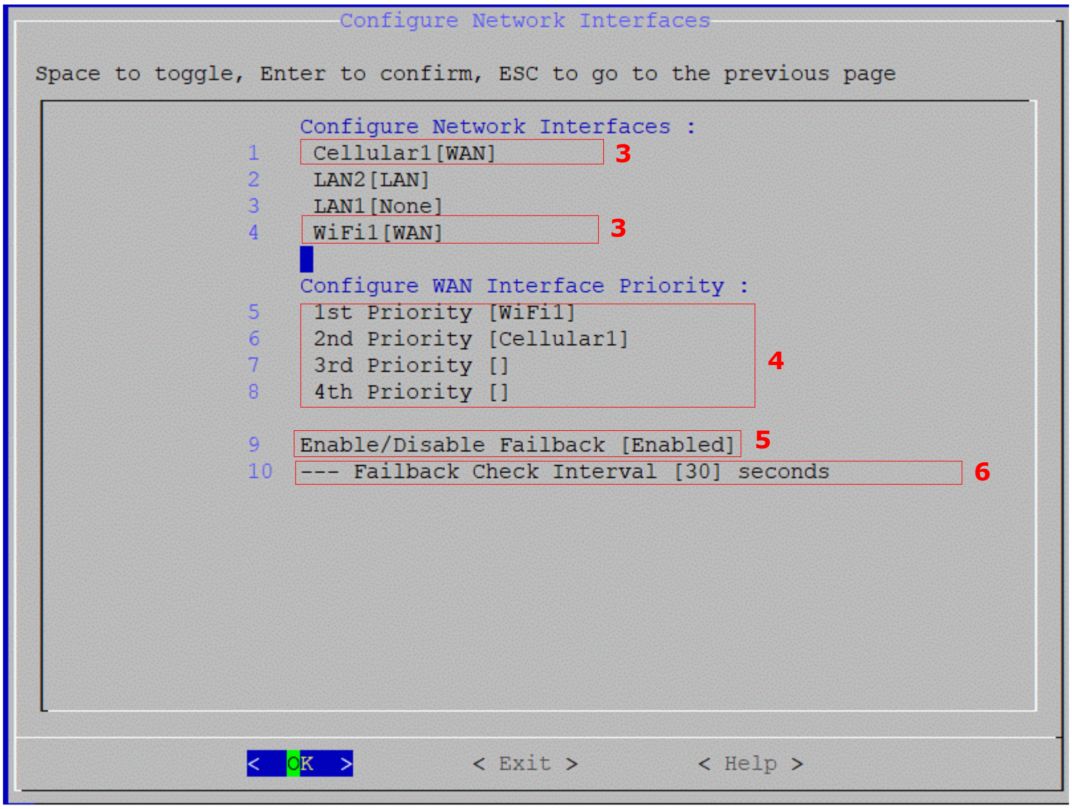
1. Run **# mx-connect-mgmt configure** to launch a simple GUI dialog configurator

```
root@moxa-tbbbb1182827:/# mx-connect-mgmt configure
```



```
Moxa Connection Manager (MCM)

Select Operation (Enter to confirm and ESC to exit):

          1  Configure Network Interfaces
          2  Configure Log level [INFO]
          3  Set to Default MCM Configuration

          <  OK  >              < Exit >
```

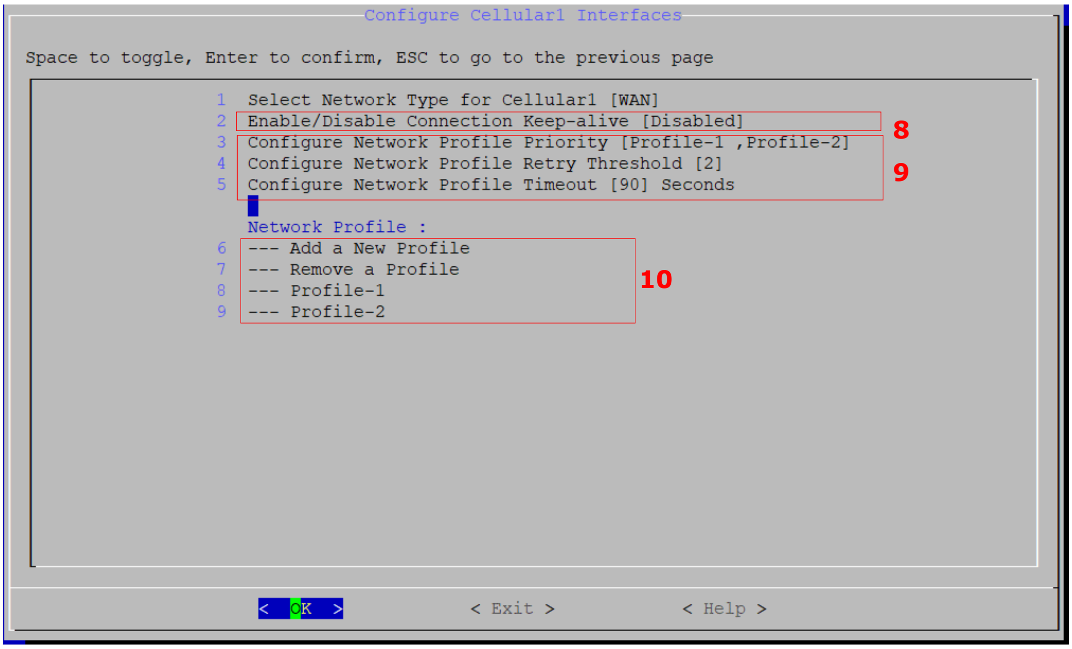
2. Select "Configure Network Interfaces"
3. Set interface Cellular1 and WiFi1 both to WAN, and
4. Set WiFi1 as the 1st priority and Cellular1 as 2nd priority
5. Make sure Failback is enabled if you would like MCM to automatically switch back to Wi-Fi from cellular when it is back online.
6. Failback Check Interval [30] seconds mean MCM will make sure Wi-Fi connection is alive and stable for 30 seconds before failback to use Wi-Fi as the primary connection (default gateway). The purpose is to avoid unstable connections causing frequent failover and failback.



```
Configure Network Interfaces

Space to toggle, Enter to confirm, ESC to go to the previous page

            Configure Network Interfaces :
         1   Cellular1[WAN]
         2   LAN2[LAN]
         3   LAN1[None]
         4   WiFi1[WAN]

            Configure WAN Interface Priority :
         5   1st Priority [WiFi1]
         6   2nd Priority [Cellular1]
         7   3rd Priority []
         8   4th Priority []

         9  Enable/Disable Failback [Enabled]
        10  --- Failback Check Interval [30] seconds

         <  OK  >          < Exit >          < Help >
```

7. Go to the interface configuration page of WiFi1 and Cellular1 (Figure 5.5 is an example of Cellular)
8. The option “**Enable/Disable Connection Keep-alive**” is disabled by default. It means there will be a short period without network during Wi-Fi to cellular failover process since MCM will only initiate the cellular connection when failover is triggered.

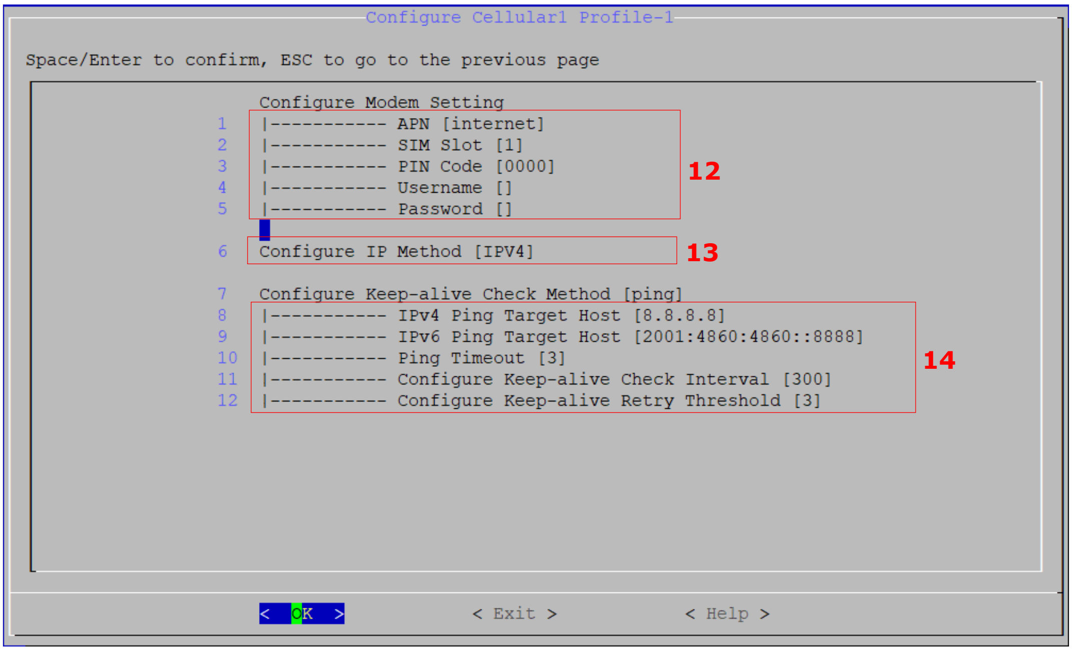
   You can enable this setting if a seamless failover experience is desired. When enabled, it allows MCM to failover to a ready-to-use backup connection without the initialization downtime.
9. MCM also supports network profile failover. For example, on a Moxa Arm-based computer with dual SIM slots, you can set up two profiles for cellular interface; each uses a different SIM slot and SIM card.
   - **Network Profile Priority:** in this example, MCM will use profile-1 by default and failover to use profile-2 when it cannot establish a connection with profile-1.
   - **Network Profile Timeout and Retry Threshold:** in this example, MCM will try to connect with profile-1 two times, each with a maximum of 90 seconds timeout before switching to profile-2.
10. You can modify the default profile-1 and profile-2 or add/remove a profile.



```
Configure Cellular1 Interfaces

Space to toggle, Enter to confirm, ESC to go to the previous page

 1  Select Network Type for Cellular1 [WAN]
 2  Enable/Disable Connection Keep-alive [Disabled]
 3  Configure Network Profile Priority [Profile-1 ,Profile-2]
 4  Configure Network Profile Retry Threshold [2]
 5  Configure Network Profile Timeout [90] Seconds

    Network Profile :
 6  --- Add a New Profile
 7  --- Remove a Profile
 8  --- Profile-1
 9  --- Profile-2
```

*Figure 5.6 –Interface configuration page of Cellular1*

11. Go to profile configuration page.
12. Configure the cellular modem related attribute. In this example, a SIM card in SIM slot 1 with PIN code "9917" and APN "internet" is used for Profile-1
13. Select the IP protocol generation. IPv4, IPv6, and IPv4v6 are the available options.
14. Select how MCM determine the connection is alive. Currently, only "ping' method is supported for WAN network. In this example, following configuration are set for Profile-1 of Cellular1 interface
    - ➢ MCM will ping the IP of Google public DNS every 700 seconds
    - ➢ MCM will try to ping the target host maximum 3 times (Retry Threshold) before concluding profile-1 cannot connect. For each ping attempt, MCM will consider ping fails if server doesn't response in 3 seconds (Ping timeout)
15. Once completed the configuration, exit MCM and select save and reload configuration file for the configuration to take effect



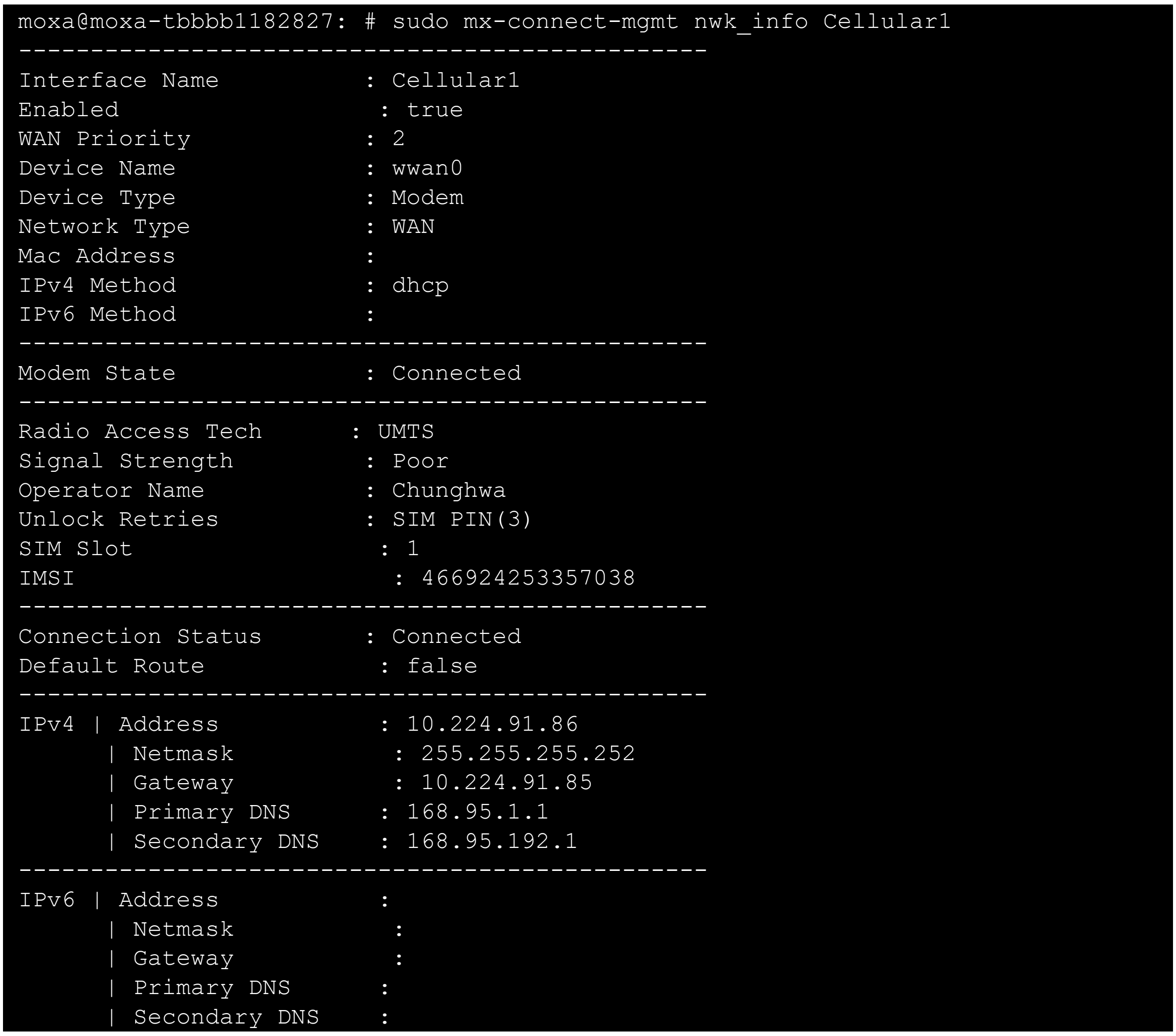
```
Configure Cellular1 Profile-1

Space/Enter to confirm, ESC to go to the previous page

     Configure Modem Setting
 1   |----------- APN [internet]
 2   |----------- SIM Slot [1]
 3   |----------- PIN Code [0000]
 4   |----------- Username []
 5   |----------- Password []

 6   Configure IP Method [IPV4]

 7   Configure Keep-alive Check Method [ping]
 8   |----------- IPv4 Ping Target Host [8.8.8.8]
 9   |----------- IPv6 Ping Target Host [2001:4860:4860::8888]
 10  |----------- Ping Timeout [3]
 11  |----------- Configure Keep-alive Check Interval [300]
 12  |----------- Configure Keep-alive Retry Threshold [3]
```

*Figure 5.7–network profile configuration page of Cellular1 interface*

# Checking the Network Status

## Checking the Interface and Connection Status

- Use **# mx-connect-mgmt nwk_info [Interface name]** to check the interface and connection status
- Use **# mx-connect-mgmt nwk_info [Interface name]**



```
moxa@moxa-tbbbb1182827: # sudo mx-connect-mgmt nwk_info Cellular1
------------------------------------------------
Interface Name           : Cellular1
Enabled                   : true
WAN Priority             : 2
Device Name              : wwan0
Device Type              : Modem
Network Type             : WAN
Mac Address              :
IPv4 Method              : dhcp
IPv6 Method              :
------------------------------------------------
Modem State              : Connected
------------------------------------------------
Radio Access Tech       : UMTS
Signal Strength          : Poor
Operator Name            : Chunghwa
Unlock Retries           : SIM PIN(3)
SIM Slot                  : 1
IMSI                       : 466924253357038
------------------------------------------------
Connection Status        : Connected
Default Route             : false
------------------------------------------------
IPv4 | Address            : 10.224.91.86
      | Netmask            : 255.255.255.252
      | Gateway            : 10.224.91.85
      | Primary DNS       : 168.95.1.1
      | Secondary DNS     : 168.95.192.1
------------------------------------------------
IPv6 | Address            :
      | Netmask            :
      | Gateway            :
      | Primary DNS       :
      | Secondary DNS     :
```

*Figure 5.8 –an example of nwk_info result of interface Cellular1*

Most of the data fields and values are self-explanatory. Below are additional details to some of the data fields:

| Fields | Description | Available Interface |
|---|---|---|
| Enabled | • **True:** This interface is managed by MCM<br>• **False:** This interface is not managed by MCM | Wi-Fi, Ethernet, Cellular |
| WAN priority | The WAN priority set in Figure 5.2 | Wi-Fi, Ethernet, Cellular |
| Network Type | WAN/LAN/Manual/None according to the set value in Figure 5.2 | Wi-Fi, Ethernet, Cellular |

| Fields | Description | Available Interface |
|---|---|---|
| Modem State | • **Not Ready:** The cellular modem can't be detected, or some configuration is not set correctly in MCM configuration files.<br>• **Initializing:** The cellular is initializing<br>• **SIM PIN Locked:** SIM PIN is locked; you can unlock with unlock_pin command<br>• **SIM PUK Locked:** SIM PUK is locked; you can unlock with unlock_puk command<br>• **Radio Power Off:** The cellular modem is entering flight mode<br>• **Radio Power On:** The cellular modem is exiting flight mode<br>• **Searching Base Station:** The cellular modem has exited flight mode and searching for base-station<br>• **Attached to Base Station:** The cellular modem is registered with a network provider but without data connections.<br>• **Connecting:** The cellular modem is connecting<br>• **Connected:** The cellular modem is connected<br>• **No SIM:** SIM card is missing or malfunctioning | Cellular only |
| Radio Access Tech | GSM/GSM COMPACT/UMTS/LTE, etc. | Cellular only |
| Signal Strength | • None/Very Poor<br>• Poor<br>• Fair<br>• Good<br>• Excellent<br>*Note: see* cellular signal strength *for defined criteria* | Cellular only |
| SIM Slot | The SIM slot number being used | Cellular only |
| Connection Status | • **Initializing:** Initializing network connection<br>• **Device Ready:** Detected the network interface is ready<br>• **Connecting:** Connecting according to setting in profile<br>• **Configuration Error:** Profile configuration error<br>• **Disabling:** Stopping the connection<br>• **Disabled:** When an interface is not managed by MCM, or MCM service is stopped<br>• **Connected:** Connection is "working". The criteria for "working" are determine by the Keep-alive Check Method in Figure 5.5. For example, if method is set to ping, the connection is consider working if ping is successful<br>• **Unable to connect:** The network profile is set correctly but the connection is not working determined by the Keep-alive Check Method in Figure 5.5<br>• **Reconnecting:** Connection is being reconnecting | Wi-Fi, Ethernet, Cellular |
| Default Route | • **True:** This interface is currently being used as default route<br>• **False:** This interface is not the default route | Wi-Fi, Ethernet, Cellular |

# Cellular Signal Strength

Below are the criteria that MCM uses to determine the signal strength for 3G(UMTS) and 4G(LTE):

Using 4G(LTE) signal level as an example:

- For the signal level "Excellent", both RSSI and EC/IO need to meet the defined criteria in below table
- If the RSSI value meets the "Excellent" criteria but EC/IO meets only the "Good" criteria, then the MCM will show "Good" signal level

| 3G(UMTS) Signal Level | RSSI (dBm) | EC/IO (db) |
|---|---|---|
| Excellent | >=-77 | >=-6 |
| Good | >=-87 | >=-10 |
| Fair | >=-97 | >=-14 |
| Poor | >=-107 | >=-20 |
| None/Very Poor | <-107 | <-20 |

| 4G(LTE) Signal Level | RSRP (dBm) | RSSNR (db) |
|---|---|---|
| Excellent | >=-85 | >=13 |
| Good | >=-95 | >=5 |
| Fair | >=-105 | >=1 |
| Poor | >=-115 | >=-3 |
| None/Very Poor | <-115 | <-3 |

## Monitoring the Data Usage

Use **# mx-connect-mgmt datausage** to check the data usage of a specified interface between a specified start and end date

```
moxa@moxa-tbbbb1182827:# sudo mx-connect-mgmt datausage -h

mx-connect-mgmt-datausage
Show interface data usage information and related functions

USAGE:
    mx-connect-mgmt datausage [FLAGS] [OPTIONS] [interface]
FLAGS:
    -h, --help     Prints help information
    -r, --reset    data usage database
OPTIONS:
    -s, --since <date>    Sets the begin date of data usage cumulative period,
                            expected date format YYYY-MM-DD HH:MM or YYYY-MM-DD
    -t, --to <date>       Sets the end date of data usage cumulative period,
                            expected date format YYYY-MM-DD HH:MM or YYYY-MM-DD
ARGS:
    <interface>
```

Below is an example of how to check the data usage of Wi-Fi interface between 2022/7/3 and 2022/7/4

```
moxa@moxa-tbbbb1182827:# sudo mx-connect-mgmt datausage --since 2022-07-03 --to
2022-07-04 WiFi1
moxa@moxa-tbbbb1182827:
rx: 21884544 bytes
tx: 116086 bytes
```

# Upgrading the Cellular Modem Firmware

Use **# mx-connect-mgmt modem upgrade [Interface name]** will check and install the latest cellular modem firmware tested by Moxa from Moxa APT server.

- Your cellular network will be down temporary during the upgrade and the connection will be reconnected by MCM after the upgrade is complete
- You can also upgrade the firmware locally by specifying a file path following **-F** or **--filepath** option
- By default, firmware downgrade is not allowed and not recommended. If you insist to downgrade the firmware, you can add -f flag to force the downgrade.
- You can use **mx-connect-mgmt nwk_info [interface name] -a** command to check the current cellular modem firmware version
- MCM will perform auto-reinstallation if upgrade fails.

```
moxa@moxa-tbbbb1182827:/# sudo mx-connect-mgmt modem upgrade -h
mx-connect-mgmt-modem-upgrade
Upgrade modem FWR

USAGE:
    mx-connect-mgmt modem upgrade [FLAGS] [OPTIONS] [interface]
FLAGS:
    -f              force upgrade FWR
    -h, --help    Prints help information
OPTIONS:
    -F, --filepath <filename>    Sets the FWR file path
ARGS:
    <interface>
```

An example of automatically updating the cellular modem firmware from Moxa APT server is given below:

```
moxa@moxa-tbbbb1182827:/# sudo mx-connect-mgmt modem upgrade Cellular1
```

An example of manually updating the cellular modem firmware by specifying a firmware file is given below:

```
moxa@moxa-tbbbb1182827:/# sudo mx-connect-mgmt modem upgrade Cellular1 -F /etc/
firmware/Telit-LE910C4-EU-Info-1.1.0
```

An example given below indicates how to manually force the cellular modem firmware update even if the current firmware is newer than the provided firmware:

```
moxa@moxa-tbbbb1182827:/# sudo mx-connect-mgmt modem upgrade Cellular1 -f -F
/etc/ firmware/Telit-LE910C4-EU-Info-1.0.0
```

# Cellular Network Diagnosis

Use **`# mx-connect-mgmt debug`** to perform diagnosis on the cellular network if you have trouble getting it to connect. The diagnosis tool can identify common issues such has missing antenna, weak signal strength, SIM card pin code error, SIM locked, etc.

```
moxa@moxa-tbbbb1182827:# sudo mx-connect-mgmt debug -h
mx-connect-mgmt-debug
Debug and diagnose cellular connection

USAGE:
    mx-connect-mgmt debug [SUBCOMMAND]

FLAGS:
    -h, --help    Prints help information

SUBCOMMANDS:
    diag      Perform diagnosis on the cellular interface
    help      Prints this message or the help of the given subcommand(s)
    listen    Listen to properties changed
```

# Using API to Retrieve the MCM Status

MCM provides C application programming interfaces (APIs) for developer to retrieve various network and interface status from MCM

Please refers to following link for the C API document

https://moxa.gitlab.io/open-source/linux/gitbook/moxa-connection-manager-api-document/

To integrating your applications securely with the MC C API, you should follow the below guideline:

1. Confirm that the return value of the API is 0 and the returned struct pointer is not NULL to avoid using the wrong memory address.
2. Always free the structure pointer returned by the API to avoid memory leak.

# 6. System Installation and Update

In this chapter, we will introduce how to install and update Moxa Industrial Linux and the bootloader.

## Installing Moxa Industrial Linux

### Using a TFTP Server From Bootloader Menu

Refers to instruction in Accessing Bootloader Menu section

**NOTE**

TFTP update is disabled in Secure model by default due to TFTP is not a secure transmission protocol.

### Using a USB/SD From Bootloader Menu

Refers to instruction in Accessing Bootloader Menu section

### Automatic Installation From a USB or SD

Beside manually installing the system image from bootloader menu, you can also trigger the image installation process within the operating system using **`mx-bootloader-mgmt image_auto_install`** command. Once this process is triggered, the Arm-based computer will automatically install the specified system image in the USD or SD attached to the system. The new image will be available upon the next system boot-up.

**NOTE**

The format supported for USB and SD are FAT32 and ext4, respectively.

| Command | Description |
|---|---|
| -d, --disk | Display the name of the external storage (e.g., USB, SD) where the image file is located. You can use the **`mx-interface-mgmt disk`** command to query the external storage name. |
| -f, --file | Display the name of the image file in the external storage |
| -i, --info | Display the names of the image file and external storage configured for auto-install upon next boot-up |
| -r, --remove | Remove the auto-installation configuration |
| -h, --help | Display the available commands with a brief description |
| -v, --version | Display the version of **`mx-image-auto-install-tool`** |

Following is an example of the automatic installation of the system image from a USB device:

1. Use **`mx-interface-mgmt disk`** command to check the name of available storage device name.

```
moxa@moxa-tbzkb1090918:~# sudo mx-interface-mgmt disk
NAME    DEVICE          SYSTEM_DISK  NUMBER_OF_PARTITIONS  AUTOMOUNT_SETTING
USB     /dev/sda        N              1                         false
eMMC    /dev/mmcblk0    Y              4                         false
```

2. Mount the USB if it is not already mounted. Refer to Storage and Partition section for detail.

```
moxa@moxa-tbzkb1090923:~$ sudo mx-interface-mgmt partition
NAME       EVICE            IS_MOUNTED  FS_TYPE  MOUNTPOINT
eMMC_p1  /dev/mmcblk0p1     Y             ext4      /boot_device/p1
eMMC_p2  /dev/mmcblk0p2     Y             ext4      /boot_device/p2
eMMC_p3  /dev/mmcblk0p3     Y             ext4      /boot_device/p3
eMMC_p4  /dev/mmcblk0p4     Y             ext4      /boot_device/p4
USB_p1   /dev/sdb1          N             N/A       N/A

moxa@moxa-tbzkb1090923:~$ sudo mx-interface-mgmt partition USB_p1 mount
```

3. Configure an auto-installation event in partition 1 of the USB device with the image file **IMG_UC-8200_MIL3_V1.0_Build_22053011_ImageBuild_220530_133813.img**:

```
moxa@moxa-tbzkb1090918:~# sudo mx-bootloader-mgmt image_auto_install -d USB
-f
IMG_UC-8200_MIL3_V1.0_Build_22053011_ImageBuild_220530_133813.img
```

**NOTE**

Ensure that the image file and sha256 hash files is available in partition 1 of USB or SD before configuring the event.

4. Reboot the system to trigger the auto installation of the system image from the USB device.

```
moxa@moxa-tbzkb1090918:~# sudo reboot
```

# Updating Moxa Industrial Linux Using SecureApt

Moxa Arm-based computers support **SecureApt**, which uses a GPG public key system to ensure the integrity and authenticity of patches are validated before download, and x.509 certification authentication for secure transmission via HTTPS. The private key pair of the GPG key for the Moxa APT repository is stored in an on-premises Sign Server, accessible only by authorized Moxa personnel.

**NOTE**

Click the following link for more information on how SecureAPT works:
https://wiki.debian.org/SecureApt

## Querying the System Image Version

Use the mx-ver command to check the system image version on your Arm-based computers.

```
moxa@moxa-tbzkb1090923:# mx-ver
UC-8220-T-LX-US-S MIL3 version 1.0 Build 22052300
```

## Failback Update

We strongly recommend enabling the failback function before performing an update. Refer to failback feature in the Moxa System Manager (MSM) for details.

## Managing the APT Repository

The APT Repository is the network server from which APT downloads packages that are installed on your Moxa Arm-based computer. By default, Moxa Arm-based computers include the following repositories that contain stable and well-tested packages best suited for ensuring the stability of your project.

| Source list | Repository URL | Description |
|---|---|---|
| /etc/apt/sources.list | https://deb.debian.org/debian bullseye | Debian official repository containing the latest stable Debian 11 release (released about every 2 months) |
| | https://deb.debian.org/debian bullseye-updates | Debian official repository containing bug fixes that will be included in the upcoming Debian 11 release |
| | https://deb.debian.org/debian-security/bullseye-security | Debian official repository containing security hotfixes that will be included in the upcoming Debian 11 release |
| /etc/apt/sources.list.d/ moxa.list | https://debian.moxa.com/mil3 bullseye | Moxa repository containing Moxa's proprietary library, tools, utilities, and kernel. Moxa will maintain security and bug fixes even after Debian 11 has reached its end of life (EOL). |

To add a new repository, you must add the repository URL and official GPG key to the source list and keyring in your Moxa Arm-based computer.

Here is an example for adding the Docker repository https://docs.docker.com/engine/install/debian/.

1. Add the repository URL to the source list on your Arm-based computer.

```
moxa@moxa-tbzkb1090923:# echo "deb https://download.docker.com/linux/debian
bullseye stable" > /etc/apt/sources.list.d/docker.list
```

2. Add the official GPG public key of the Docker repository to the keyring in your computer for SecureAPT.

```
moxa@moxa-tbzkb1090923:# curl -fsSL
https://download.docker.com/linux/debian/gpg | gpg --dearmor -o
/etc/apt/trusted.gpg.d/docker.gpg
```

3. Verify the newly added Docker repository by running an update.

```
moxa@moxa-tbzkb1090923:# apt update
Get:1 https://download.docker.com/linux/debian bullseye InRelease [43.3 kB]
Hit:2 http://deb.debian.org/debian bullseye InRelease Get:3
http://deb.debian.org/debian-security bullseye-security InRelease [48.4 kB]
Get:4 https://download.docker.com/linux/debian bullseye/stable amd64
Packages [13.8 kB] Get:5 http://deb.debian.org/debian bullseye-updates
InRelease [44.1 kB] Get:6 http://deb.debian.org/debian-security bullseye-
security/main amd64 Packages [191 kB] Fetched 341 kB in 1s (356 kB/s)
Reading package lists... Done Building dependency tree... Done Reading state
information... Done 30 packages can be upgraded. Run 'apt list --upgradable'
to see them.
```

# Updating Your System

## Preparing a Staging Environment

Since Moxa Arm-based computers are open platforms, you are free to install any software that you would like to use. However, we highly recommend that you test all new software on a staging platform before installing them on your production gateways.

## Synchronizing the Repository Information

The first and most important step is to synchronize the package index files in your Arm-based computer with the source repositories specified in the file **/etc/apt/sources.list**. When you perform the synchronization, information related to the packages, including versions and dependencies, will also be downloaded from the repositories.

To perform the synchronization, make sure that your network environment can connect to the APT repositories, and then run the **apt update** command with root permission to synchronize the package index.

```
moxa@moxa-tbbbb1182827:# sudo apt update
```

### Updating the Entire System

Use the **apt full-upgrade** command to upgrade all packages used by your Moxa Arm-based computer to latest versions.

```
moxa@moxa-tbbbb1182827:# sudo apt full-upgrade
```

# Updating the Bootloader

When a updated Bootloader firmware is available, Moxa will publish a notification on the Moxa Arm-based computer product page and upload the new firmware to the Moxa APT repository. You can download the firmware (**.bin** format) via SecureAPT so that the authenticity and integrity of the firmware is verified.

**NOTE**

Click the following link for more information on how SecureAPT
https://wiki.debian.org/SecureApt

## Querying the Current Bootloader Version

Use the **mx-bootloader-mgmt upgrade -i** command to check the current Bootloader version of your Arm-based computer.

```
root@moxa-tbbbb1182827:# mx-bootloader-mgmt upgrade -i

Current bootloader information:
compatible model: UC-8200
bootloader version: 3.0.0S05
sha256sum: 28e2409b9a255e72c5ddd6f8007217be0d49bea21536086f67c2cabb29a9ee05
md5sum: 70199c3b44b37b7e07fecb8df675fd4c
```

## Updating Bootloader With the Firmware Binary

Use the **mx-bootloader-mgmt upgrade -f [file path]** command to update the Bootloader

```
root@moxa-tbbbb1182827:# mx-bootloader-mgmt upgrade -f
/media/USB_p1/bootloader.bin

The version of bootloader being updated: 3.0.0S07
The version of current bootloader: 3.0.0S07
Your bootloader version is the same as the version of bootloader being updated.
Do you want to continue? (y/N)y
Start to upgrade bootloader…
Upgrade /dev/mtd1 bootloader to version 3.0.0S07 successfully
```

## Updating with the Failback Function Enabled

We highly recommend you enable failback before performing the bootloader update due to a power outage may cause the device to be unable to boot. Refer to failback feature of Moxa System Manager (MSM) tool.

# 7. Backup, Decommission, and Recovery

In this chapter, we will introduce how to use Moxa System Management (MSM) utility to perform snapshot, backup, decommission, and recovery of your system. MSM provides an automatic failback mechanism to ensure that the device can recover to the last known working and secure state when the device fails after a critical event such as a system update.

| Function | Description |
|---|---|
| Snapshot | • The snapshot has a smaller footprint as it saves just the differences (partition 3 in Figure 7.1) compared to the out-of-factory rootfs (partition 2 in Figure 7.1).<br>• The snapshot is saved in the Moxa Arm-based computer and cannot be exported. Hence, a snapshot can only be used to restore the computer that the snapshot was taken from. |
| Backup | • The backup has a larger footprint as it saves the entire system including the out-of-factory rootfs.<br>• The backup can be exported to an external storage.<br>• The backup can be used to restore the Moxa Arm-based computer that the backup is taken from or another computer of the same model. |
| Automatic Failback Recovery | • When failback recovery is enabled, a replica of the system including the snapshot and bootloader is created.<br>• If a boot failure event occurs after failback recovery is enabled, the system will automatically use the replica to recover the system<br>• Failback recovery should be enabled before performing any critical actions that may potentially result in a device failure (e.g., power loss during a bootloader update could brick a computer). |

Below diagram illustrate an overview of MIL3 system layout:

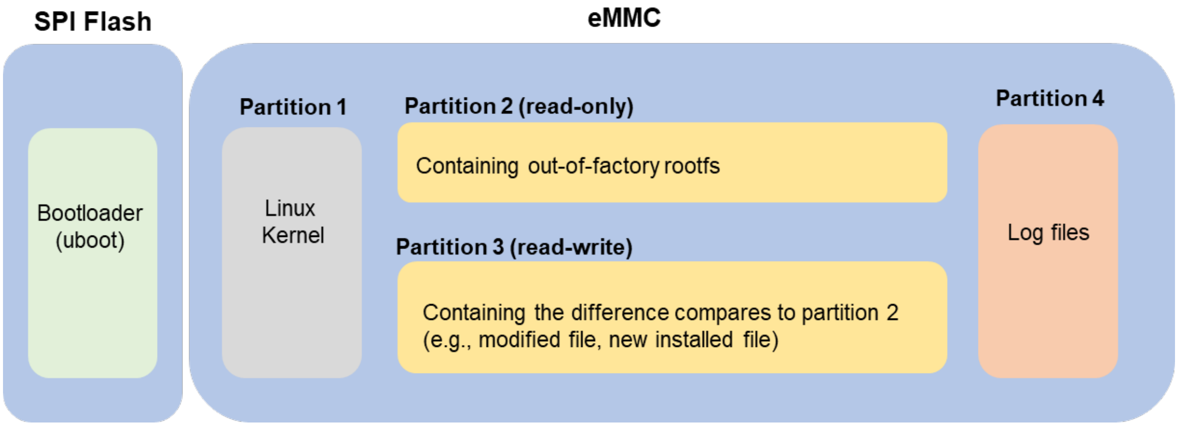

SPI Flash
eMMC
Bootloader (uboot)
Partition 1
Linux Kernel
Partition 2 (read-only)
Containing out-of-factory rootfs
Partition 3 (read-write)
Containing the difference compares to partition 2 (e.g., modified file, new installed file)
Partition 4
Log files

*Figure 7.1 - Layout Overview of Arm-based Computer with MIL3*

# Creating a System Snapshot

A snapshot preserves the state and data of the Moxa Arm-based computer as a restoration point at a specific point in time so that you can restore it to that point if something goes wrong. Snapshots only save the Linux kernel and new and modified files to the out-of-factory rootfs (partition 2). Therefore, the size of a snapshot is much smaller than a backup.

Use the **# mx-system-mgmt snapshot <sub-command> <flag>** to create restore a system. You must use **sudo** or run the command with root permission.

| Sub-commands | Description |
|---|---|
| create | Creates a snapshot of system<br>• A snapshot includes **kernel (partition 1)** and **rootfs (partition 3)**<br>• Only one snapshot is saved. A new snapshot will overwrite the previous snapshot<br>• Snapshot is stored in **rootfs (partition 3)** |
| restore | Restores the system with the snapshot. System failback will be disabled after a system is restored from the snapshot. |
| delete | Deletes the existing snapshot |
| Info | Displays the create time and size of the existing snapshot |

| Flag | Description |
|---|---|
| -y or --yes | Automatically consent to the prompts during create, restore, and delete processes |

# Creating a System Backup

Compares to snapshot, a backup saves Linux kernel and the rootfs on your Moxa Arm-based Computer. Therefore, a backup can be exported and use to restore a Moxa Arm-based computer of the same model with MIL 3.0. For example, if you create a backup on UC-8200 Secure model with MIL3, you can use the backup to restore another UC-8200 Secure model with MIL3

Use **# mx-system-mgmt backup <sub-command> <flag>** command to create, delete, and restore a backup. You must use **sudo** or run the command with the root permission.

| Sub-commands | Description |
|---|---|
| create | Creates a backup of the system<br>• The backup includes **kernel (partition 1), rootfs (partition 2)**, and **rootfs (partition 3)**<br>• By default, the backup is created in the **/boot_device/p3/backup/** directory with the name **backup.tar**, together with an info file that contains the backup information and cryptographic hash of the backup.<br>• The backup includes system snapshot. If you would like to reduce the size of backup, you can delete the snapshot in the system before performing the backup if the snapshot is not needed. |
| delete | Deletes the backup from default directory |
| restore | Restores the system using the backup from default directory.<br>• System failback will be disabled after restoration.<br>• Existing snapshot on system will be deleted after restoring the system from a backup.<br>• The cryptographic hash in the **info** file will be used to validate the integrity of the backup file before the restore process begin.<br>• A system reboot is required after restoration. |
| info | Displays the create time and size of the backup in the default directory |
| -D or --directory | Specifies the directory for **create, delete, restore** and **info** commands |

| Flag | Description |
|---|---|
| -y or --yes | Automatically consent to the prompt during create, delete and restore |

The following example shows how to back up a system to a USB storage drive with the mounting point

**/media/USB_p1**:

```
moxa@moxa-tbzkb1090923:# sudo mx-system-mgmt backup create -D /media/USB_p1
Set /media/USB_p1 as backup directory.
Check the backup information...
There is no backup information
```

```
Start evaluating space, please wait...
Estimation of Required Space: 628MB
Available Space: 32756MB
Would you like to continue? (y/N)y
Synchronize boot files...
              0   0%    0.00kB/s    0:00:00 (xfr#0, to-chk=0/2)
Start creating backup file...
 628MiB 0:00:57 [11.0MiB/s] [ <=> ]
Type: backup
Create Time: 2021.11.06-17:32:29
Size: 628MB
The backup has been created successfully under: /media/USB_p1
```

The following example shows how to restore a backup from the USB storage drive with the mounting point **/media/USB_p1**:

```
moxa@moxa-tbzkb1090923:# sudo mx-system-mgmt backup restore -D /media/USB_p1
Set /media/USB_p1 as backup directory.
Check the backup information...
Type: backup
Create Time: 2021.11.06-17:44:43
Size: 628MB
Start verifying backup file, please wait...
Verified OK!
Start evaluating space, please wait...
Estimation of Required Space: 628MB
Available Space: 5125MB
Would you like to continue? (y/N)y
Check the snapshot information...
Type: snapshot
Create Time: 2021.11.06-15:42:47
Size: 235MB
This will delete the existing snapshot.
Do you want to continue? (y/N)y
Check the snapshot information...
Type: snapshot
Create Time: 2021.11.06-15:42:47
Size: 235MB
The snapshot has been deleted successfully.
To restore the backup file will overwrite current system and factory default
system.
Do you want to continue? (y/N)y
Start using the backup file to restore the system...
 628MiB 0:01:00 [10.4MiB/s] [============================================>]
100%
Synchronize boot files...
              0   0%    0.00kB/s    0:00:00 (xfr#0, to-chk=0/2)
System has been restored successfully. Reboot is required to take effect.
moxa@moxa-tbzkb1090923:# sudo reboot
```

# Setting the System to the Default

Press and hold the **FN** button for 7 to 9 seconds to reset the computer to the factory default settings. When the reset button is held down, the LED will blink once every second. The LED will become steady when you hold the button continuously for 7 to 9 seconds. Release the button immediately when the LED become steady to load the factory default settings. For additional details on the LEDs, refer to the quick installation guide or the user's manual for your Arm-based computer

### ATTENTION

**Reset-to-default will erase all data stored on the boot-up storage**

Back up your files before resetting the system to factory defaults. All the data stored in the Arm-based computer's boot-up storage will be destroyed after resetting to factory defaults.

You can also use the **`mx-system-mgmt default restore`** command to restore the computer to factory default settings. You must use sudo or run the command with the root permission.

```
moxa@moxa-tbzkb1090923:/# sudo mx-system-mgmt default restore
```

If you would like to configure the **FN** button for a different action (e.g., restore to a snapshot), refer to Customize the Button Action section.

# Decommissioning the System

Compared with the set-to-default function, decommissioning will further erase all data stored in the log partition to help erase security-sensitive information.

### ATTENTION

**Decommission will erase all the data including event and audit logs**

Please back up your files before resetting the system to factory defaults. All user data including logs in your Arm-based computer will be destroyed after performing decommissioning. Bootloader configuration, including administrator password, will also be set to factory default.

You can also use the **`mx-system-mgmt default decommission`** command to restore the computer to factory default. You must use sudo or run the command with the root permission.

```
moxa@moxa-tbzkb1090923:/# sudo mx-system-mgmt default decommission
```

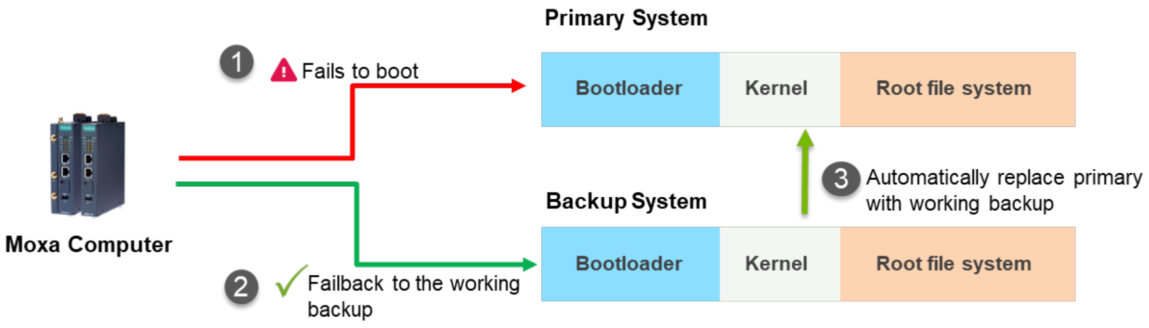
The decommissioning process will do the following:

1. Overwrite the system partition 4 times with shred so that all user files will be deleted and cannot be recovered.
2. Overwrite the log partition 4 times with shred so that all log files will be deleted and cannot be recovered.
3. Trigger the bootloader decommissioning function, so all configurations and log messages in the bootloader are also deleted and cannot be recovered.

# System Failback Recovery

A system bootup failure may occur when critical files are lost or corrupted. A typical and common cause of boot up failure is power lost during system update. Moxa System Management (MSM) provides system failback capability which can automatically recovers your system to the last known working state if boot up failure is detected after critical change(s) are made to the primary system. The boot failure criteria are customizable by user.

Before applying critical update or changes to the device, it is recommended to enable system failback first.



Use # **`mx-system-mgmt system-failback <sub-command> <flag>`** to enable or disable system failback. You must use sudo or run the command with the root permission.

| Sub-commands | Description |
|---|---|
| enable | Enables system failback and create a replica of the system<br>• The replica includes **Bootloader**, **kernel (partition 1)** and **rootfs (partition 3)**<br>• The replica is stored in **rootfs (partition 3)**<br>• When the Moxa Arm-based computer fails to boot up, the device will automatically reboot and replace the broken system with the working replica.<br>• The replica includes a system snapshot. If you would like to reduce the size of the replica, you can delete the snapshot if you no longer need it. |
| disable | Disables the system failback and delete the existing system replica |
| info | Displays the create time and size of replica |
| state | Displays the status of system failback (enabled/disabled) |

| Flag | Description |
|---|---|
| -y or --yes | Automatically consent to the prompts during the enable and disable processes |

Below is an example of how to enable system failback and display the information of the system replica:

```
moxa@moxa-tbzkb1090923:/# sudo mx-system-mgmt system-failback enable
Start evaluating space, please wait...
Estimation of Required Space: 233MB
Available Space: 5333MB
Would you like to continue? (y/N) y
Start processing...
Synchronize boot files...
              0   0%    0.00kB/s    0:00:00 (xfr#0, to-chk=0/2)
              0   0%    0.00kB/s    0:00:00 (xfr#0, to-chk=0/2)
Start creating replica...
   244,670,045  99%   11.94MB/s   0:00:19 (xfr#170, to-chk=0/294)
Type: replica
Create Time: 2021.11.06-14:35:14
Size: 235MB
The system failback has been enabled and the replica has been created
successfully.
moxa@moxa-tbzkb1090923:/# sudo mx-system-mgmt system-failback info
Check the replica information...
Type: replica
Create Time: 2021.11.06-14:35:14
Size: 235MB
```

## Customize the Boot Up Failure Criteria

If you would like to customize the boot failure criteria, you can edit below script to add criteria you like Moxa System Manager to check.

**`/etc/moxa-system-manager/check-hooks.d/99-example.sh`**

In below example in **`99-example.sh`**, Moxa System Manager will consider the boot up is successful if "moxa-connection-manager.service" start successfully by returning a zero value. If the program returns a non-zero value, the moxa-system-manager service will not mark this startup as successful, and it will enter the system-failback process to restore the system.

```
#systemctl is-active moxa-connection-manager.service && exit 0 || exit 1
```

# 8. Security Capability

In this chapter, we will introduce Moxa Arm-based computers key security functions and a security hardening guide to deploy and operate Moxa computer in a secure manner

## Communication Integrity and Authentication

Below is a list of network communication services and protocols available in the Moxa Arm-based computer and their data integrity and authentication protection mechanisms.

| Service | Protocol | Data Integrity | Data Authentication |
|---|---|---|---|
| SSH server and client | SSH | HMAC algorithm is used to guarantee data integrity | Uses key signature algorithms such as ED25519 or ECDSA to verify authenticity |
| SFTP server | SSH | | |
| SCP server | SSH | | |
| APT client | HTTPS | SecureAPT uses checksum to guarantee data integrity | SecureAPT uses GPG public key system to validate data authenticity |
| NTP client (NTS support) | TLS/SSL, NTP | NTS guarantees data integrity via NTS Authenticator and Encrypted EF | NTS provides TLS layer to guarantee authenticity |

**ATTENTION**

For post-installed communication services and protocols, you must ensure data integrity and authentication are implemented. If integrity and authentication are not available, you must use additional compensating countermeasures in system to compensate the risk. For example, physical cable protection for serial Modbus RTU.

## User Account Permissions and Privileges

### Switching to the Root Privilege

In Moxa Arm-based computers, the root account is disabled in favor of better security. The default user account **moxa** belongs to the sudo group. Sudo is a program designed to let system administrators allow permitted users to execute some commands as the root user or another user. The basic philosophy is to give as few privileges as possible but still allow people to get their work done. Using sudo is better (safer) than opening a session as root for a number of reasons, including:

- Nobody needs to know the root password (sudo prompts for the current user's password). Extra privileges can be granted to individual users temporarily, and then taken away without the need for a password change.
- It is easy to run only the commands that require special privileges via sudo; the rest of the time, you work as an unprivileged user, which reduces the damage caused by mistakes.
- Some system-level commands are not available to the user moxa directly, as shown in the sample output below:

```
moxa@Moxa-tbzkb1090923:~$ sudo ifconfig
eth0      Link encap:Ethernet  HWaddr 00:90:e8:00:00:07
          inet addr:192.168.3.127  Bcast:192.168.3.255  Mask:255.255.255.0
          UP BROADCAST ALLMULTI MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

eth1      Link encap:Ethernet  HWaddr 00:90:e8:00:00:08
          inet addr:192.168.4.127  Bcast:192.168.4.255  Mask:255.255.255.0
          UP BROADCAST ALLMULTI MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:16436  Metric:1
          RX packets:32 errors:0 dropped:0 overruns:0 frame:0
          TX packets:32 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:2592 (2.5 KiB)  TX bytes:2592 (2.5 KiB)
```

You can switch to the root account using the **sudo -i (or sudo su)** command. For security reasons, do not operate the **all** commands from the root account.

### NOTE

Click the following link for more information on the **sudo** command.
https://wiki.debian.org/sudo

### ATTENTION

You might get the permission denied message when using pipe or redirect behavior with a non-root account.

You must use '**sudo su –c**' to run the command instead of using >, <, >>, <<, etc.

**Note:** The single quotes enclosing the full command are required.

## Controlling Permissions and Privileges

Moxa Industrial Linux uses Discretionary Access Control (DAC) based on Access Control Lists (ACLs) to manage permissions and privileges, which an object has an owner that controls the permissions to access the object. Subjects can transfer their access to other subjects. In other words, the owner of the resource has full access and can determine the access type (rwx: read, write, execute) of other users.

You can use **chmod** command to configure who (user, group, other) can do what (read, write, execute) to a file or directory. The access permission is extended by Access Control Lists (ACLs) authorization. ACL provides a more flexible mechanism that allows multiple users and groups to own an object. You can check and configure access control lists of a specific file or directory using **getfacl** and **setfacl** commands.

### NOTE

Click the following link for more information on usages of chmod and Access Control Lists (ACLs)
https://wiki.debian.org/Permissions

Moxa Arm-based computers only provide one account in sudo group by default because it is intended for the system integrator to customize and build their applications on top.

The system integrator shall be responsible for setting the appropriate permissions to roles and user accounts to enforce the concept of least privilege.

# Linux Login Policy

## Invalid Login Attempts

Moxa Industrial Linux provides the capability to configure allowed invalid login attempts to mitigate against Denial-of-Service (DoS) and Brute-force attack.

| Security Model | Default Rule |
|---|---|
| Secure model | **[5]** consecutive invalid login within **[60]** seconds will deny access for **[300]** seconds. |
| Standard model | Not set |

Following is the configuration file and variable to configure the setting:

| Configuration Option | Configuration file | Variable to Set |
|---|---|---|
| Consecutive invalid login | /etc/security/faillock.conf | deny |
| Within how many seconds | /etc/security/faillock.conf | fail_interval |
| Deny access for how long (in seconds) | /etc/security/faillock.conf | unlock_time |

More configurable options can be found in following reference:

- login.defs(5) — login — Debian bullseye — Debian Manpages
- faillock.conf(5) — libpam-modules — Debian bullseye — Debian Manpages

## Session Termination After Inactivity

This setting automatically terminates the login sessions after a standard period of inactivity. Below is the default configuration set in Moxa Arm-based computer.

| Security Model | Default Value |
|---|---|
| Secure model | • Automatically logout standard user after 900 second of inactivity<br>• Automatically terminate root privilege of sudo user after 900 second of inactivity |
| Standard model | Not set |

Follow below instructions to configure the inactivity time:

| Login Method | Configuration |
|---|---|
| Serial Console and SSH (Secure Shell) | • Set the value (in seconds) of variable **TMOUT** in **/etc/profile.d/99-moxa-profile.conf**<br>• Apply the same value to variable **ClientAliveInterval** in **/etc/ssh/sshd_config.d/00-moxa-sshd.conf**<br>• To apply the rule to sudo user, make sure variable **env_keep+="TMOUT"** exist in **/etc/sudoers.d/00-moxa-sudoers-conf** |

## Login Banner Message

You can set a message banner message to displaying welcome or informational messages or warming message to un-authorized users. Follow below instructions to add a banner Moxa Industrial Linux 3.0 UM for Arm-based Computers Moxa Industrial Linux 3.0 UM for Arm-based Computers.

| Login Method | Banner Content | Additional Configuration Required |
|---|---|---|
| Serial Console | /etc/issue | n/a |
| SSH (Secure Shell) | /etc/issue.net | Add variable **Banner /etc/issue.net** is added in **/etc/ssh/sshd_config.d/00-moxa-sshd.conf** |

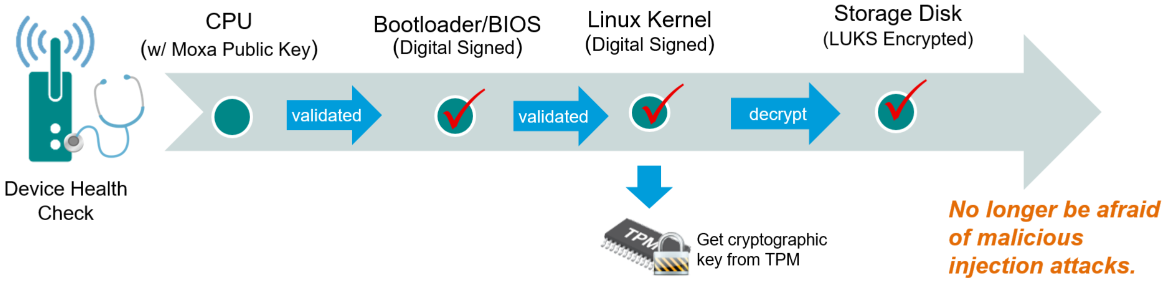
# Bootloader Login Policy

For bootloader login policy management, refers to the bootloader configuration section.

# Secure Boot and Disk Encryption

Secure boot and disk encryption are available in Secure model, designed to make platform integration more secure. Moxa's secure boot process begins from CPU as hardware root-of-trust to ensure integrity and authenticity of bootloaders and Linux kernels are validated with Moxa digital signature before execution, preventing malicious or un-authenticated bootloader and kernels to run on Moxa Arm-based computer.

Next, only after bootloader and kernel have been validated, the LUKS (Linux Unified Key Setup) encrypted root file system (rtfs) will be decrypted by a key provisioned in TPM during factory production. The disk encryption prevent confidential data could be read without authorization when the device is stolen or lost.



## Public key infrastructure (PKI)

Moxa secure boot use X.509 public key infrastructure (PKI) to validate authenticity and integrity of bootloader and Linux kernel.

## How are private keys protected?

Private keys used to digital sign Moxa software are stored in on-premises tamper and intrusion-resistant hardware security module (HSM), where strict access authorization and 24-hour video surveillance are applied.

## Key lifecycle and revocation

In an unlikely scenario where the private key stored in HSM is compromised, Moxa will announce the news on Moxa Security Advisory, including instructions to revoke the compromised public key burned in the CPU via a utility downloadable from Moxa APT repository. Then update the bootloader and system image signed by a new private key.

⚠ **ATTENTION**

DO NOT arbitrarily replace the kernel or bootloader on Secure models, or the computer will not be able to boot up.

# Trusted Platform Module (TPM 2.0)

The Moxa Arm-based computer includes a TPM 2.0 hardware module. TPM provides a hardware-based approach to manage user authentication, network access, data protection and more that takes security to higher level than software-based security. It is strongly recommended to manage keys with TPM and also store digital credentials such as passwords

The TPM can be managed via the tpm2_tools pre-installed in Moxa Industrial Linux (https://github.com/tpm2-software/tpm2-tools).

TPM software stack & tool is maintained by tpm2-software community
https://tpm2-software.github.io/

A good reference of TPM 2.0 introduction
https://link.springer.com/chapter/10.1007/978-1-4302-6584-9_3

# Host Intrusion Detection

**Secure model** of Moxa Arm-based computer comes with **AIDE** (Advanced Intrusion Detection Environment) preconfigured. AIDE is a lightweight but powerful host intrusion detection utility for checking the integrity of files.

The out-of-factory Moxa Arm-based computer comes with a database created by AIDE at the first time bootup containing all security configurations set by Moxa. You can compare the system's status against this database to find out if there is any integrity breach. You can also update the database after making changes to the configuration or adding additional software.

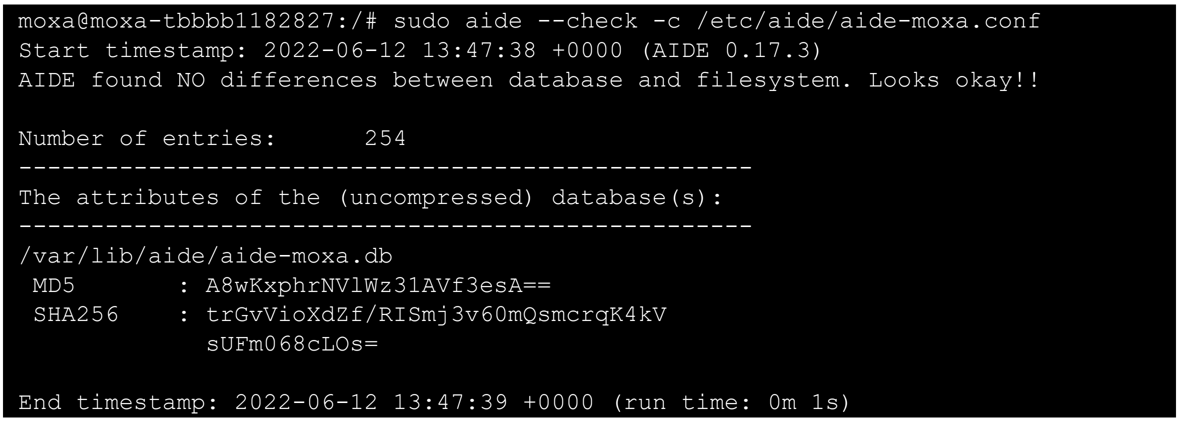
## Default Monitored Files

Below are the security configuration files and directories included in the default database created by Moxa.

- The database is **`aide-moxa.db`** and put under **`/var/lib/aide/aide-moxa.db`**
- The configuration file of AIDE is **`/etc/aide/aide-moxa.conf`**; you can add additional files and directories to the database

| Configuration Type | Path |
|---|---|
| File | /etc/adduser.conf |
| | /etc/login.defs |
| | /etc/logrotate.conf |
| | /etc/nftables.conf |
| | /etc/profile |
| | /etc/rsyslog.conf |
| | /etc/sudoers |
| Directory | /etc/aide |
| | /etc/audit |
| | /etc/logrotate.d |
| | /etc/moxa/MoxaComputerInterfaceManager |
| | /etc/moxa/MoxaConnectionManager |
| | /etc/moxa/moxa-guardian |
| | /etc/pam.d |
| | /etc/security |
| | /etc/profile.d |
| | /etc/rsyslog.d |
| | /etc/ssh |
| | /etc/sudoers.d |
| | /var/lib/moxa-guardian |

To run a comparison between current system against the Moxa AIDE database, run **`aide --check -c /etc/aide/aide-moxa.conf`**



```
moxa@moxa-tbbbb1182827:/# sudo aide --check -c /etc/aide/aide-moxa.conf
Start timestamp: 2022-06-12 13:47:38 +0000 (AIDE 0.17.3)
AIDE found NO differences between database and filesystem. Looks okay!!

Number of entries:      254
---------------------------------------------------
The attributes of the (uncompressed) database(s):
---------------------------------------------------
/var/lib/aide/aide-moxa.db
 MD5        : A8wKxphrNVlWz31AVf3esA==
 SHA256     : trGvVioXdZf/RISmj3v60mQsmcrqK4kV
              sUFm068cLOs=

End timestamp: 2022-06-12 13:47:39 +0000 (run time: 0m 1s)
```

To update the database after you have make configuration changes, run **`aide --init -c /etc/aide/aide-moxa.conf`**

You should see following output which created a new AIDE database **aide-moxa.db.new** under **/var/lib/aide**

```
moxa@moxa-tbbbb1182827:/# sudo aide --init -c /etc/aide/aide-moxa.conf

Start timestamp: 2022-06-12 14:39:30 +0000 (AIDE 0.17.3)
AIDE initialized database at /var/lib/aide/aide-moxa.db.new

Number of entries:      254
---------------------------------------------------
The attributes of the (uncompressed) database(s):
---------------------------------------------------

/var/lib/aide/aide-moxa.db.new
 MD5        : Mb74vEG93jjVfJMGSZa+DA==
 SHA256     : ENl5QGVgYXuKEwE3FSXRfzxl3vJg0TxU
              WsQnHN16E74=

End timestamp: 2022-06-12 14:39:30 +0000 (run time: 0m 0s)
```

For AIDE to use the new database, you need to rename it to **`aide-moxa.db`**

```
moxa@moxa-tbbbb1182827:/# sudo mv /var/lib/aide/aide-moxa.db.new
/var/lib/aide/aide-moxa.db
```

At this point, you can run **`aide --check -c /etc/aide/aide-moxa.conf`** to compare current system against the updated AIDE database

# How to Perform Authenticity an Integrity Check on All Files

If you would like to ensure authenticity and integrity of all files in the Moxa Arm-based computer, you can create a openSSL signed database containing every single file under the filesystems, then validate the authenticity of the database before using AIDE to check the integrity of all files in the filesystem. Following below steps to create such AIDE database.

1. Create a database using **`/etc/aide/aide-fs.conf`**; this configuration file monitors every single file in the filesystem.

   ```
   moxa@moxa-tbbbb1182827:/# sudo aide --init -c /etc/aide/aide-fs.conf
   ```

2. Rename the created database to **`/var/lib/aide/aide-fs-moxa.db`**
3. Generate a 4096-bit RSA private key.

   ```
   moxa@moxa-tbbbb1182827:/# sudo openssl genrsa -out aide-key.pem 4096
   Generating RSA private key, 4096 bit long modulus (2 primes)
   ...........................................................................+
   +++
   ....................................++++
   e is 65537 (0x010001)
   Enter pass phrase for aide-key.pem:
   ```

⚠

## ATTENTION

You MUST keep the private key and pass phrase in a secure location.

4. Generate a public key from the private key:

   ```
   moxa@moxa-tbbbb1182827:~$ sudo openssl rsa -in aide-key.pem -pubout -out
   aide-
   key.pub
   Enter pass phrase for aide-key.pem:
   writing RSA key
   moxa@moxa-tbbbb1182827:~$
   ```

5. Generate a digital signature of **aide-filesystem-moxa.db** by the private key.

```
moxa@moxa-tbbbb1182827:~$ sudo openssl dgst -sha256 -sign aide-key.pem -out
aide-filesystem-moxa.db.sha256 /var/lib/aide/aide-fs-moxa.db
Enter pass phrase for aide-key.pem:
```

6. Now, you can distribute the database, public key and signed signature to other location, such as a centralized remote system.
7. Verify the database has been tampered or not.

```
moxa@moxa-tbbbb1182827:~$ sudo openssl dgst -sha256 -verify aide-key.pub -
signature aide-filesystem-moxa.db.sha256 /var/lib/aide/aide-fs-moxa.db
Verified OK
```

8. After the AIDE database' authenticity has been validated, you can run a comparison between current system against the AIDE database using **aide --check -c /etc/aide/aide-fs.conf**

### NOTE

Click the following link for more information on usages of AIDE
https://manpages.debian.org/bullseye/aide-dynamic/aide.1.en.html

# Intrusion Prevention

**Fail2ban** is pre-installed in Moxa Industrial Linux as an intrusion prevention software framework designed to prevent against brute-force attacks

### NOTE

Click the following link for detail instructions of Fail2ban usage
https://www.fail2ban.org/wiki/index.php/Main_Page

# Network Security Monitoring

**Zeek** is pre-installed in Moxa Industrial Linux for network security monitoring. Zeek is a passive network traffic analyzer. Many operators use Zeek as a network security monitor (NSM) to support investigations of suspicious or malicious activity. Zeek also supports a wide range of traffic analysis tasks beyond the security domain, including performance measurement and troubleshooting. Zeek provides an extensive set of logs describing network activity. These logs include not only a comprehensive record of every connection seen on the wire, but also application-layer transcripts

If you have configured **cellular(4G/LTE)** and **ethernet** networks in Moxa Connection Manager (MCM). You can also enable Zeek to monitor the network traffic of these interfaces. Following the simple instruction below:

1. Export the Zeek environment.

```
export PATH=$PATH:/opt/zeek/bin
export ZEEK_PREFIX=/opt/zeek
```

2. [Required] Configure the interface to monitor by running **# vim $ZEEK_PREFIX/etc/node.cfg**.

3. [Required] Modify the interface list according to the interface you like to monitor. For example, add LAN1, LAN2, and cellular (4G/LTE) in the list.

```
# This example has a standalone node ready to go except for possibly
changing
# the sniffing interface.

# This is a complete standalone configuration.  Most likely you will
# only need to change the interface.
[zeek]
type=standalone
host=localhost
interface=eth0,eth1,wwan0
```

4. [Optional] change the **MailTo** email address to a desired recipient and the **LogRotationInterval** to a desired log archival frequency

   **vim $ZEEK_PREFIX/etc/zeekctl.cfg**

```
# Recipient address for all emails sent out by Zeek and ZeekControl.
MailTo = root@localhost

# Rotation interval in seconds for log files on manager (or standalone)
node.
# A value of 0 disables log rotation.
LogRotationInterval = 3600
```

5. [Required] Run **$ZEEK_PREFIX/bin/zeekctl** to start **Zeek**

```
root@moxa-tbbbb1182827:/home/moxa# $ZEEK_PREFIX/bin/zeekctl

Hint: Run the zeekctl "deploy" command to get started.
Welcome to ZeekControl 2.4.0

Type "help" for help.
[ZeekControl] >
```

6. [Required] For the first-time use of the shell, use **install** command to perform initial installation of the ZeekControl configuration.

```
[ZeekControl] > install

creating policy directories ...
installing site policies ...
generating standalone-layout.zeek ...
generating local-networks.zeek ...
generating zeekctl-config.zeek ...
generating zeekctl-config.sh ...
[ZeekControl] >
```

7. [Required] Start Zeek instance by **Start** command (Use CTRL+D to exit if initializing successfully).

```
[ZeekControl] > start

starting zeek ...
(zeek still initializing)
```

8. View the Zeek logs under **$ZEEK_PREFIX/logs**.

```
root@moxa-tbbbb1182816:/# ls -alh /opt/zeek/logs/current/
total 96K
drwxr-sr-x 2 root zeek 4.0K Jun 19 04:18 .
drwxrws--- 1 root zeek 4.0K Jun 19 04:17 ..
-rw-r--r-- 1 root zeek  250 Jun 19 04:18 capture_loss.log
-rw-r--r-- 1 root zeek  128 Jun 19 04:17 .cmdline
-rw-r--r-- 1 root zeek  583 Jun 19 04:18 conn.log
-rw-r--r-- 1 root zeek  352 Jun 19 04:17 .env_vars
-rw-r--r-- 1 root zeek  30K Jun 19 04:17 loaded_scripts.log
-rw-r--r-- 1 root zeek  753 Jun 19 04:18 notice.log
-rw-r--r-- 1 root zeek  227 Jun 19 04:17 packet_filter.log
-rw-r--r-- 1 root zeek    5 Jun 19 04:17 .pid
```

```
-rw-r--r-- 1 root zeek   61 Jun 19 04:17 .startup
-rw-r--r-- 1 root zeek  686 Jun 19 04:17 stats.log
-rwxr-xr-x 1 root zeek   19 Jun 19 04:17 .status
-rw-r--r-- 1 root zeek   19 Jun 19 04:17 stderr.log
-rw-r--r-- 1 root zeek  204 Jun 19 04:17 stdout.log
-rw-r--r-- 1 root zeek  367 Jun 19 04:18 weird.log
```

**NOTE**

Click the following link for Zeek's detail instruction and also the explanation on log types
https://docs.zeek.org/en/master/quickstart.html

If you prefer not to use ZeekControl (e.g., you don't need its automation and management features), you can refer to https://docs.zeek.org/en/master/quickstart.html#zeek-as-a-command-line-utility on how to directly control Zeek for your analysis activities from the command line for both live traffic and offline working from traces.

# Firewall

**nftable** is the built-in firewall in Moxa Industrial Linux. Secure model of Moxa Arm-based computer has pre-configured rules to further protect your device from network attacks.

**NOTE**

Click the following link for detail instructions of nftable usages
https://wiki.nftables.org/wiki-nftables/index.php/Main_Page
https://wiki.nftables.org/wiki-nftables/index.php/Quick_reference-nftables_in_10_minutes

## Pre-configured Rule

Below is a summary of nftable rules in **`/etc/nftables.conf`** set by Moxa in Secure model of Moxa Arm-based computer. For Standard model, nftable is not enabled by default.

| Rules Set | Location/Parameters |
|---|---|
| Allowed only ports following port<br>• TCP: SSH (22), HTTPS (443)<br>• UDP: NTP (123), DNS (53) | define tcp_port_allow = { ssh, https };<br>define udp_port_allow = { 53, ntp }; |
| Allow all traffic from loopback interface | iifname "lo" accept |
| Drop all input traffic except for traffic from allowed ports and icmp (ping) | chain input { ……} |
| Allow related and established traffic by using conntrack | ct state invalid drop<br>ct state established,related accept |
| Drop all forward traffic | chain forward { ……} |
| Accept all output traffic | chain output { ……} |

```
flush ruleset

define tcp_port_allow = { 22, 443 };
define udp_port_allow = { 53, 123 };

table inet filter {
        # input: drop all traffic
        chain input {
                type filter hook input priority 0; policy drop;

                ct state invalid drop
                ct state established,related accept

                # allow icmp
                icmp type {
                        echo-request,
                        echo-reply,
                        time-exceeded,
                        parameter-problem,
                        destination-unreachable
                } accept

                # allow icmp6
                icmpv6 type {
                        echo-request,
                        echo-reply,
                        time-exceeded,
                        parameter-problem,
                        destination-unreachable,
                        nd-neighbor-solicit,
                        nd-router-advert,
                        nd-neighbor-advert
                } accept

                # accept lo
                iifname "lo" accept

                tcp dport $tcp_port_allow accept
                udp dport $udp_port_allow accept
        }

        # foward: drop all traffic
        chain forward {
                type filter hook forward priority 0; policy drop;
        }

        # output: accept all traffic
        chain output {
                type filter hook output priority 0; policy accept;
        }
}
```

## Common nftable Usage

1. List the currently loaded nftable rules **`# nft list ruleset`**
2. Debug and tracing if traffic are drop or accept as expected **`# nft monitor trace`**
   a. Add trace_chain before the existing input chain

   ```
   nft add chain inet filter trace_chain { type filter hook prerouting
   priority -1\; }
   ```

   b. Add nftrace flag

   ```
   nft add rule inet filter trace_chain meta nftrace set 1
   ```

   c. Monitor trace (you can use another device with ncat tool to test it)dd nftrace flag

   ```
   moxa@moxa-tbbbb1182816:/# sudo nft monitor trace

   trace id d51bda11 inet filter trace_chain packet: iif "eth0" ether saddr
   d8:5e:d3:a5:7b:29 ether daddr 00:90:e8:a6:37:cb ip saddr 192.168.1.102 ip
   daddr 192.168.1.107 ip dscp cs0 ip ecn not-ect ip ttl 128 ip id 36481 ip
   protocol tcp ip length 52 tcp sport 1142 tcp dport 53 tcp flags == syn
   tcp window 64240 trace id d51bda11 inet filter trace_chain rule meta
   nftrace set 1 (verdict continue) trace id d51bda11 inet filter
   trace_chain verdict continue trace id d51bda11 inet filter trace_chain
   policy accept trace id d51bda11 inet filter input packet: iif "eth0"
   ether saddr d8:5e:d3:a5:7b:29 ether daddr 00:90:e8:a6:37:cb ip saddr
   192.168.1.102 ip daddr 192.168.1.107 ip dscp cs0 ip ecn not-ect ip ttl
   ```

```
128 ip id 36481 ip protocol tcp ip length 52 tcp sport 1142 tcp dport 53
tcp flags == syn tcp window 64240 trace id d51bda11 inet filter input
verdict continue trace id d51bda11 inet filter input policy drop
```

d. Once debugging is completed, make sure to remove the debug flag by either method below:

- ❒ Restart nftable **# `systemctl restart nftables`** or
- ❒ Reload the configuration again **# `nft -f /etc/nftables.conf`**

# Rate Limiting

Rate limiting is a common strategy to prevent network attacks such as DOS, DDOS, and brute force by limiting the network traffic within a specified time. As the suitable rate limit configuration depends heavily on the asset owner's applications, rate limiting is not configured by default in Moxa Industrial Linux.

| nftable Rate Limit Usage | Example of Rate Limit Configuration |
|---|---|
| rate [over] <value> <unit> [burst <value> <unit>] | limit rate 400/minute<br>limit rate 400/hour<br>limit rate over 40/day<br>limit rate over 400/week<br>limit rate over 1023/second burst 10 packets<br>limit rate 1025 kbytes/second<br>limit rate 1023000 mbytes/second<br>limit rate 1025 bytes/second burst 512 bytes<br>limit rate 1025 kbytes/second burst 1023 kbytes<br>limit rate 1025 mbytes/second burst 1025 kbytes<br>limit rate 1025000 mbytes/second burst 1023 mbytes |

You can directly add rate limit to existing rule in **`/etc/nftables.conf`**:

Below is an example of limiting TCP and UDP network traffic to 4 packets per second

```
#!/usr/sbin/nft -f

flush ruleset

define tcp_port_allow = { ssh, https };
define udp_port_allow = { 53, ntp };

table inet filter {
        # input: drop all traffic
        chain input {
                type filter hook input priority 0; policy drop;

                ct state invalid drop
                ct state established,related accept

                # allow icmp
                ip protocol icmp icmp type {
                        echo-request,
                        echo-reply,
                        time-exceeded,
                        parameter-problem,
                        destination-unreachable
                } accept

                # allow icmp6
                ip6 nexthdr icmpv6 icmpv6 type {
                        echo-request,
                        echo-reply,
                        time-exceeded,
                        parameter-problem,
                        destination-unreachable
                } accept
                # accept lo
iifname "lo" accept

                tcp dport $tcp_port_allow limit rate 4/second accept
                udp dport $udp_port_allow limit rate 4/second accept        }
```

## Mitigating a NTP Amplification Attack

The default configured NTP servers in Moxa Industrial Linux(MIL) are with NTS support. If you use public NTP servers without NTS support, it is vulnerable to the **NTP amplification attack**, in which the attacker could exploit the public NTP servers to overwhelm Moxa Arm-based computer with UDP traffic. Under such an incident, you can follow the steps to stop the attack:

1. Stop NTP service temporarily with the # systemctl stop systemd-timesyncd command.
2. Block the tainted NTP server by nftables command
    a. Create new firewall table

    ```
    nft add table inet firewall-filter
    ```

    b. Create new chain input in firewall table

    ```
    nft add chain inet firewall-filter input
    ```

    c. Create new chain input in firewall table

    ```
    nft add rule inet firewall-filter input tcp dport { ntp } ip saddr <your
    ip> reject
    ```

    d. Block NTP server IP

    ```
    nft add rule inet firewall-filter input tcp dport { ntp } ip saddr <your
    ip> reject
    ```

    e. Check the rule set

    ```
    nft list ruleset

    ...
    table inet firewall-filter {
            chain input {
                    tcp dport { 123 } ip saddr 10.213.123.55 reject
            }
    }
    ```

3. You can choose to specify another NTP server (modify **/etc/systemd/timesyncd.conf**) or wait for this server to finish troubleshooting
4. Remember to flush the rule after recovery

    ```
    nft delete chain inet firewall-filter input # delete chain
    # or
    nft delete table inet firewall-filter # delete table
    ```

# Service and Ports

Only activate protocols that you require to use the system. Below is the list for the protocol and port numbers used for all external interfaces. Please refer to Firewall section to modify the list of allowed port if additional port is required.

| Protocol | Port Number |
|---|---|
| SSH | 22 |
| HTTPS | 443 |
| NTS | 123/4460 |
| DNS | 53 |

## Disable Unnecessary Protocols, Services, and Ports

You can use **#ss** to list all the current running processes using with the associated service, protocol, and network port.

```
moxa@moxa-tbbbb1182827:~$ sudo ss -tulpn
Netid        State        Recv-Q        Send-Q              Local Address:Port
Peer Address:Port        Process
tcp          LISTEN        0             128                        0.0.0.0:22
0.0.0.0:*             users:(("sshd",pid=974,fd=3))
tcp          LISTEN        0             128                           [::]:22
[::]:*             users:(("sshd",pid=974,fd=4))
```

You can disable a daemon or service by killing process ID (PID) directly. For example:

```
moxa@moxa-tbbbb1182827:~$ sudo kill 974
```

Or you can just stop and disable the service using **#systemctl**. For example:

```
moxa@moxa-tbbbb1182827:~$ sudo systemctl stop sshd
moxa@moxa-tbbbb1182827:~$ sudo systemctl disable sshd
```

## Restrict Unnecessary Protocols, Services, and Ports

1. Protocols:

   Use **nfables** meta to match kind of TCP traffic Matching packet metainformation. Refers to nftables wiki.

2. Services:

   Use **# systemctl list-unit-files** to find unused services and disable them by **systemctl disable <service>**.

3. Ports:

   Use nftables to add accepted ports in whitelist. Refers to the Firewall section for detail instructions.

## Services Enabled by Default

Below is the list for the services enabled by default in the secure model of the Moxa Arm-based computers.

| Service Name | Description |
|---|---|
| auditd.service | Security Audit log service |
| dbus.service | System Message Bus |
| fail2ban.service | Fail2ban IPS (intrusion prevention software) |
| getty@tty1.service | Getty on tty1 |
| ifupdown-pre.service | Helper to synchronize boot up for ifupdown |
| kmod-static-nodes.service | Create list of static device nodes for the current kernel |
| ModemManager.service | DBus-activated daemon which controls mobile broadband (2G/3G/4G) devices and connections |
| moxa-connection-manager.service | Moxa Connection Manager (MCM) |
| moxa-guardian.service | Initializing security configuration for Moxa Industrial Linux |
| moxa-system-manager-init.service | Moxa System Manager initialization service |
| moxa-system-manager.service | Moxa System Manager |
| MoxaComputerInterfaceManager.service | Moxa Computer Interface Manager |
| networking.service | Raises or downs the network interfaces |
| NetworkManager.service | Network Manager |
| nftables.service | nftable |
| polkit.service | For controlling system-wide privileges is Moxa Industrial Linux |
| rsyslog.service | System Logging Service |
| serial-getty@ttymxc0.service | Serial Getty on ttymxc0al-getty@ttymxc0.service |
| ssh.service | SSH Server |
| systemd-journal-flush.service | Flush journal to persistent storage |
| systemd-journald.service | Journal service |
| systemd-logind.service | User login management |
| systemd-modules-load.service | Early boot service that loads kernel modules |
| systemd-random-seed.service | Service that loads an on-disk random seed into the kernel entropy pool during boot and saves it at shutdown |

| Service Name | Description |
|---|---|
| systemd-remount-fs.service | early boot service that applies mount options listed in fstab(5) |
| systemd-sysctl.service | An early boot service that configures sysctl(8) kernel parameters |
| systemd-sysusers.service | Creates system users and groups, based on the file format and location specified in sysusers.d(5) |
| systemd-timesyncd.service | System service that synchronizes the local system clock with a remote Network Time Protocol (NTP) server |
| systemd-tmpfiles-setup-dev.service | Create Static Device Nodes in /dev |
| systemd-tmpfiles-setup.service | Create Volatile Files and Directories |
| systemd-udev-trigger.service | Coldplug all udev devicesd-udev-trigger.service |
| systemd-udevd.service | Listens to kernel uevents |
| systemd-update-utmp.service | Service that writes SysV runlevel changes to utmp and wtmp, as well as the audit logs |
| systemd-user-sessions.service | a service that controls user logins through pam_nologin(8) |
| user-runtime-dir@1000.service | Default user |
| user@1000.service | Default user |
| vnstat.service | network traffic monitor |
| watchdog.service | Watchdog service |
| wpa_supplicant.service | WPA supplicant |

# Managing Resources

## Setting The Process Priority

A process can be manually adjusted to increase or decrease its priority. Use the **top** or **ps** commands to find out the process priority.

```
moxa@moxa-tbbbb1182827:/# sudo top
top - 22:08:43 up 6 min,  1 user,  load average: 0.01, 0.04, 0.01
Tasks: 105 total,   1 running, 104 sleeping,   0 stopped,   0 zombie
%Cpu(s):  0.2 us,  0.8 sy,  0.0 ni, 98.8 id,  0.1 wa,  0.0 hi,  0.0 si,  0.0 st
KiB Mem :  2068192 total,  1874520 free,    57416 used,   136256 buff/cache
KiB Swap:        0 total,        0 free,        0 used.  1799712 avail Mem

PID USER      PR  NI    VIRT    RES    SHR S %CPU %MEM     TIME+ COMMAND
  1 root      20   0    9492   6220   5236 S  0.0  0.3   0:00.98 systemd
  2 root      20   0       0      0      0 S  0.0  0.0   0:00.00 kthreadd
  3 root      20   0       0      0      0 S  0.0  0.0   0:00.01 ksoftirqd/0
  4 root      20   0       0      0      0 S  0.0  0.0   0:00.02 kworker/0:0
  5 root       0 -20       0      0      0 S  0.0  0.0   0:00.00 kworker/0:0H
  6 root      20   0       0      0      0 S  0.0  0.0   0:00.01 kworker/u2:0
  7 root      20   0       0      0      0 S  0.0  0.0   0:00.02 rcu_sched
 ...
```

You can also use the **ps** command with the **-l**, long list option to find out the priority of the process.

```
moxa@moxa-tbbbb1182827:/# sudo ps -efl
F S UID         PID  PPID  C PRI  NI ADDR SZ WCHAN  STIME TTY   TIME CMD
4 S root          1     0  0  80   0 -  2373 ep_pol 22:02 ?     00:00:01
/sbin/init
1 S root          2     0  0  80   0 -     0 kthrea 22:02 ?     00:00:00
[kthrreadd]
1 S root          3     2  0  80   0 -     0 smpboo 22:02 ?     00:00:00
[ksoftirqd/0]
1 S root          5     2  0  60 -20 -     0 worker 22:02 ?     00:00:00
[kworker/0:0H]
1 S root          6     2  0  80   0 -     0 worker 22:02 ?     00:00:00
[kworker/u2:0]
1 S root          7     2  0  80   0 -     0 rcu_gp 22:02 ?     00:00:00
[rcu_sched]
```

```
1 S root          8      2  0  80    0 -      0 rcu_gp 22:02 ?     00:00:00
[rcu__bh]
...
```

The PRI (Priority) or NI (Nice) is the priority of the process. The PRI is adjusted by kernel automatically. The NI can have a value in the range -20 to 19. A smaller value means that the program could use more CPU resources.

The nice utility can be given a specific nice value while running a program. This example shows how to launch the **tar** utility with the nice value 5.

```
moxa@moxa-tbbbb1182827:/# sudo nice -n 20 tar -czvf TheCompressFile.tar /src1
/src2 ...
OR
moxa@moxa-tbbbb1182827:/# sudo nice -adjustment 20 tar -czvf
TheCompressFile.tar /src1 /src2 ...
```

You can use the **renice** utility to dynamically adjust the nice value of a program. This example uses renice to adjust the auditd, PID 639, with highest priority as -20.

```
moxa@moxa-tbbbb1182827:/# sudo renice -n 20 -p 639
moxa@moxa-tbbbb1182827:/# sudo ps -efl|grep auditd
1 S root       639      1  0  75  -20 -  1519 poll_s 22:02 ?        00:00:00
/sbin/auditd -n
...
```

## NOTE

Click the following link for more information on usages of nice and renice
https://manpages.debian.org/bullseye/coreutils/nice.1.en.html
https://manpages.debian.org/bullseye/bsdutils/renice.1.en.html

### Setting the Process I/O Scheduling Class and Priority

The **ionice** command can adjust the priority of the program using I/O. The class and priority are adjustable for a process.

| | |
|---|---|
| -c class | 0: none<br>1: realtime<br>2: best-effort<br>3: idle |
| -n classdata | The realtime and best-effort can set from 0 to 7. A smaller value means the program has a higher priority. |
| -p PID | Process ID |

```
moxa@moxa-tbbbb1182827:/# sudo ps -l
F S   UID   PID  PPID  C PRI  NI ADDR SZ WCHAN  TTY          TIME CMD
4 S     0   895   886  0  80   0 -  1794 wait   pts/0    00:00:00 bash
4 S     0  1099   895  0  80   0 -  1659 poll_s pts/0    00:00:00 sudo
4 R     0  1100  1099  0  80   0 -  1850 -      pts/0    00:00:00 ps
moxa@moxa-tbbbb1182827:/# sudo ionice -c 2 -n 0 -p 895
moxa@moxa-tbbbb1182827:/# sudo ionice  -p 895
best-effort: prio 0
```

## NOTE

Click the following link for more information on usages of ionice
https://manpages.debian.org/bullseye/util-linux/ionice.1.en.html

### Limiting the CPU Usage of a Process Using cpulimit

cpulimit is a simple program that attempts to limit the CPU usage of a process (expressed in percentage, not in CPU time). This is useful to control batch jobs, when you don't want them to eat too much CPU.

This example, use the cpulimit to limit the usage of sshd process CPU limit percentage to 25% in background. The -p is the process ID. The -e switch take the executable program file name. The -l is the CPU limit percentage. The option, -b, to run cpulimit in the background, freeing up the terminal.

```
moxa@moxa-tbbbb1182827:/# sudo cpulimit -p 895 -l 25 -b
```

**NOTE**

Click the following link for more information on usages of cpulimit
https://manpages.debian.org/bullseye/cpulimit/cpulimit.1.en.html

### Limiting the Rate

Refer to the Chapter 8 Security Firewall Rate Limiting to customize the network limitation of the firewall configuration.

# Audit Log

In this section, we will introduce the audit event log design in Moxa Industrial Linux and bootloader, including the security event monitored and recommended response and approach for audit processing failures.

## Linux Audit log

**Auditd** is being used in Moxa Industrial Linux for system administrators to monitor detailed information about system operation. It provides a way to track and record security-relevant information on the system.

1. Log partition size: **256MB**
2. Log partition applies Linux Unified Key Setup (LUKS) encryption and restrict non root user from access
3. Logs are stored under **`/var/log/audit/`** and the log format follows **`auditd`** standard.
   - Below is a reference of where to find the commonly used log data fields in audit log

| Common Log Data Fields | Data Fields in auditd log |
|---|---|
| timestamp | msg=audit(TIMESTAMP) |
| source | proctitle, comm, exec, uid, gid, etc. |
| category | key |
| type | type |
| eventID | pid, ppid |

4. Audit log records are automatically rotated daily and up to 14 achieved logs are kept at a time. When log rotates, the oldest archive will be deleted if 14 achieved logs exist.
   - Audit log rotation rule can be modified in **`/etc/logrotate.d/auditd`**
5. The log timestamp is the local system time which synchronize with a remote Network Time Protocol (NTP) server.
   - For time synchronization status and configuration, refers to timedatectl(1)

**NOTE**

Click the following link for more information on usages of auditd and log search
https://manpages.debian.org/bullseye/auditd/auditd.8.en.html
https://manpages.debian.org/bullseye/auditd/ausearch.8.en.html

Below are the security events that Moxa Industrial Linux is pre-configured to monitor in Secure model of Moxa Arm-based computer

| Event Category | Event Logged | File or Directory to Monitor | key used for ausearch |
|---|---|---|---|
| Access control | Users logins, logouts, system events, etc. | /var/run/utmp<br>/var/run/btmp<br>/var/run/wtmp | session |
| Backup and restore | Use of Moxa System Manager tool | /sbin/mx-system-mgmt | system_mgmt |
| Control System | Shutdown system | /sbin/shutdown | system_mgmt |
| | Power off system | /sbin/poweroff | power |
| | Reboot system | /sbin/reboot | power |
| | Halt system | /sbin/halt | power |
| | Use of APT package management system | /usr/bin/apt | system_package |
| | Use of aptitude tool | /usr/bin/aptitude | system_package |
| | Use of add-apt-repository tool | /usr/bin/apt-add-repository | system_package |
| | Use of apt-get tool | /usr/bin/apt-get | system_package |
| | Use of dpkg package manager tool | /usr/bin/dpkg | system_package |
| Security configurations | Add user configuration change | /etc/adduser.conf | adduser |
| | AIDE configuration and database change | /etc/aide<br>/var/lib/aide | aide<br>aide-db |
| | Audit configuration and log change | /etc/audit<br>/var/log/audit | auditconfig<br>auditlog |
| | Login policy change | /etc/login.defs | login |
| | Log rotate configuration change | /etc/logrotate.conf<br>/etc/logrotate.d | logrotate |
| | Moxa Computer Interface Management configuration change | /etc/moxa/ MoxaComputerInterfaceManager | mcim |
| | Moxa Connection Manger configuration change | /etc/moxa/MoxaConnectionManager | mcm |
| | Moxa Guardian configuration change | /etc/moxa/MoxaConnectionManager<br>/var/lib/moxa-guardian | moxa-guardian<br>moxa-guardian-registry |
| | Password policy change | /etc/pam.d<br>/etc/security/limits.conf<br>/etc/security/limits.d<br>/etc/security/faillock.conf<br>/etc/security/pwquality.conf<br>/etc/security/pwquality.conf.d | pam |
| | Linux system wide environment configuration change | /etc/profile<br>/etc/profile.d | profile |
| | Rsyslog configuration change | /etc/rsyslog.conf<br>/etc/rsyslog.d | rsyslog |
| | SSH (Secure Shell) configuration change | /etc/ssh/sshd_config<br>/etc/ssh/sshd_config.d | sshd |
| | Sudo configuration change | /etc/sudoers | sudo |

# Bootloader Audit Log

1. Log is stored in SPI flash with **1MB** storage size
2. Log can be viewed via **(2) Advance Setting > (4) View Bootloader Log** in Bootloader menu
3. Maximum number of logs is 4,000 records, where the oldest log will be overwritten when the maximum capacity is reached.
4. The time stamp of the log read from the local Real-time Clock (RTC) which is synchronize with Network Time Protocol (NTP) server.
5. Log format and log events are described below

## Audit Log Structure

| Header | Explanation | Possible Values |
|---|---|---|
| Time | Time stamp of the device | Format: [YYYY-MM-DDThh:mm:ss]<br>For example: [2022-06-03T15:54:38] |
| User | Identifies the authenticated user | Admin |
| Category | Event category | • System<br>• Bootcfg (refers to boot configuration)<br>• Install<br>• Security |
| Event ID | ID of a logged event | 1 ~ 15 |
| Event Message | Description of the logged event | See below table for the list of events |

## Audit Events

| Category | Event ID | Event Type | Event Message |
|---|---|---|---|
| System | 1 | Info | All bootloader configuration set to default |
| System | 2 | Info | Exit bootloader and reboot system |
| System | 3 | Info | Exit bootloader and boot to Linux |
| bootcfg | 4 | Info | Set boot configuration to default ok |
| bootcfg | | Warning | Set boot configuration to default fail |
| bootcfg | 5 | Info | Set boot from SD/USB/eMMC ok |
| bootcfg | | Warning | Set boot from SD/USB/eMMC fail |
| bootcfg | 6 | Warning | USB is not available on this device |
| bootcfg | 7 | Info | Bootarg and bootcmd changed |
| Install | 8 | Info | Install system image from TFTP ok |
| Install | | Warning | Destination net unreachable |
| Install | | Warning | Hash/Signature file not find |
| Install | | Warning | System image file error |
| Install | | Warning | File size is too large |
| Install | | Warning | Upgrade system image fail |
| Install | | Alert | System image authenticity check fail |
| Install | 9 | Info | Install system image from SD ok |
| Install | | Warning | SD/USB/eMMC device not find |
| Install | | Warning | Hash/Signature file not find |
| Install | | Warning | System image file error |
| Install | | Warning | File size is too large |
| Install | | Warning | Upgrade system image fail |
| Install | | Alert | System image authenticity check fail |
| Secure | 10 | Info | Install system image from USB ok |
| Secure | | Warning | SD/USB/eMMC device not find |
| Secure | | Warning | Hash/Signature file not find |
| Secure | | Warning | System image file error |
| Secure | | Warning | File size is too large |
| Secure | | Warning | Upgrade system image fail |
| Secure | | Alert | System image authenticity check fail |
| Secure | 11 | Info | TFTP setting changed |
| Secure | 12 | Info | Login success |
| Secure | | Warning | login fail |
| Secure | 13 | Alert | Boot failure due to system image integrity or authenticity check fail |
| Secure | 14 | Info | Admin password disabled |
| Secure | | Info | Admin password enabled |
| Secure | 15 | Info | Admin password set to default |
| Secure | 16 | Info | Admin password changed |
| Secure | 17 | Info | Admin password policy changed |
| Secure | 18 | Info | Advance settings set to default |
| Secure | 19 | Info | Auto reboot threshold changed |
| Secure | 20 | Info | Login message changed |
| Secure | 21 | Info | Invalid Login Attempts changed |
| Secure | 22 | Info | Clear TPM ok |
| Secure | | Warning | Clear TPM fail |

| Category | Event ID | Event Type | Event Message |
|---|---|---|---|
| audit | 23 | Info | View bootloader log ok |

## Audit Failure Response

The section is a guideline for protection of critical system functions in case of audit processing failure. Without appropriate response to audit processing failure, an attacker's activities can go unnoticed, and evidence of whether the attack led to a breach can be inconclusive. Following are some common approaches:

1. **Log rotation**

   Log rotation is enabled by default in Moxa Arm-based computer to prevent audit storage capacity full. Refers to **Linux Audit Log** and **Bootloader Audit log** sections for details.

   In Linux, configure the logrotate to limit the disk space usage to prevent running out of space. The logrotate configuration file is at /etc/logrotate.config and all the files in /etc/logrotate.d/* to rotate the log file.

   This example we configure /etc/logrotate.d/rsyslog to rotate /var/log/syslog while it overs the size 2M with only 3 rotation.

```
/var/log/syslog

  {
    {
      rotate 3
      maxsize 2M
      ...
    }
  }
```

2. **Saving the logs in external storage**

   - For auditd, change the file path of parameter **log_file** in **/etc/audit/auditd.conf**
   - For rsyslog, change the default file path **/var/log/** in **/etc/rsyslog.conf** to external storage

3. **Use a centralized log Server**

   Use a centralized log managements system to collect and store the logs from Log from multiple devices. Refers to How to Set Up Centralized Logging on Linux with Rsyslog

4. **Assign appropriate action when audit storage space is full, or error occurs**

   You can configure **space_left** and **space_left_action** parameters in **/etc/audit/auditd.conf** to specify the remaining space (in megabytes or %) for low disk alert and what action to take. The actions are ignore, syslog, rotate, exec, suspend, single, and halt.

   In example below, warning email will be sent to email account specified in **action_mail_acct** parameter when the free space in the filesystem containing log files drop below 75 megabytes

```
space_left = 75
space_left_action = email
```

   Configure **disk_full_action** and **disk_error_action** in **/etc/audit/auditd.conf** to specify what actions to take when audit storage disk got error or full. The actions are ignore, syslog, rotate (for disk full only), exec, suspend, single, and halt.

   Refers to auditd(8) for detail explanation of each action and parameters.

# Security Diagnosis Tool (Moxa Guardian)

The secure models of Moxa’s Arm-based computer are secure-by-default and certified to IEC 62443-4-2 SL2. However, on many occasions, the default security settings are unintentionally changed and they no longer adhere to the standard, especially when conducting customization development on the computer.

Moxa Guardian is a security diagnosis tool that gives you an overview of the gap between the current security configurations based on the IEC 62443-4-2 Security Level 2 standards and the Moxa recommended security configurations. You can also use the tool to restore the security configurations to the default out-of-box secured configurations.

Use the **# mx-guardian** command to display the menu page.

```
Moxa Guardian is a cli tool allows users to operate security configs

Moxa Guardian is a CLI security diagnosis tool that gives you an overview of
the gap between the current security configurations against the IEC 62443-4-2
Security Level 2 host device requirement and the Moxa recommended security
configurations.

Usage:
  mx-guardian [command]

Available Commands:
  diagnose   Diagnose security settings and output report
  help        Help about any command
  set         Apply a pre-defined security profile
  version     Show Moxa Guardian version and build info

Flags:
  -f, --force      force mode
  -h, --help       help for mx-guardian
      --no-color   disable color
  -q, --quiet      quiet mode (imply force)
  -v, --verbose    verbose mode
      --version    get version

Use "mx-guardian [command] --help" for more information about a command.
```

**ATTENTION**

As the Moxa computer is an open platform that allows users to install any software they desire, Moxa Guardian's diagnosis tool only compares the current configurations against the default out-of-box IEC 62443-4-2 compliance configurations. For example, if additional protocols are installed, Moxa Guardian will not diagnose such protocols' communication integrity and authenticity capabilities. It is the responsibility of the user to follow the hardening guidelines and the IEC 62443 standard to meet the security requirements.

## Diagnosing Issues in the Current Security Configuration

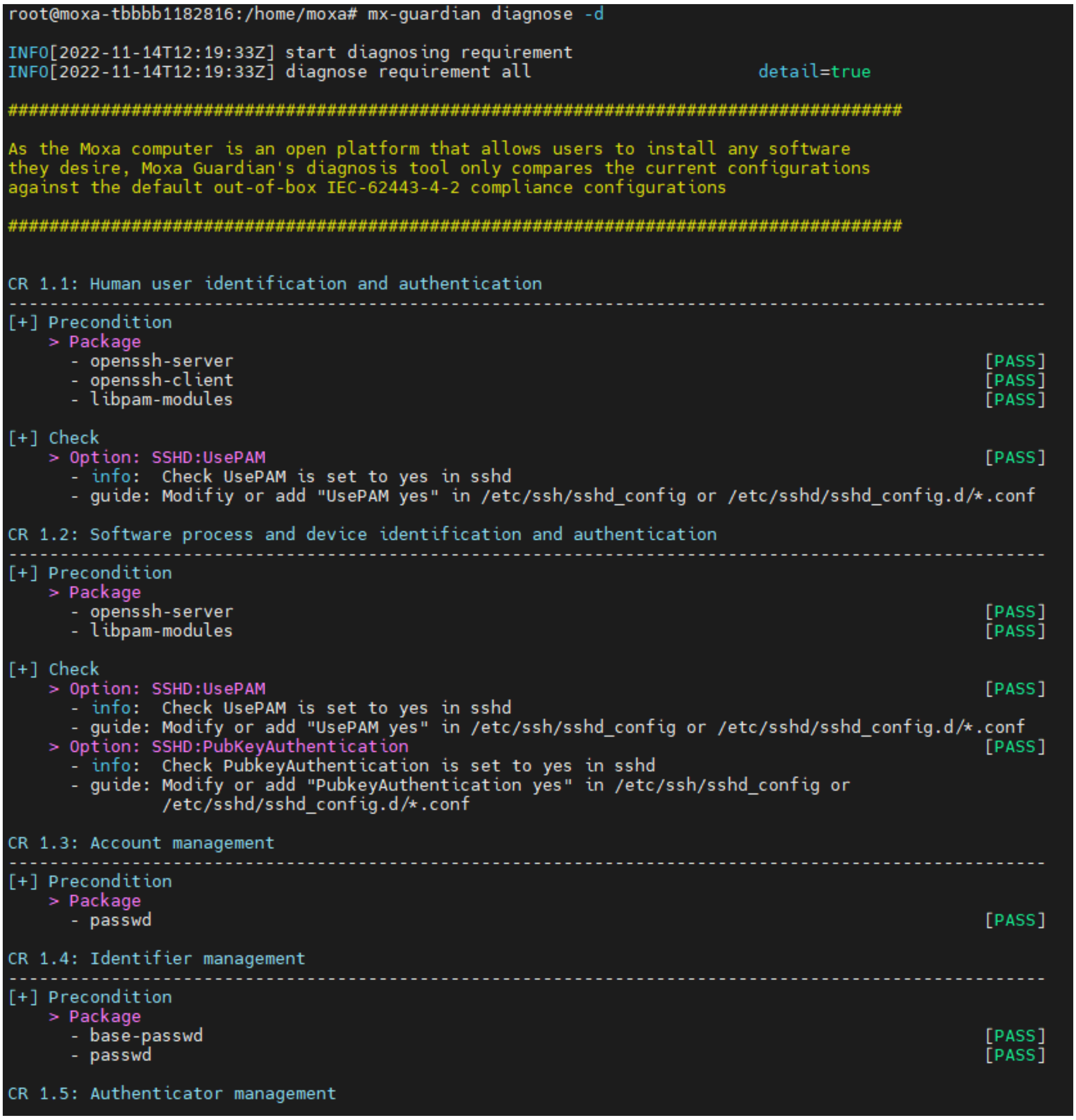
Use **# mx-guardian diagnose <flags>** to initiate a diagnosis of the current security configurations against the default out-of-box secured configuration, which include all IEC 62443-4-2 security level 2 compliance configurations and also additional Moxa recommended security setting not covered in IEC 62443 standard. The diagnosed result are shown in the sequential orders of IEC 62443-4-2 requirement (CR 1.1 to CR 7.8), followed by Moxa's recommended security settings.

| Flags | Description |
|---|---|
| -d or –detail | Show details including the reason and guideline for the failed requirements |
| -h or –help | Print the help menu for diagnose command |
| -o or –output <target filepath> | Output the diagnose result to a file |

The diagnosis result could be one of the following:

- **PASS:** The device’s security configuration meets the IEC 62443-4-2 security level 2 standard or Moxa recommended setting.
- **FAIL:** The device’s security configuration fails to meet the IEC 62443-4-2 security level 2 standard or Moxa recommended setting.
- **INFO:** The device’s security configuration meet the IEC 62443-4-2 security level 2 standard but additional configuration can be applied if suitable.

An example of Moxa Guardian’s diagnosis output is given below:



```
root@moxa-tbbbb1182816:/home/moxa# mx-guardian diagnose -d

INFO[2022-11-14T12:19:33Z] start diagnosing requirement
INFO[2022-11-14T12:19:33Z] diagnose requirement all                      detail=true

########################################################################################

As the Moxa computer is an open platform that allows users to install any software
they desire, Moxa Guardian's diagnosis tool only compares the current configurations
against the default out-of-box IEC-62443-4-2 compliance configurations

########################################################################################


CR 1.1: Human user identification and authentication
------------------------------------------------------------------------------------------------------
[+] Precondition
    > Package
      - openssh-server                                                                           [PASS]
      - openssh-client                                                                           [PASS]
      - libpam-modules                                                                           [PASS]

[+] Check
    > Option: SSHD:UsePAM                                                                        [PASS]
      - info:  Check UsePAM is set to yes in sshd
      - guide: Modifiy or add "UsePAM yes" in /etc/ssh/sshd_config or /etc/sshd/sshd_config.d/*.conf

CR 1.2: Software process and device identification and authentication
------------------------------------------------------------------------------------------------------
[+] Precondition
    > Package
      - openssh-server                                                                           [PASS]
      - libpam-modules                                                                           [PASS]

[+] Check
    > Option: SSHD:UsePAM                                                                        [PASS]
      - info:  Check UsePAM is set to yes in sshd
      - guide: Modify or add "UsePAM yes" in /etc/ssh/sshd_config or /etc/sshd/sshd_config.d/*.conf
    > Option: SSHD:PubKeyAuthentication                                                          [PASS]
      - info:  Check PubkeyAuthentication is set to yes in sshd
      - guide: Modify or add "PubkeyAuthentication yes" in /etc/ssh/sshd_config or
               /etc/sshd/sshd_config.d/*.conf

CR 1.3: Account management
------------------------------------------------------------------------------------------------------
[+] Precondition
    > Package
      - passwd                                                                                   [PASS]

CR 1.4: Identifier management
------------------------------------------------------------------------------------------------------
[+] Precondition
    > Package
      - base-passwd                                                                              [PASS]
      - passwd                                                                                   [PASS]

CR 1.5: Authenticator management
```

## Restoring the Security Configuration to the Default

Use **`# mx-guardian set <command> <flags>`** to restore the Moxa Arm-based security configuration to the to the default out-of-box IEC 62443-4-2 compliance secured configurations.

| Command | Description |
|---|---|
| secure | Restore the Moxa Arm-based configuration to a pre-defined security profile |

| Flags | Description |
|---|---|
| -d or –detail | Show details including the reason and guideline for the failed requirements |
| -h or –help | Print the help menu |
| -m or --mode <string> | The <string> parameter support 2 values (m1 or m2)<br>Description of each mode is given below :<br>**M1:** Apply only the IEC 62443-4-2 security level 2 required settings<br>**M2:** Apply both M1 and Moxa recommended settings<br>*Note : M2 is the default out-of-box security setting* |

An example of restoring the computer’s security profile to M2 (IEC 62443-4-2 security level 2 and Moxa recommended settings) is give below:

```
moxa@moxa-tbzkb1090923:~$ sudo mx-guardian set secure -m m2
INFO[2022-11-10T05:53:51Z] start setting secure command
INFO[2022-11-10T05:53:51Z] apply all changes with
force=false mode="IEC62443-4-2 and MOXA suggested settings" quiet=false
INFO[2022-11-10T05:53:51Z] no changes
file=/etc/adduser.conf
INFO[2022-11-10T05:53:51Z] no changes
file=/etc/audit/auditd.conf
INFO[2022-11-10T05:53:51Z] no changes
file=/etc/profile.d/99-moxa-profile.conf
INFO[2022-11-10T05:53:51Z] no changes
file=/etc/security/faillock.conf
INFO[2022-11-10T05:53:51Z] no changes
file=/etc/security/pwquality.conf.d/99-moxa-pwquality.conf
INFO[2022-11-10T05:53:51Z] no changes
file=/etc/login.defs
INFO[2022-11-10T05:53:51Z] no changes
file=/etc/logrotate.d/00-moxa-logrotate.conf
INFO[2022-11-10T05:53:51Z] no changes
file=/etc/ssh/sshd_config.d/00-moxa-sshd.conf
INFO[2022-11-10T05:53:51Z] no changes
file=/etc/sysctl.d/99-moxa-sysctl.conf
INFO[2022-11-10T05:53:51Z] no changes
file=/etc/rsyslog.d/99-moxa-rsyslog.conf

Attention : you must reboot your computer for the changes to take effect
```

## ATTENTION

You must reboot your computer for the changes to take effect.

# 9. Security Hardening Guide

In this chapter, we will provide guidance on how to deploy and operate Secure model of Moxa Arm-based computer in a secure manner

## Defense-in-depth Strategy

| Security Layer | Security Measures | Threat mitigated/handled | Responsibility |
|---|---|---|---|
| Policy and procedure | Establish policies and procedures to guide employee on their role and responsibilities to for safe use of security sensitive assets.<br>Refers to Operation and Maintenance section for some recommendations | Vulnerabilities created due to employee lack of security policies and procedures awareness | Asset owner (Essential) |
| | | Malicious code attack that could create or exploit system vulnerabilities (Threat ID #6) | |
| Perimeter Security | Use LTE service provide with Carrier Grade NAT (CGNAT) and firewall | Unauthorized and malicious communications from untrusted network | Asset owner (Essential) |
| | Perimeter firewall | Unauthorized and malicious communications from untrusted network | Asset owner (Essential) |
| | Physical security<br>(Refers to section Physical Installation) | Physical modification, manipulation, theft, removal, or destruction of asset | |
| Network Security | Network IDS/IPS | Network attacks from various sources such as port scanning, DDOS, etc. | Asset owner (Recommended) |
| | VPN | Man-in-the-middle attacks that allow hackers to intercept and manipulate network traffic (Threat ID #4) | |
| Endpoint Security | End point Firewall (nftable) | Unauthorized and malicious communications from untrusted network<br>(Threat ID #2, Threat ID #5) | Provided by Moxa Arm-based Computer |
| | Brute-force attacks IPS (fail2ban) | Trial and error attack attempting to crack login credentials (Threat ID #3) | |
| | Automatic network Connection failover<br>(Refers to MCM failover configuration) | Radio jamming attack (Threat ID #1) | |
| | Patch management | Vulnerabilities from outdated software could expose to security breach. | |
| | Secure transmission protocol | Man-in-the-middle attacks that allow hackers to intercept and manipulate network traffic (Threat ID #4) | Asset owner / Moxa Arm-based Computer (Essential) |

| Security Layer | Security Measures | Threat mitigated/handled | Responsibility |
|---|---|---|---|
| | Audit processing failure response | Audit processing failure without appropriate response results in the attacker's activities can go unnoticed, and evidence of whether the attack led to a breach can be inconclusive (Threat ID #7) | |
| Application Security | IEC 62443-4-1 certified secure design, implementation, validation, and defect management process | Potential vulnerabilities generated from development and testing process that doesn't follow the security best practices. | Provided by Moxa Arm-based Compute |
| Data Security | Host Intrusion Detection System (AIDE) | Unexpected changes to important files that could potentially lead to security breach. | Provided by Moxa Arm-based Computer |
| | Access control and login policy including limit invalid login attempts, automatic session termination and login banner | Unauthorize operation to Moxa Arm-based computer that could lead to system confidentiality and integrity breach or availability attack. | |
| | Disk encryption | Access to confidential data in storage without authorization. | |
| | Secure boot | Tampering of bootloader, OS kernel and rootFS. | |

*Table 9.1 – Defense-in-Depth Strategy*

*Essential: Security measure that must be taken by asset owner to ensure secure use of Moxa Arm-based computer *Recommended: Security measures that need to be taken by the asset owner if the threats apply.

### Potential Threats and Corresponding Security Measures

Below is a list of potential security threats that can harm Moxa Arm-based computers and the corresponding security measures that need to be taken by the **asset owner** if the threats apply.

| Threat ID | Threat mitigated/handled | Security Measures |
|---|---|---|
| 1 | Radio jamming attack resulting in Wi-Fi and cellular connection DOS | • For Moxa Arm-based computer with both Wi-Fi and cellular interface, configure connection failover to use backup connection when primary connection is attack by radio jamming<br>• Extend the perimeter of physical security to reduce the impact from radio jamming attack |
| 2 | Network data flow through ethernet, Wi-Fi, cellular interface could be potentially interrupted, crashed or stopped by DOS attack | • Setup network monitoring tool to detect abnormal traffic<br>• Configure rate limiting to limit the network traffic |
| 3 | SSH server could be potentially interrupted, crashed or stopped by DOS attack | 1. Following parameters are set in SSH server configuration file by Moxa as countermeasure.<br>➢ MaxSessions: set to 6 to protect a system from denial of service due to a large number of concurrent sessions<br>➢ MaxStartups: set to 6:30:60 to protect a system from denial of service due to a large number of pending authentication connection attempts<br>2. Fail2ban is pre-installed and running in Moxa Arm-based computer to automatically ban malicious IP |
| 4 | Data flowing across ethernet may be sniffed by an attacker | 1. Make sure secure protocol with encryption and authentication are used for data transmission (e.g., SSHv2, HTTPS)<br>2. Install and use VPN for secure data transmission |
| 5 | DOS attack from untrusted NTP server when Moxa Arm-based computer attempt to synchronize time | If a public NTP server without NTS support is used, it is vulnerable to an NTP amplification attack which the attacker could exploit public NTP servers to overwhelm Moxa Arm-based computer with UDP traffic; therefore, refers to Mitigate NTP Amplification Attack to mitigate it. |

| Threat ID | Threat mitigated/handled | Security Measures |
|---|---|---|
| 6 | Data read from USB or SD card could be spoofed | 1. Use sha256 or other checksums tools to check the integrity of the file before installing or transferring to device. If the file is Debian package (.deb), refers to "How to manually check for package's integrity" to validate.<br>2. Scan the file with Clamav before installing or transferring it to the device<br>3. Use OpenSSL to verify the signature of the file before installing or transferring to the device. |
| 7 | Insufficient auditing storage causing logs to rotate frequently | Store log in external storage or use a centralized log managements system to collect and store the logs from multiple devices. Refers to How to Set Up Centralized Logging on Linux with Rsyslog |

# Installation

## Physical Installation

1. Secure model of Moxa Arm-based computer MUST be used to ensure safe use. Refer to Secure and Standard Model for details of model difference.
2. The secure model of Moxa Arm-based computer MUST be protected by physical security that can include CCTV surveillance, security guards, protective barriers, locks, access control, perimeter intrusion detection, etc. The proper form of physical security should apply depending on the environment and the physical attack risk level.
3. Moxa Arm-based computer has anti-tamper labels on the enclosures. This allows the administrator to tell whether the device has been tampered with.
4. Moxa Arm-based computer uses security screw on the enclosures as physical tamper resistance measure to increase the difficulty of probing the product internals in case of physical security breach.
5. Moxa Arm-based computer MUST not be used to **control** the operation of mission-critical IACS component which failure to maintain control of such device could result in threat to human, safety, environment or massive financial lost.

## Environment Requirement

1. If Moxa Arm-based computer connects to untrust network (e.g., Internet) via ethernet or Wi-Fi, it MUST NOT directly connected to the untrust network, which means a firewall must be setup between ethernet and Wi-Fi connection from Moxa Arm-based computer and the untrust network.
2. For security-critical applications, we strongly recommend using a private APN for cellular networks.

## Access Control

1. The default user account **Moxa** of Linux belongs to the sudo group. Before deploying Moxa Arm-based computer after development, you must disable this default account and create new account(s) following the least privilege principle, granting only the necessary access right and permission for the intended operation.
2. Each account should be assigned the correct privileges. Moxa Industrial Linux uses Discretionary Access Control (DAC) based on Access Control Lists (ACLs) to manage permissions and privileges. Refers to Permissions and Privileges Control for details.
3. The default password policy requires the password to be at least 8 characters in length. We strongly recommend keeping the default setting, or you can reduce the password length by adding additional complexity rules to the password, such as special character or numeric character enforcement. Refers to instructions to configure the policy for Linux and Bootloader, respectively.
4. Update user passwords on a timely manner. For administrator, we recommend refreshing password at least every 3 months.

5. Bootloader configuration menu comes with a single administrator account shared by all users. Asset owner MUST have access and identity records of the personnel who accessed the bootloader to ensure non-repudiation in case of security breach incidents.
6. Below is a list of all services in Moxa Arm-based computer uses to connect with external processes and components.

| Service | Protocol | Interfaces | Owner (uid/gid) | Authorization Enforcement |
|---|---|---|---|---|
| SSH server | SSH | Ethernet, cellular, Wi-Fi | root/root | Yes |
| SFTP server | SSH | Ethernet, cellular, Wi-Fi | root/root | Yes |
| SCP server | SSH | Ethernet, cellular, Wi-Fi | root/root | Yes |
| Serial Getty service | RS-232 | Serial console port | root/root | Yes |
| APT client | HTTPS | Ethernet, cellular, Wi-Fi | root/root | Yes |
| NTP client (NTS support) | TLS/SSL, NTP | Ethernet, cellular, Wi-Fi | root/root | Yes |

## Security Configuration Check

The secure models of Moxa's Arm-based computer are secure-by-default and certified to IEC 62443-4-2 SL2. However, on many occasions, the default security settings are unintentionally changed and they no longer adhere to the standard, especially when conducting customization development on the computer.

Moxa Guardian is a security diagnosis tool that gives you an overview of the gap between the current security configurations based on the IEC 62443-4-2 Security Level 2 standards and the Moxa recommended security configurations. Make sure you run the security diagnosis before deploying the product. Refer to Security Diagnosis Tool section for details usage of Moxa Guardian

# Operation

### Administrator

1. **Disable default account**

   Use the **passwd** command to lock the default user account so that the **moxa** user cannot log in. Make sure to create a new account before disable the default account

   ```
   moxa@moxa-tbzkb1090923:# sudo passwd -l moxa
   ```

2. **Disabled interfaces that are not in use**

   The interfaces that are not in use should be deactivated. Please refer to Disabled Unused Interface for detailed instructions.

3. **Periodically regenerate the SSH server key**

   Periodically regenerate the SSH server key in order to secure your system in case the key is compromised. Please refer to Rekey SSH

4. **Trusted administrator**

   Make sure only trusted and reliable persons are registered in the sudo groups for root privilege.

5. **Audit failure response**

   Refer to Audit Failure Response Guideline to protection of critical system functions in case of audit processing failure

6. **System integrity validation**

   - Frequently run system integrity check to protect your system against malware, viruses and detect unauthorized activities. Refers to Intrusion Detection System for the utility that come with Moxa Arm-based computer
   - We recommend you reset Moxa Arm-based computer to factory default upon receiving it to avoid the risk of potential software tampering before the computer reaches your hand.

7. **Only use secure cryptographic**

   - Moxa Industrial Linux on Moxa Arm-based computer only uses secure cryptographic that are commonly accepted industry best practices and recommendations as defined in NIST SP 800-57.

- Moxa Industrial Linux installed OpenSSL by default but doesn’ t disable weak algorithms such as TLS 1.0/1.1 and SSLv3. It is recommended that your application deployed on Moxa Industrial Linux only uses secure algorithms defined in NIST SP 800-57. You can disable the weaker cryptographic algorithm in OpenSSl by setting CipherString = DEFAULT@SECLEVEL=[desired level] in /etc/ssl/openssl.cnf to a higher level. For details, refers to : https://www.openssl.org/docs/man1.1.1/man3/SSL_CTX_set_security_level.html

8. **Malicious code protection**
   - Downloading file from untrusted sources is not recommended. If you still want to do it, make sure to verify the file using following recommendation:
     - ❒ Use sha256 or stronger algorithms checksums tools to check the integrity of the file before installing or transferring to device
     - ❒ If the file is Debian package (.deb), follow “How to manually check for package’s integrity” for the instruction.
     - ❒ Use OpenSSL to verify the signature of the file before installing or transferring to the device.

### Administrator and User

1. **Periodically refresh password**

   Update user passwords on a timely manner. For administrator, we recommend refreshing password at least every 3 months

2. **Encrypt confidential file**

   Use GPG to encrypt confidential file or directory with a password in Linux. You can reference How To Encrypt And Decrypt Files With A Password for quick instructions.

# Maintenance

1. **Perform Update Frequently**
   - Perform software upgrades frequently to enhance features, deploy security patches, or fix bugs.
   - We recommend you enable System Failback Recovery before performing critical update.
2. **Perform Backup Frequently**

   Frequently backup of system on timely manner
3. **Examine Audit Logs Frequently**

   Examine audit logs frequently to detect any anomalies.
4. **Report Vulnerability to Moxa**

   To report vulnerabilities of Moxa products, please submit your findings on the following web page: https://www.moxa.com/en/support/product-support/security-advisory/report-a-vulnerability.

# Decommissioning

1. To avoid any sensitive information such as your account password or certificate from being disclosed, always use the **`mx-system-mgmt default decommission`** command to reset the computer to factory default and further wipe out all user data, including logs, in an unrecoverable manner before removing the Moxa Arm-based computer from .

   You must use sudo or run the command with the root permission.

   ```
   moxa@moxa-tbzkb1090923:/# sudo mx-system-mgmt default decommission
   ```

   The decommissioning process will do the following actions：

   a. Overwrite the system partition 4 times with shred so that all user files will be deleted and cannot be recovered.

   b. Overwrite the log partition4 times with shred so that all log files will be deleted and cannot be recovered.

   c. Trigger the bootloader decommissioning function, so all configurations and log messages in the bootloader are also deleted and cannot be recovered.

2. If asset owner key or sensitive data is stored in the TPM, switch to bootloader Developer Mode and then perform Clear TPM action will clear all data stored in TPM

# 10. Customization and Programming

## MIL1 (Debian 9) to MIL3 (Debian 11) Migration

Moxa Arm-based computers with MIL1 (Debian 9) does not support direct upgrade to MIL3 (Debian 11). If you have such request, contact your regional sales representative.

If you are migrating an application previously developed on MIL1 to MIL3 please reference the below table for the major changes.

| Category | Description | MIL1 (Debian 9) | MIL3 (Debian 11) |
|---|---|---|---|
| Password rule | Password change enforced upon first log-in | n/a | ✓ |
|  | Password complexity enforcement | n/a | At least 8 characters in length<br>Password dictionary check |
| Backup & Store utilities | Reinstall a system image | Via bootloader menu | Via bootloader menu |
|  | Create a backup & restore | n/a | Moxa System Manager (MSM) utility |
|  | Create a snapshot & restore | n/a | Moxa System Management (MSM) utility under Linux |
|  | Automatic system failback recovery | n/a | Moxa System Management (MSM) utility under Linux |
| Network connection utilities | Default LAN (ethernet) port configuration | LAN1(static IP):192.168.3.127<br>LAN2(static IP):192.168.4.127 | • LAN1: Assigned by DHCP server. Link-local IP addresses will be assigned when DHCP server is not available<br>• LAN2(static IP):192.168.4.127 |
|  | Cellular connection utility | Use **cell_mgmt** | Use **mx-interface-mgmt**<br>Refers to Moxa Connection Manager (MCM) with **additional** features added below:<br>• GUI to configure and manage network<br>• Connection keep-alive<br>• Connection failover/failback<br>• Cellular, Wi-Fi and ethernet management<br>• DHCP server<br>• Data usage monitoring<br>• IPv6 support<br>• Cellular connection diagnosis<br>• Cellular modem firmware upgrade<br>• C API for network and connection status inquiry |
|  | Wi-Fi connection utility | Use **wifi_mgmt** |  |
| I/O and Interface Management utilities | Serial port mode change (RS-232, RS-422, and RS-485 2-wire) | Use **mx-uart-ctl** | Use **mx-interface-mgmt**<br>Refers to serial port in Moxa Computer Interface Manager (MCIM) section |
|  | Module control including power control, module detection, initialize setting, and SIM slot switching | Use **mx-module-ctl** or **cell_mgmt** for cellular module control |  |
|  | Buzzer control | n/a |  |
|  | LED control | Use **mx-led-ctl** |  |
|  | Digital I/O control | Use **moxa-dio-control** |  |

| Category | Description | MIL1 (Debian 9) | MIL3 (Debian 11) |
|---|---|---|---|
| | Mount a SD/USB storage device | Use **moxa-auto-mountd.service** | |
| | Push button control | n/a | |
| Other Configuration | Check product serial number | Use **fw_printenv serialnumber** | Use **mx-interface-mgmt deviceinfo** |
| | Check system image version | Use **kversion or mx-ver** | Use **mx-ver** |
| | APT repository source list | All repository in **/etc/apt/sources.list** | 3rd party repository in **/etc/apt/sources.list**<br>Moxa repository in **/etc/apt/sources.list.d/moxa.list** |
| API and libraries | Moxa Platform Libraries | ✓ | API and libraries not available. Use **mx-interface-mgmt**<br>Refers to Moxa Computer Interface Manager (MCIM) |

# Building an Application

## Introduction

Moxa's Arm-based computers support both native and cross-compiling of code. Native compiling is more straightforward since all the coding and compiling can be done directly on the device. However, Arm architecture is less powerful and hence the compiling speed is slower. To overcome this, you can cross compile your code on a Linux machine using a toolchain; the compiling speed is much faster.

## Native Compilation

Follow these steps to update the package menu:

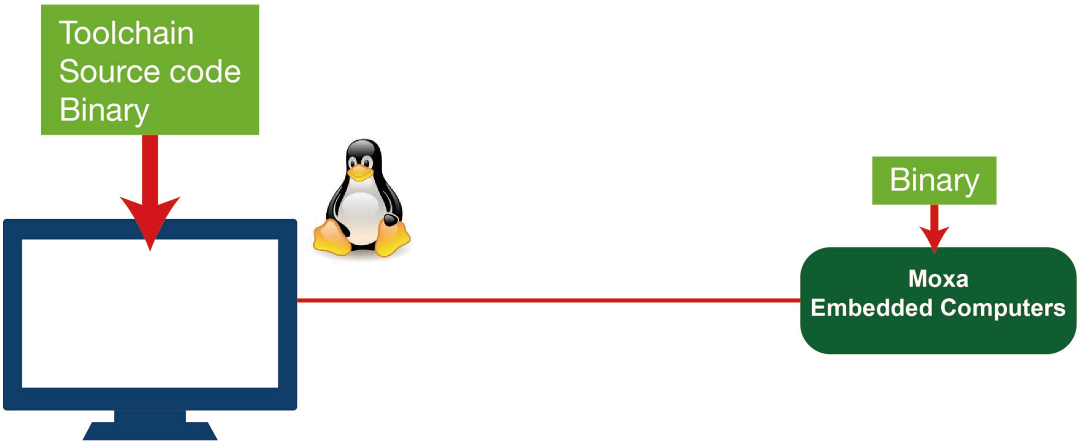
1. Make sure a network connection is available.
2. Use **aptupdate** to update the Debian package list.

```
moxa@Moxa-tbzkb1090923:~$ sudo apt update
```

3. Install the native compiler and necessary packages.

```
moxa@Moxa-tbzkb1090923:~$ sudo apt install gcc build-essential flex bison
automake
```

## Cross Compilation



Moxa Industrial Linux (MIL) in Moxa's Arm-based computers is based on Debian. So, we recommend setting up a Debian environment on the host device to ensure best compatibility during cross compilation.

The toolchain will need about 300 MB of hard disk space on your PC.

To cross compile your code, do the following:

1. Set up a Debian 10 environment using a VM or Docker.
2. Update the information.

```
user@Linux:~$ apt update
```

3. (Optional) During the update process, if you don't want to see messages related to "server certificate verification failed", you can install Moxa apt **keyring**. These messages, however, will not affect the operation.

```
user@Linux:~$ apt install moxa-archive-keyring
```

4. In order to install non-amd64 packages, such as armhf and u386, add the external architecture.

   In the example, we are adding the armhf architecture.

```
user@Linux:~$ dpkg --add-architecture armhf
```

5. Update the apt information again.

```
user@Linux:~$ apt update
```

6. Download the toolchain file from apt server (all Moxa UC series computers use the official Debian toolchain).

```
user@Linux:~$ apt install crossbuild-essential-armhf
```

7. Install **dev** or **lib** packages depending on whether Debian or Moxa packages are applicable for the procedure.

   Example for installing a Debian official package:

```
user@Linux:~$ apt install libssl-dev:armhf
```

You can now start compiling programs using the toolchain.

**NOTE**

For all available libraries and headers offered by Debian, visit: https://packages.debian.org/index.

# Example Program—hello

In this section, we use the standard "hello" example program to illustrate how to develop a program for Moxa computers. All example codes can be downloaded from Moxa’s website. The "hello" example code is available in the **hello** folder; hello/hello.c:

```
#include <stdio.h>

int main(int argc, char *argv[])
{
    printf("Hello World\n");
    return 0;
}
```

## Native Compilation

1. Compile the hello.c code.

```
moxa@Moxa-tbzkb1090923:~$ gcc -o hello hello.c
moxa@Moxa-tbzkb1090923:~$ strip -s hello
```

   or

   use the Makefile as follows:

```
moxa@Moxa-tbzkb1090923:~$ make
```

2. Run the program.

```
moxa@Moxa-tbzkb1090923:~$ ./hello
Hello World
```

## Cross Compiling

1. Compile the hello.c code.

```
user@Linux:~$ arm-linux-gnueabihf-gcc -o hello \
    hello.c
user@Linux:~$ arm-linux-gnueabihf-strip -s hello
```

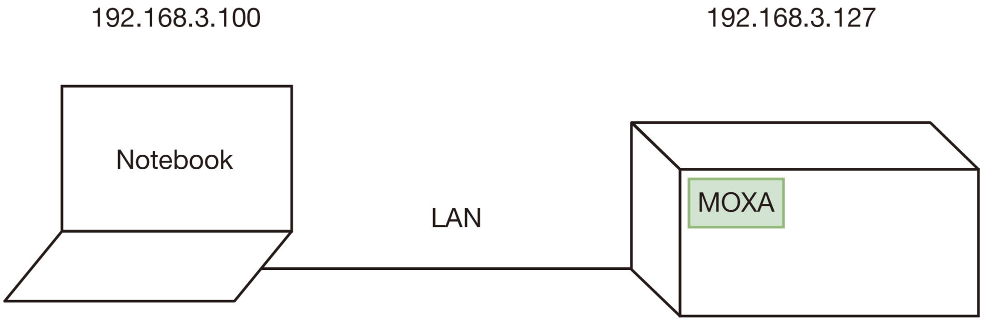
   or

   use the Makefile as follows:

```
user@Linux:~$ make CC=arm-linux-gnueabihf-gcc \
    STRIP=arm-linux-gnueabihf-strip
```

2. Copy the program to a Moxa computer:

   For example, if the IP address of your device used for cross compiling the code is "192.168.3.100" and the IP address of the Moxa computer is "192.168.3.127", use the following command:



```
user@Linux:~$ scp hello moxa@192.168.3.127:~
```

3. Run the hello.c program on the Moxa computer.

```
moxa@Moxa-tbzkb1090923:~$ ./hello
Hello World
```

# Example Makefile

You can create a Makefile for the “hello" example program using the following code. By default, the Makefile is set for native compiling.

"hello/Makefile":

```
CC:=gcc
STRIP:=strip

all:
    $(CC) -o hello hello.c
    $(STRIP) -s hello

.PHONY: clean
clean:
    rm -f hello
```

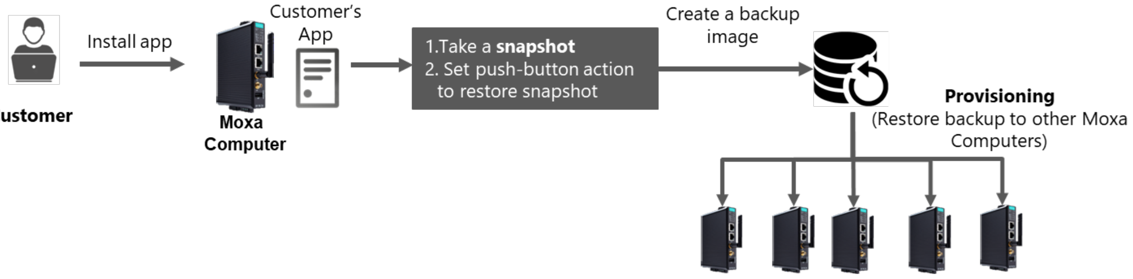
To set the hello.c program for cross compilation, modify the toolchain settings as follows:

```
CC:=arm-linux-gnueabihf-gcc
STRIP:=arm-linux-gnueabihf-strip
```

# Creating a Customized Image

## Introduction

This section introduces how to build a customized image that set the push-button on Moxa Computer to reset to customized environment instead of Moxa out-of-factory setting. This customized image can also be used for provisioning other Moxa Computers.



## Using System Snapshots and Backups

1. Configure Moxa Arm-based computer and install application
2. Create a Snapshot
3. Reference Customize the Button Action section to configure the action of push-button on Moxa Arm-based computer to restore Snapshot
   - Copy content of default script to custom.script, change to reset-to-default
   - Change to set-to-factory-default command ( mx-system-mgmt default restore –y) of button to restore snapshot (**mx-system-mgmt snapshot restore -y**)

```
#!/bin/sh
ACTION="${1}"
SECONDS="${2}"
if [ "${ACTION}" = "press" ]; then
        /usr/bin/mx-interface-mgmt led SYS set_state heartbeat
elif [ "${ACTION}" = "hold" ]; then
        if [ ${SECONDS} -eq 7 ]; then
                /usr/bin/mx-interface-mgmt led SYS set_state on
        elif [ ${SECONDS} -eq 9 ]; then
                /usr/bin/mx-interface-mgmt led SYS set_state off
        fi
elif [ "${ACTION}" = "release" ]; then
        if [ ${SECONDS} -lt 1 ]; then
                /usr/sbin/reboot
        elif [ ${SECONDS} -ge 7 ] && [ ${SECONDS} -lt 9 ]; then
                /usr/sbin/mx-system-mgmt snapshot restore -y
                /usr/sbin/reboot
        fi
        /usr/bin/mx-interface-mgmt led SYS set_state on
fi
```

4. Create a Backup Image, the backup will include the snapshot taken in step #2
5. The Backup Image can now be used for provisioning other Moxa computers of the same model using backup restore command.

# A. Software Process List

Below is a list of software processes of Moxa Industrial Linux in Moxa Arm-based Computer

| Software Process for Adminstrator | UID | GID |
|---|---|---|
| addgnupghome | root | root |
| addgroup | root | root |
| add-shell | root | root |
| adduser | root | root |
| agetty | root | root |
| applygnupgdefaults | root | root |
| arp | root | root |
| arpd | root | root |
| audisp-syslog | root | root |
| auditctl | root | root |
| auditd | root | root |
| augenrules | root | root |
| aureport | root | root |
| ausearch | root | root |
| autrace | root | root |
| badblocks | root | root |
| blkdeactivate | root | root |
| blkdiscard | root | root |
| blkid | root | root |
| blkzone | root | root |
| blockdev | root | root |
| bridge | root | root |
| capsh | root | root |
| cfdisk | root | root |
| chcpu | root | root |
| chgpasswd | root | root |
| chmem | root | root |
| chpasswd | root | root |
| chronyd | root | root |
| chroot | root | root |
| cpgr | root | root |
| cppw | root | root |
| cracklib-check | root | root |
| cracklib-format | root | root |
| cracklib-packer | root | root |
| cracklib-unpacker | root | root |
| create-cracklib-dict | root | root |
| ctrlaltdel | root | root |
| debugfs | root | root |
| delgroup | root | root |
| deluser | root | root |
| depmod | root | root |
| devlink | root | root |
| dhclient | root | root |
| dhclient-script | root | root |
| dmsetup | root | root |
| dmstats | root | root |
| dnsmasq | root | root |
| docfdisk | root | root |
| doc_loadbios | root | root |

| Software Process for Adminstrator | UID | GID |
|---|---|---|
| dpkg-fsys-usrunmess | root | root |
| dpkg-preconfigure | root | root |
| dpkg-reconfigure | root | root |
| dumpe2fs | root | root |
| e2freefrag | root | root |
| e2fsck | root | root |
| e2image | root | root |
| e2label | root | root |
| e2mmpstatus | root | root |
| e2scrub | root | root |
| e2scrub_all | root | root |
| e2undo | root | root |
| e4crypt | root | root |
| e4defrag | root | root |
| faillock | root | root |
| fdformat | root | root |
| fdisk | root | root |
| filefrag | root | root |
| findfs | root | root |
| flashcp | root | root |
| flash_erase | root | root |
| flash_eraseall | root | root |
| flash_lock | root | root |
| flash_otp_dump | root | root |
| flash_otp_info | root | root |
| flash_otp_lock | root | root |
| flash_otp_write | root | root |
| flash_unlock | root | root |
| fsck | root | root |
| fsck.cramfs | root | root |
| fsck.ext2 | root | root |
| fsck.ext3 | root | root |
| fsck.ext4 | root | root |
| fsck.minix | root | root |
| fsfreeze | root | root |
| fstab-decode | root | root |
| fstrim | root | root |
| ftl_check | root | root |
| ftl_format | root | root |
| genl | root | root |
| getcap | root | root |
| getpcaps | root | root |
| getty | root | root |
| groupadd | root | root |
| groupdel | root | root |
| groupmems | root | root |
| groupmod | root | root |
| grpck | root | root |
| grpconv | root | root |
| grpunconv | root | root |
| halt | root | root |
| hwclock | root | root |
| iconvconfig | root | root |
| ifconfig | root | root |
| ifdown | root | root |
| ifquery | root | root |
| ifup | root | root |
| init | root | root |

| Software Process for Adminstrator | UID | GID |
|---|---|---|
| insmod | root | root |
| installkernel | root | root |
| invoke-rc.d | root | root |
| ip | root | root |
| ipmaddr | root | root |
| iptunnel | root | root |
| isosize | root | root |
| iw | root | root |
| jffs2dump | root | root |
| jffs2reader | root | root |
| killall5 | root | root |
| ldattach | root | root |
| ldconfig | root | root |
| locale-gen | root | root |
| logrotate | root | root |
| logsave | root | root |
| losetup | root | root |
| lsmod | root | root |
| lsmtd | root | root |
| lxfp | root | root |
| mcmd | root | root |
| mii-tool | root | root |
| mke2fs | root | root |
| mkfs | root | root |
| mkfs.bfs | root | root |
| mkfs.cramfs | root | root |
| mkfs.ext2 | root | root |
| mkfs.ext3 | root | root |
| mkfs.ext4 | root | root |
| mkfs.jffs2 | root | root |
| mkfs.minix | root | root |
| mkfs.ubifs | root | root |
| mkhomedir_helper | root | root |
| mklost+found | root | root |
| mkswap | root | root |
| ModemManager | root | root |
| modinfo | root | root |
| modprobe | root | root |
| MoxaComputerInterfaceManager | root | root |
| moxa-telit-firmware-upgrade-tool | root | root |
| mtd_debug | root | root |
| mtdinfo | root | root |
| mtdpart | root | root |
| mx-bootloader-mgmt | root | root |
| mx-connect-mgmt | root | root |
| mx-guardian | root | root |
| mx-guardian-init | root | root |
| mx-system-mgmt | root | root |
| nameif | root | root |
| nanddump | root | root |
| nandtest | root | root |
| nandwrite | root | root |
| NetworkManager | root | root |
| newusers | root | root |
| nft | root | root |
| nftldump | root | root |
| nftl_format | root | root |
| nologin | root | root |

| Software Process for Adminstrator | UID | GID |
|---|---|---|
| pam-auth-update | root | root |
| pam_getenv | root | root |
| pam_timestamp_check | root | root |
| parted | root | root |
| partprobe | root | root |
| pivot_root | root | root |
| plipconfig | root | root |
| poweroff | root | root |
| pwck | root | root |
| pwconv | root | root |
| pwunconv | root | root |
| rarp | root | root |
| raw | root | root |
| readprofile | root | root |
| reboot | root | root |
| recv_image | root | root |
| regdbdump | root | root |
| remove-shell | root | root |
| resize2fs | root | root |
| rfddump | root | root |
| rfdformat | root | root |
| rmmod | root | root |
| rmt | root | root |
| rmt-tar | root | root |
| route | root | root |
| rsyslogd | root | root |
| rtacct | root | root |
| rtcwake | root | root |
| rtmon | root | root |
| runlevel | root | root |
| runuser | root | root |
| serve_image | root | root |
| service | root | root |
| setcap | root | root |
| sfdisk | root | root |
| shadowconfig | root | root |
| shutdown | root | root |
| slattach | root | root |
| sshd | root | root |
| start-stop-daemon | root | root |
| sudo_logsrvd | root | root |
| sudo_sendlog | root | root |
| sulogin | root | root |
| sumtool | root | root |
| swaplabel | root | root |
| swapoff | root | root |
| swapon | root | root |
| switch_root | root | root |
| sysctl | root | root |
| tarcat | root | root |
| tc | root | root |
| telinit | root | root |
| tipc | root | root |
| tune2fs | root | root |
| tzconfig | root | root |
| ubiattach | root | root |
| ubiblock | root | root |
| ubicrc32 | root | root |

| Software Process for Adminstrator | UID | GID |
|---|---|---|
| ubidetach | root | root |
| ubiformat | root | root |
| ubihealthd | root | root |
| ubimkvol | root | root |
| ubinfo | root | root |
| ubinize | root | root |
| ubirename | root | root |
| ubirmvol | root | root |
| ubirsvol | root | root |
| ubiupdatevol | root | root |
| unix_chkpwd | root | shadow |
| unix_update | root | root |
| update-ca-certificates | root | root |
| update-cracklib | root | root |
| update-locale | root | root |
| update-passwd | root | root |
| update-rc.d | root | root |
| useradd | root | root |
| userdel | root | root |
| usermod | root | root |
| validlocale | root | root |
| vigr | root | root |
| vipw | root | root |
| visudo | root | root |
| vnstatd | root | root |
| watchdog | root | root |
| wd_identify | root | root |
| wd_keepalive | root | root |
| wipefs | root | root |
| wpa_action | root | root |
| wpa_cli | root | root |
| wpa_supplicant | root | root |
| zic | root | root |
| zramctl | root | root |

| Software Process for Non-Adminstrator | UID | GID |
|---|---|---|
| addpart | root | root |
| addr2line | root | root |
| aide | root | root |
| apt | root | root |
| apt-cache | root | root |
| apt-cdrom | root | root |
| apt-config | root | root |
| apt-extracttemplates | root | root |
| apt-ftparchive | root | root |
| apt-get | root | root |
| apt-key | root | root |
| apt-mark | root | root |
| apt-sortpkgs | root | root |
| ar | root | root |
| arch | root | root |
| arm-linux-gnueabihf-addr2line | root | root |
| arm-linux-gnueabihf-ar | root | root |
| arm-linux-gnueabihf-as | root | root |
| arm-linux-gnueabihf-c++filt | root | root |
| arm-linux-gnueabihf-dwp | root | root |
| arm-linux-gnueabihf-elfedit | root | root |

| Software Process for Non-Adminstrator | UID | GID |
|---|---|---|
| arm-linux-gnueabihf-gold | root | root |
| arm-linux-gnueabihf-gprof | root | root |
| arm-linux-gnueabihf-ld | root | root |
| arm-linux-gnueabihf-ld.bfd | root | root |
| arm-linux-gnueabihf-ld.gold | root | root |
| arm-linux-gnueabihf-nm | root | root |
| arm-linux-gnueabihf-objcopy | root | root |
| arm-linux-gnueabihf-objdump | root | root |
| arm-linux-gnueabihf-ranlib | root | root |
| arm-linux-gnueabihf-readelf | root | root |
| arm-linux-gnueabihf-size | root | root |
| arm-linux-gnueabihf-strings | root | root |
| arm-linux-gnueabihf-strip | root | root |
| as | root | root |
| asc2log | root | root |
| aulast | root | root |
| aulastlog | root | root |
| ausyscall | root | root |
| auvirt | root | root |
| awk | root | root |
| b2sum | root | root |
| base32 | root | root |
| base64 | root | root |
| basename | root | root |
| basenc | root | root |
| bash | root | root |
| bashbug | root | root |
| bcmserver | root | root |
| bootctl | root | root |
| busctl | root | root |
| cal | root | root |
| canbusload | root | root |
| can-calc-bit-timing | root | root |
| candump | root | root |
| canfdtest | root | root |
| cangen | root | root |
| cangw | root | root |
| canlogserver | root | root |
| canplayer | root | root |
| cansend | root | root |
| cansequence | root | root |
| cansniffer | root | root |
| captoinfo | root | root |
| cat | root | root |
| catchsegv | root | root |
| c++filt | root | root |
| chacl | root | root |
| chage | root | shadow |
| chattr | root | root |
| chcon | root | root |
| chfn | root | root |
| chgrp | root | root |
| chmod | root | root |
| choom | root | root |
| chown | root | root |
| chronyc | root | root |
| chrt | root | root |

| Software Process for Non-Adminstrator | UID | GID |
|---|---|---|
| chsh | root | root |
| cksum | root | root |
| clear | root | root |
| clear_console | root | root |
| cmp | root | root |
| col | root | root |
| colcrt | root | root |
| colrm | root | root |
| column | root | root |
| comm | root | root |
| corelist | root | root |
| cp | root | root |
| cpan | root | root |
| cpan5.32-arm-linux-gnueabihf | root | root |
| cpulimit | root | root |
| c_rehash | root | root |
| csplit | root | root |
| ctstat | root | root |
| curl | root | root |
| cut | root | root |
| cvtsudoers | root | root |
| dash | root | root |
| date | root | root |
| dbus-cleanup-sockets | root | root |
| dbus-daemon | root | root |
| dbus-monitor | root | root |
| dbus-run-session | root | root |
| dbus-send | root | root |
| dbus-update-activation-environment | root | root |
| dbus-uuidgen | root | root |
| dd | root | root |
| debconf | root | root |
| debconf-apt-progress | root | root |
| debconf-communicate | root | root |
| debconf-copydb | root | root |
| debconf-escape | root | root |
| debconf-set-selections | root | root |
| debconf-show | root | root |
| debsums | root | root |
| deb-systemd-helper | root | root |
| deb-systemd-invoke | root | root |
| delpart | root | root |
| df | root | root |
| dh_bash-completion | root | root |
| dialog | root | root |
| diff | root | root |
| diff3 | root | root |
| dir | root | root |
| dircolors | root | root |
| dirmngr | root | root |
| dirmngr-client | root | root |
| dirname | root | root |
| dmesg | root | root |
| dnsdomainname | root | root |
| domainname | root | root |
| dpkg | root | root |
| dpkg-deb | root | root |

| Software Process for Non-Adminstrator | UID | GID |
|---|---|---|
| dpkg-divert | root | root |
| dpkg-maintscript-helper | root | root |
| dpkg-query | root | root |
| dpkg-realpath | root | root |
| dpkg-split | root | root |
| dpkg-statoverride | root | root |
| dpkg-trigger | root | root |
| du | root | root |
| dumpimage | root | root |
| dwp | root | root |
| echo | root | root |
| editor | root | root |
| egrep | root | root |
| elfedit | root | root |
| enc2xs | root | root |
| encguess | root | root |
| env | root | root |
| ex | root | root |
| expand | root | root |
| expiry | root | shadow |
| expr | root | root |
| factor | root | root |
| fail2ban-client | root | root |
| fail2ban-python | root | root |
| fail2ban-regex | root | root |
| fail2ban-server | root | root |
| fail2ban-testcases | root | root |
| faillog | root | root |
| fallocate | root | root |
| FALSE | root | root |
| fgrep | root | root |
| file | root | root |
| fincore | root | root |
| find | root | root |
| findmnt | root | root |
| flock | root | root |
| fmt | root | root |
| fold | root | root |
| free | root | root |
| fw_printenv | root | root |
| fw_setenv | root | root |
| getconf | root | root |
| getent | root | root |
| getfacl | root | root |
| getopt | root | root |
| gold | root | root |
| gpasswd | root | root |
| gpg | root | root |
| gpg-agent | root | root |
| gpgcompose | root | root |
| gpgconf | root | root |
| gpg-connect-agent | root | root |
| gpgparsemail | root | root |
| gpgsm | root | root |
| gpgsplit | root | root |
| gpgtar | root | root |
| gpgv | root | root |

| Software Process for Non-Adminstrator | UID | GID |
|---|---|---|
| gpg-wks-server | root | root |
| gpg-zip | root | root |
| gprof | root | root |
| grep | root | root |
| groups | root | root |
| gunzip | root | root |
| gzexe | root | root |
| gzip | root | root |
| h2ph | root | root |
| h2xs | root | root |
| hd | root | root |
| head | root | root |
| helpztags | root | root |
| hexdump | root | root |
| hostid | root | root |
| hostname | root | root |
| hostnamectl | root | root |
| iconv | root | root |
| id | root | root |
| infocmp | root | root |
| infotocap | root | root |
| install | root | root |
| instmodsh | root | root |
| ionice | root | root |
| ip | root | root |
| ipcmk | root | root |
| ipcrm | root | root |
| ipcs | root | root |
| ischroot | root | root |
| isotpdump | root | root |
| isotpperf | root | root |
| isotprecv | root | root |
| isotpsend | root | root |
| isotpserver | root | root |
| isotpsniffer | root | root |
| isotptun | root | root |
| j1939acd | root | root |
| j1939cat | root | root |
| j1939spy | root | root |
| j1939sr | root | root |
| join | root | root |
| journalctl | root | root |
| jq | root | root |
| json_pp | root | root |
| kbxutil | root | root |
| kernel-install | root | root |
| kill | root | root |
| kmod | root | root |
| kwboot | root | root |
| last | root | root |
| lastb | root | root |
| lastlog | root | root |
| lcf | root | root |
| ld | root | root |
| ld.bfd | root | root |
| ldd | root | root |
| ld.gold | root | root |

| Software Process for Non-Adminstrator | UID | GID |
|---|---|---|
| libnetcfg | root | root |
| link | root | root |
| linux32 | root | root |
| linux64 | root | root |
| ln | root | root |
| lnstat | root | root |
| locale | root | root |
| localectl | root | root |
| localedef | root | root |
| log2asc | root | root |
| log2long | root | root |
| logger | root | root |
| login | root | root |
| loginctl | root | root |
| logname | root | root |
| look | root | root |
| ls | root | root |
| lsattr | root | root |
| lsblk | root | root |
| lscpu | root | root |
| lsipc | root | root |
| lslocks | root | root |
| lslogins | root | root |
| lsmem | root | root |
| lsmod | root | root |
| lsns | root | root |
| lspgpot | root | root |
| mawk | root | root |
| mcookie | root | root |
| md5sum | root | root |
| md5sum.textutils | root | root |
| mesg | root | root |
| migrate-pubring-from-classic-gpg | root | root |
| mkdir | root | root |
| mkenvimage | root | root |
| mkfifo | root | root |
| mkimage | root | root |
| mknod | root | root |
| mksunxiboot | root | root |
| mktemp | root | root |
| mmcli | root | root |
| more | root | root |
| mount | root | root |
| mountpoint | root | root |
| mv | root | root |
| mx-interface-mgmt | root | root |
| mx-ver | root | root |
| namei | root | root |
| nawk | root | root |
| ncal | root | root |
| netstat | root | root |
| networkctl | root | root |
| newgrp | root | root |
| nice | root | root |
| nisdomainname | root | root |
| nl | root | root |
| nm | root | root |

| Software Process for Non-Adminstrator | UID | GID |
|---|---|---|
| nmcli | root | root |
| nm-online | root | root |
| nmtui | root | root |
| nmtui-connect | root | root |
| nmtui-edit | root | root |
| nmtui-hostname | root | root |
| nohup | root | root |
| nproc | root | root |
| nsenter | root | root |
| nstat | root | root |
| numfmt | root | root |
| objcopy | root | root |
| objdump | root | root |
| od | root | root |
| openssl | root | root |
| pager | root | root |
| partx | root | root |
| passwd | root | root |
| paste | root | root |
| pathchk | root | root |
| pdb3 | root | root |
| pdb3.9 | root | root |
| perl | root | root |
| perl5.32.1 | root | root |
| perl5.32-arm-linux-gnueabihf | root | root |
| perlbug | root | root |
| perldoc | root | root |
| perlivp | root | root |
| perlthanks | root | root |
| pgrep | root | root |
| piconv | root | root |
| pidof | root | root |
| pidwait | root | root |
| pinentry | root | root |
| pinentry-curses | root | root |
| ping | root | root |
| ping4 | root | root |
| ping6 | root | root |
| pinky | root | root |
| pkaction | root | root |
| pkcheck | root | root |
| pkexec | root | root |
| pkill | root | root |
| pkttyagent | root | root |
| pl2pm | root | root |
| pldd | root | root |
| pmap | root | root |
| pod2html | root | root |
| pod2man | root | root |
| pod2text | root | root |
| pod2usage | root | root |
| podchecker | root | root |
| pr | root | root |
| printenv | root | root |
| printf | root | root |
| prlimit | root | root |
| prove | root | root |

| Software Process for Non-Adminstrator | UID | GID |
|---|---|---|
| ps | root | root |
| ptar | root | root |
| ptardiff | root | root |
| ptargrep | root | root |
| ptx | root | root |
| pv | root | root |
| pwd | root | root |
| pwdx | root | root |
| py3clean | root | root |
| py3compile | root | root |
| py3versions | root | root |
| pydoc3 | root | root |
| pydoc3.9 | root | root |
| pygettext3 | root | root |
| pygettext3.9 | root | root |
| python3 | root | root |
| python3.9 | root | root |
| ranlib | root | root |
| rbash | root | root |
| rcp | root | root |
| rdebsums | root | root |
| rdma | root | root |
| readelf | root | root |
| readlink | root | root |
| realpath | root | root |
| renice | root | root |
| reset | root | root |
| resizepart | root | root |
| resolvectl | root | root |
| rev | root | root |
| rgrep | root | root |
| rlogin | root | root |
| rm | root | root |
| rmdir | root | root |
| routef | root | root |
| routel | root | root |
| rrsync | root | root |
| rsh | root | root |
| rsync | root | root |
| rsync-ssl | root | root |
| rtstat | root | root |
| runcon | root | root |
| run-parts | root | root |
| rview | root | root |
| rvim | root | root |
| savelog | root | root |
| scp | root | root |
| script | root | root |
| scriptlive | root | root |
| scriptreplay | root | root |
| sdiff | root | root |
| sed | root | root |
| select-editor | root | root |
| sensible-browser | root | root |
| sensible-editor | root | root |
| sensible-pager | root | root |
| seq | root | root |

| Software Process for Non-Adminstrator | UID | GID |
|---|---|---|
| setarch | root | root |
| setfacl | root | root |
| setpriv | root | root |
| setsid | root | root |
| setterm | root | root |
| sftp | root | root |
| sg | root | root |
| sh | root | root |
| sha1sum | root | root |
| sha224sum | root | root |
| sha256sum | root | root |
| sha384sum | root | root |
| sha512sum | root | root |
| shasum | root | root |
| shred | root | root |
| shuf | root | root |
| size | root | root |
| skill | root | root |
| slabtop | root | root |
| slcan_attach | root | root |
| slcand | root | root |
| slcanpty | root | root |
| sleep | root | root |
| slogin | root | root |
| snice | root | root |
| sort | root | root |
| splain | root | root |
| split | root | root |
| ss | root | root |
| ssh | root | root |
| ssh-add | root | root |
| ssh-agent | root | ssh |
| ssh-argv0 | root | root |
| ssh-copy-id | root | root |
| ssh-keygen | root | root |
| ssh-keyscan | root | root |
| stat | root | root |
| stdbuf | root | root |
| streamzip | root | root |
| strings | root | root |
| strip | root | root |
| stty | root | root |
| su | root | root |
| sudo | root | root |
| sudoedit | root | root |
| sudoreplay | root | root |
| sum | root | root |
| sync | root | root |
| systemctl | root | root |
| systemd | root | root |
| systemd-analyze | root | root |
| systemd-ask-password | root | root |
| systemd-cat | root | root |
| systemd-cgls | root | root |
| systemd-cgtop | root | root |
| systemd-delta | root | root |
| systemd-detect-virt | root | root |

| Software Process for Non-Adminstrator | UID | GID |
|---|---|---|
| systemd-escape | root | root |
| systemd-hwdb | root | root |
| systemd-id128 | root | root |
| systemd-inhibit | root | root |
| systemd-machine-id-setup | root | root |
| systemd-mount | root | root |
| systemd-notify | root | root |
| systemd-path | root | root |
| systemd-resolve | root | root |
| systemd-run | root | root |
| systemd-socket-activate | root | root |
| systemd-stdio-bridge | root | root |
| systemd-sysusers | root | root |
| systemd-tmpfiles | root | root |
| systemd-tty-ask-password-agent | root | root |
| systemd-umount | root | root |
| tabs | root | root |
| tac | root | root |
| tail | root | root |
| tar | root | root |
| taskset | root | root |
| tee | root | root |
| tempfile | root | root |
| test | root | root |
| testj1939 | root | root |
| tic | root | root |
| timedatectl | root | root |
| timeout | root | root |
| tload | root | root |
| toe | root | root |
| top | root | root |
| touch | root | root |
| tpm2 | root | root |
| tpm2_activatecredential | root | root |
| tpm2_certify | root | root |
| tpm2_certifycreation | root | root |
| tpm2_certifyX509certutil | root | root |
| tpm2_changeauth | root | root |
| tpm2_changeeps | root | root |
| tpm2_changepps | root | root |
| tpm2_checkquote | root | root |
| tpm2_clear | root | root |
| tpm2_clearcontrol | root | root |
| tpm2_clockrateadjust | root | root |
| tpm2_commit | root | root |
| tpm2_create | root | root |
| tpm2_createak | root | root |
| tpm2_createek | root | root |
| tpm2_createpolicy | root | root |
| tpm2_createprimary | root | root |
| tpm2_dictionarylockout | root | root |
| tpm2_duplicate | root | root |
| tpm2_ecdhkeygen | root | root |
| tpm2_ecdhzgen | root | root |
| tpm2_ecephemeral | root | root |
| tpm2_encryptdecrypt | root | root |
| tpm2_eventlog | root | root |

| Software Process for Non-Adminstrator | UID | GID |
|---|---|---|
| tpm2_evictcontrol | root | root |
| tpm2_flushcontext | root | root |
| tpm2_getcap | root | root |
| tpm2_getcommandauditdigest | root | root |
| tpm2_geteccparameters | root | root |
| tpm2_getekcertificate | root | root |
| tpm2_getrandom | root | root |
| tpm2_getsessionauditdigest | root | root |
| tpm2_gettestresult | root | root |
| tpm2_gettime | root | root |
| tpm2_hash | root | root |
| tpm2_hierarchycontrol | root | root |
| tpm2_hmac | root | root |
| tpm2_import | root | root |
| tpm2_incrementalselftest | root | root |
| tpm2_load | root | root |
| tpm2_loadexternal | root | root |
| tpm2_makecredential | root | root |
| tpm2_nvcertify | root | root |
| tpm2_nvdefine | root | root |
| tpm2_nvextend | root | root |
| tpm2_nvincrement | root | root |
| tpm2_nvread | root | root |
| tpm2_nvreadlock | root | root |
| tpm2_nvreadpublic | root | root |
| tpm2_nvsetbits | root | root |
| tpm2_nvundefine | root | root |
| tpm2_nvwrite | root | root |
| tpm2_nvwritelock | root | root |
| tpm2_pcrallocate | root | root |
| tpm2_pcrevent | root | root |
| tpm2_pcrextend | root | root |
| tpm2_pcrread | root | root |
| tpm2_pcrreset | root | root |
| tpm2_policyauthorize | root | root |
| tpm2_policyauthorizenv | root | root |
| tpm2_policyauthvalue | root | root |
| tpm2_policycommandcode | root | root |
| tpm2_policycountertimer | root | root |
| tpm2_policycphash | root | root |
| tpm2_policyduplicationselect | root | root |
| tpm2_policylocality | root | root |
| tpm2_policynamehash | root | root |
| tpm2_policynv | root | root |
| tpm2_policynvwritten | root | root |
| tpm2_policyor | root | root |
| tpm2_policypassword | root | root |
| tpm2_policypcr | root | root |
| tpm2_policyrestart | root | root |
| tpm2_policysecret | root | root |
| tpm2_policysigned | root | root |
| tpm2_policytemplate | root | root |
| tpm2_policyticket | root | root |
| tpm2_print | root | root |
| tpm2_quote | root | root |
| tpm2_rc_decode | root | root |
| tpm2_readclock | root | root |

| Software Process for Non-Adminstrator | UID | GID |
|---|---|---|
| tpm2_readpublic | root | root |
| tpm2_rsadecrypt | root | root |
| tpm2_rsaencrypt | root | root |
| tpm2_selftest | root | root |
| tpm2_send | root | root |
| tpm2_setclock | root | root |
| tpm2_setcommandauditstatus | root | root |
| tpm2_setprimarypolicy | root | root |
| tpm2_shutdown | root | root |
| tpm2_sign | root | root |
| tpm2_startauthsession | root | root |
| tpm2_startup | root | root |
| tpm2_stirrandom | root | root |
| tpm2_testparms | root | root |
| tpm2_unseal | root | root |
| tpm2_verifysignature | root | root |
| tpm2_zgen2phase | root | root |
| tput | root | root |
| tr | root | root |
| TRUE | root | root |
| truncate | root | root |
| tset | root | root |
| tsort | root | root |
| tty | root | root |
| tzselect | root | root |
| ucf | root | root |
| ucfq | root | root |
| ucfr | root | root |
| udevadm | root | root |
| ul | root | root |
| umount | root | root |
| uname | root | root |
| uncompress | root | root |
| unexpand | root | root |
| uniq | root | root |
| unlink | root | root |
| unshare | root | root |
| update-alternatives | root | root |
| uptime | root | root |
| users | root | root |
| utmpdump | root | root |
| vdir | root | root |
| vi | root | root |
| view | root | root |
| vim | root | root |
| vim.basic | root | root |
| vimdiff | root | root |
| vimtutor | root | root |
| vmstat | root | root |
| vnstat | root | root |
| w | root | root |
| wall | root | tty |
| watch | root | root |
| watchgnupg | root | root |
| wc | root | root |
| wdctl | root | root |
| wget | root | root |

| Software Process for Non-Adminstrator | UID | GID |
|---|---|---|
| whereis | root | root |
| which | root | root |
| whiptail | root | root |
| who | root | root |
| whoami | root | root |
| wpa_passphrase | root | root |
| write | root | root |
| write.ul | root | tty |
| xargs | root | root |
| xsubpp | root | root |
| xxd | root | root |
| yes | root | root |
| ypdomainname | root | root |
| zcat | root | root |
| zcmp | root | root |
| zdiff | root | root |
| zdump | root | root |
| zegrep | root | root |
| zfgrep | root | root |
| zforce | root | root |
| zgrep | root | root |
| zipdetails | root | root |
| zless | root | root |
| zmore | root | root |
| znew | root | root |