NetModule OEM Linux Distribution Documentation

Release 0.4.3

NetModule

Mar 01, 2022

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For more than 15 years NetModule has proven itself as a reliable OEM partner with thousands of installed devices for customers all over the world!

NetModule OEM platforms come with the feature-rich NetModule Router Software or a standard Yocto Linux for customer-specific applications.

Contents:

CHAPTER 1

Contributing

CHAPTER 2

Release Notes

CHAPTER 3

[1.4.1] - 2021.10.08

3.1 Added

3.2 Changed

- [75014] kernel 4.19 updated to 4.19.208 kernel 4.14 updated to 4.14.248
- [74966] SSF: set broker-driver log level to debug (state changes, ping request/response)
- [74958] yocto: Removed useless dtb symlinks in kernel recipe
- [74959] yocto: Removed useless PV values in kernel recipe
- [74961] yocto: Removed useless HW23 overrides in kernel recipe

3.3 Fixed

- [74861] hw25: configured uart5 rts in dts
- [74967] Fixed speedtest tool
- [74979] Fix hanging nmhw-auto-part script
- [74965] Fixed broken NAT feature

3.4 Known Issues

CHAPTER 4

Supported devices

4.1 NG800

- *Telematic Control Unit*
- Interfaces: BroadR, CAN, Ethernet, Wi-Fi, LTE, GNSS, BT
- Interna interface for user modules: Ethernet, USB, SPI, I2C, GPIO
- CPU: TI am335x, 1000MHz
- BSP: hw26

Product Page NG800

4.2 NB800

- *Customer-specific OEM Router*
- Interfaces: LTE, Wi-Fi, Bluetooth and BLE
- CPU: TI am335x, 600MHz
- BSP: nrhw16, nrhw24

Product Page NB800

4.3 NB1601

- *Ruggedized OEM Router*
- Interfaces: LTE, WiFi, GNSS and 4x Ethernet
- CPU: TI am335x, 600MHz

- BSP: nrhw20

Product Page NB1601

4.4 NB1800

- BSP: nrhw18

CHAPTER 5

Key Features

5.1 Yocto Project Support

5.2 NetModule Hardware Support

5.3 Network Configuration

5.4 Automotive Grade Firmware Upgrade (OSTree)

5.5 Package Manager

CHAPTER 6

Setup your Board

6.1 Image Installation

6.1.1 Over the Network

Note: This procedure will remove all contents on the eMMC. Make sure to backup your data!

Setup a HTTP server

1. Install python3

```
sudo apt install python3
```

2. Set your ip to 192.168.1.254 (If you use a network-manager set your static ip there! This command will not work in this case.)

```
sudo ifconfig <Your ethernet device e.g. eth0> 192.168.1.254
```

3. Make a new folder and enter it

```
sudo mkdir /srv/http
cd /srv/http
```

4. Start the http-server

```
sudo python3 -m http.server --bind 192.168.1.254 80
```

Setup a TFTP server

1. Install the following packages

```
sudo apt-get install xinetd tftpd tftp
```

2. Edit or make a file in: `/etc/xinetd.d/tftp` with the following content:

```
service tftp
{
protocol        = udp
port            = 69
socket_type     = dgram
wait            = yes
user            = nobody
server          = /usr/sbin/in.tftpd
server_args     = -s /srv/tftp
disable         = no
}
```

3. Create a tftp folder

```
mkdir -p /srv/tftp
```

4. Restart the xinetd service

```
sudo service xinetd restart
```

Instructions

1. Put the WIC file (e.g. *image-am335x-nmhw21.wic*) file on the http-server (*/srv/http*).
2. Put the Minimal Linux fitImage (e.g. *fitImage-am335x-nmhw21.bin*) on the tftp-server (*/srv/tftp*).
3. Verify the */srv* folder:

```
/srv
|-- http
|   |-- image-am335x-nmhw21.wic
|-- tftp
.   |-- fitImage-netmodule-linux-image-minimal-am335x-nmhw21
```

4. Power up the board and press 's' on the serial terminal to stop in u-boot.
5. Validate that you are in u-boot console by typing

```
# env print serverip
serverip=192.168.1.254
```

6. Load kernel binary into ram

```
# tftp $ramdisk_addr_r fitImage-netmodule-linux-image-minimal-am335x-nmhw21
```

7. restrict positioning of initrd ramdisk image

```
# setenv initrd_high 0x84000000
```

8. Set boot args

```
# setenv bootargs root=/dev/ram0 console=ttyS2,115200 ti_cpsw.rx_packet_max=1526
```

9. Boot from ramdisk. Linux will boot to login prompt within < 30s

```
# bootm $ramdisk_addr_r
```

10. Login as *root* (empty password).
11. Disable kernel messages in Linux system

```
echo 1 >  /proc/sys/kernel/printk
```

12. Burn the *.wic* file to the eMMC: (this takes about 5 min)

```
curl http://192.168.1.254/image-am335x-nmhw21.wic | dd of=/dev/mmcblk1 bs=10M && sync
```

13. Reboot your system.

```
reboot
```

6.1.2 From USB Stick

Prepare USB Stick

Format a USB-pendrive to have a with **fat** with a **maximum partition size of 4.0GB** for the first partition.

Use `gnome-disks` or *gparted*‘ for this.

The output of *parted -l* should look like this:

```
Model: Kingston DataTraveler 3.0 (scsi)
Disk /dev/sdb: ...GB
Sector size (logical/physical): 512B/512B
Partition Table: msdos
Disk Flags:

Number  Start   End       Size     Type     File system  Flags
1       1049kB  4001MB    4000MB   primary  fat32        lba
```

1. Put the *image-am335x-nmhw21.wic* file on a USB-pendrive.
2. Put the files *image-minimal-am335x-nmhw21.cpio.gz.u-boot, fitImage-am335x-nmhw21.bin* on the USB-pendrive.
3. Your USB-pendrive should no look like this:

```
USB-root
|-- image-am335x-nmhw21.wic
|-- image-minimal-am335x-nmhw21.cpio.gz.u-boot
|-- fitImage-am335x-nmhw21.bin
```

Flash from USB Stick

1. Plug the USB-pendrive into the nmhw21.
2. Power up the board and press ‘s’ on the serial terminal to stop in u-boot.
3. Boot the ramdisk (copy-paste into u-boot terminal):

```
usb reset; fatload usb 0:1 $kernel_addr_r fitImage-am335x-nmhw21.bin; fatload usb 0:1
↪$ramdisk_addr_r image-minimal-am335x-nmhw21.cpio.gz.u-boot; setenv bootargs root=/
↪dev/ram0 console=ttyS2,115200 ti_cpsw.rx_packet_max=1526; bootm $kernel_addr_r
↪$ramdisk_addr_r
```

4. When the the system has booted, log in with user *root*.
5. Mount the USB-pendrive

```
mount /dev/sda1 /mnt
```

6. Burn the *.wic* file to the eMMC: (this takes about 5 min)

```
dd if=/mnt/image-am335x-nmhw21.wic of=/dev/mmcblk1 bs=10M && sync
```

7. Reboot your system

```
reboot
```

6.1.3 From SD Card

CHAPTER 7

Build Your Image

NetModule provides its own meta layer for customized image generation.

7.1 Project Setup

7.1.1 Netmodule Meta Layer

Meta Layer	Description	Repository
meta-netmodule-distro	• Distribution specfic contents • Distribution configurations • NetModule image recipes • Firmware update tool • Disk expansion tool • General applications recipes • Example local.conf file	meta-netmodule-distro
meta-netmodule-bsp	• Distribution specific contents • Machine confguration files • U-Boot recipes • Linux kernel recipe • Applications recipes for interface support • General low level applications recipes	meta-netmodule-bsp
meta-netmodule-wlan	• Wlan module firmware • Wireless regulatory databases • WPA supplicant • Wireless tools	meta-netmodule-wlan

7.1.2 Additional Layers and Bitbake

Following additional resources are required:

- meta-openembedded
- meta-updater
- bitbake
- openembedded-core

7.1.3 Setup workspace

Start new build project with cloning all required git repositories: 1. Clone the nm-oem-linux repository 2. Move into the cloned repository and run `git submodule init` then `git submodule update` 3. Your workspace should now look similar as in the snippet below:

:: . ├── bitbake ├── build ├── env.common ├── env.image ├── env.image-minimal ├── env.image-ostree ├── machine_select ├── meta-netmodule-bsp ├── meta-netmodule-distro ├── meta-netmodule-wlan ├── meta-openembedded ├── meta-updater ├── openembedded-core └── README.md

7.1.4 Configure project

Start to source environment: `. ./env.image-ostree` select your hardware in the prompt. You will be moved to the `build` directory.

7.1.5 Build NetModule reference images

NetModule provides several reference images depends on use case:

Image	Description
netmodule-linux-image	Standard reference image. Contains required applications, drivers and tools to use interfaces, network connectivities and sensors.
netmodule-linux-image-dev	Based on `netmodule-linux-image` and extended with helpful development tools for low level access (e.g. direct access on i2c bus) and generic debug tools like strace and gdb.
netmodule-linux-image-minimal	Minimal ramdisk based image for simple bring up or can be used for emmc operations like device flashing or data recovery.

Images recipes location

Images recipes are located in layer `meta-netmodule-distro`:

:: meta-netmodule-distro/recipes-core/images/ ├── includes │ ├── firmware.inc │ └── image-preprocessing.inc ├── initramfs-ostree-image.bbappend ├── netmodule-linux-image.bb ├── netmodule-linux-image-dev.bb ├── netmodule-linux-image-mdev.bb ├── netmodule-linux-image-minimal.bb ├── netmodule-linux-image-oem.bb └── nmcontainer-python3.bb

Images build instructions

Start image build after sourcing environment with:

```
bitbake netmodule-linux-image
```

Images deploy location

Built images are located in deploy directory.:: <project root>/build/tmp/deploy/images/<hw type e.g. am335x-nmhw21>/

CHAPTER 8

Getting Started: NetModule Linux

NetModule AG provides an open source Linux Distribution based on Yoctoproject's Reference distro "Poky".

If you are new into yoctoproject you might want to read this: Getting Started: The Yocto Project Overview

8.1 NetModule Addons

Board Support Packages

- Layer *meta-netmodule-bsp*: Recipes to provide hardware support

NetModule Distro

- Layer *meta-netmodule-distro*: NetModule HW specific package selection

Integration of OSTree

- Layer *meta-updater*

8.2 Image Types

netmodule-linux-release

- OSTree support
- clean build, ready to deploy

netmodule-linux-dev

- OSTree support
- Several tools a developer would find useful already integrated.

netmodule-linux-minimal

- Minimal Kernel and Image size

- RAM Disk Support

CHAPTER 9

OSTree

OSTree is a system for versioning updates of Linux-based operating systems. It can be considered as "git for operating system binaries".

OSTree Documentation

9.1 Description

9.1.1 Difference between a "normal" OS and an "atomic" OS

On a normal OS, the updates are handled by a package-manager. If an update is executed, the package-manager updates each package to the newest version available at the current time. This results in an unique set of packages after every update.

When you do an update on an atomic OS, you update the OS as a whole, giving you a specific set of packages every time.

9.1.2 Filesystem structure

An operating system deployed with ostree is always consistent with the "ostree commit". To make sure this is the case, the os has to be immutable. Ostree does this by creating a read-only bind-mount of the /usr folder.

OSTree uses UsrMov, this means that the folders "bin", "lib" and "sbin" are moved from the root to the /usr directory. On the root those folders are replaced with links to the new location under /usr. This is done, because it reduces the need of read-only bind-mounts to the single /usr directory.

The root of an ostree-deployment is located in: `/sysroot/ostree/deploy/<os-name>/deploy/<commit hash>`

9.1.3 System Partitioning

Because ostree mounts the /usr folder as read-only, we have two options to add additional software:

1. Create a new partition on the eMMC and mount it on lets say /data. | If done like this, new software can now be added to this data-folder.
2. Create an overlay over the /usr directory. If done like this, the /usr folder behaves like a normal read-write folder. This can be done with the command `ostree admin unlock --hotfix` **Note: The changes done like this are reverted after another ostree update. Note: This is generally not recommended for production systems.**

9.1.4 Boot Sequence

1. u-boot loads a uEnv.txt file which contains:

variable	contents
kernel_image	path to the kernel image
ramdisk_image	path to the ramdisk image
bootargs	the bootargs containing the path to the ostree-root.
kernel_image2	path to the fallback kernel image
ramdisk_image2	path to the fallback ramdisk image
bootargs2	the bootargs containing the path to the fallback ostree-root.

2. u-boot loads the kernel and ramdisk given by uEnv.txt
3. the ramdisk contains a script (/sbin/init) which prepares the rootfs.
4. the script runs `pivot_root` to switch from the ramdisk to the newly generated rootfs.
5. the script calls the /sbin/init of the new rootfs.

9.1.5 Update system with ostree via USB

1. Put the "*ostree_repo*" folder on a USB-pendrive (ext4 formated).
2. Plug the USB-pendrive into the nmhw21.
3. On the nmhw21 terminal type:

```
bash # full path of repository e.g. /mnt/ostree_repo
OSTREE_REPO_PATH= # name the repository e.g. update_repo or just repo
OSTREE_REPO_NAME=
```

```
ostree remote add OSTREE_REPO_NAME file://OSTREE_REPO_PATH --no-gpg-verify
ostree --repo=$OSTREE_REPO_PATH summary -u OSTREE_REFS_REPO=
ostree remote refs $OSTREE_REPO_NAME
ostree pull $OSTREE_REFS_REPO
ostree admin deploy $OSTREE_REFS_REPO
```

verify pending update

```
ostree admin status | grep pending
```

reboot to apply update

```
reboot
```

9.1.6 Update system with ostree via network

1. Connect to the network.

```
nmcli c mod ethernet ipv4.method auto
nmcli c up ethernet
```

2. Add the repositories.

```
ostree remote add nmrepo-stable https://nmrepo.netmodule.com/chbe/stable/ --no-gpg-
↪verify
ostree remote add nmrepo-unstable https://nmrepo.netmodule.com/chbe/unstable/ --no-
↪gpg-verify
```

3. Download the image.

There are multiple architectures and images available. The naming convention is:

`{YOCTO_VERSION}-{MACHINE}-{IMAGE_TYPE}` e.g. `dunfell-am335x-nmhw21-vcu`

Do only one of the following commands.

```
# Do this to get the newest stable image.
ostree pull nmrepo-stable dunfell-am335x-nmhw21-vcu
# Do this to get the newest unstable / nightly image.
ostree pull nmrepo-unstable dunfell-am335x-nmhw21-vcu
```

4. On the nmhw21 terminal type:

Do only one of the following commands.

```
# Do this to deploy the newest stable image.
ostree admin deploy nmrepo-stable:dunfell-am335x-nmhw21-vcu
# Do this to deploy the newest unstable / nightly image.
ostree admin deploy nmrepo-unstable:dunfell-am335x-nmhw21-vcu
```

CHAPTER 10

Artifacts for nmhw21

10.1 wic-file

Address in blocks of 512B	Content
0x0000	MBR (Partition Table)
0x0100 (128kB)	MLO
0x0300 (384kB)	u-boot.img
0x2000 (4096kB)	root-partition

CHAPTER 11

Artifacts overview

11.1 wic-file

The wic file is a flashable image file. When upgrading a system with a wic-file, the contents of the wic-file are mirrored to the mass storage device.

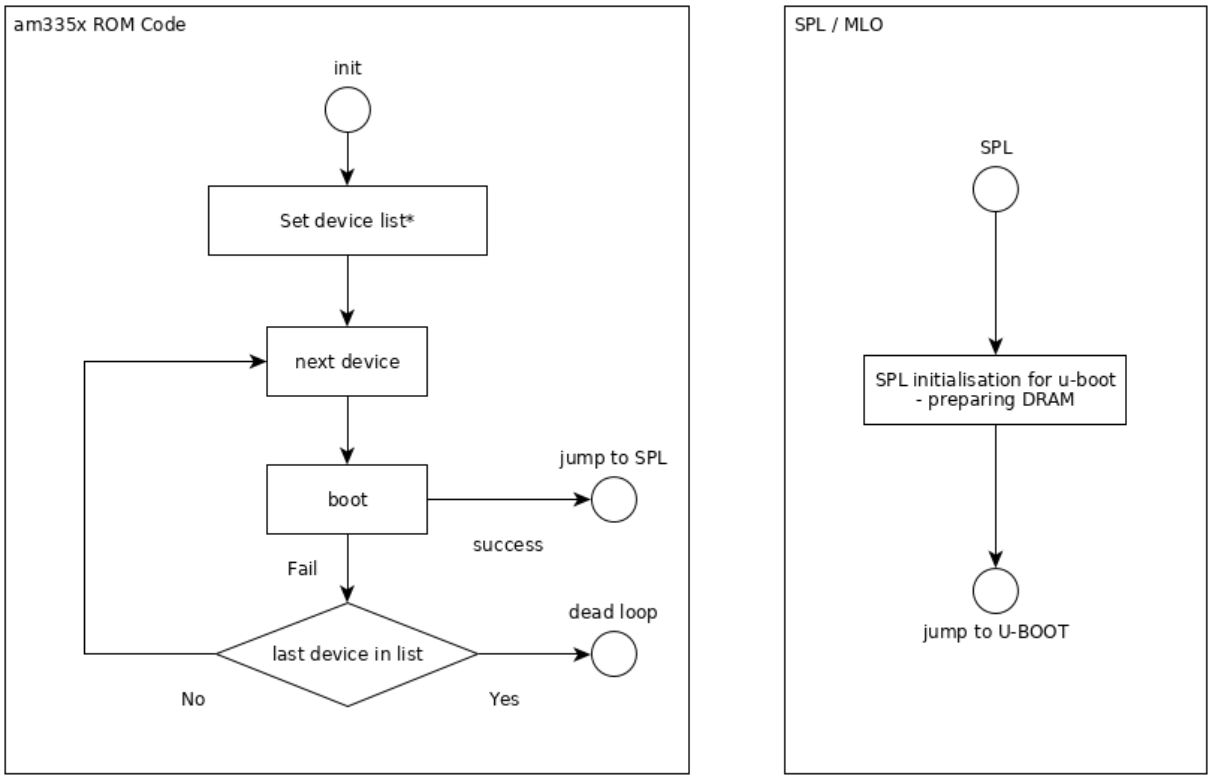
11.2 Kickstart/wks-file

The wks-file defines where the contents are placed in the wic-file. In our yocto build-system the file is located in *meta-netmodule-bsp/wic/*.wks*.

More Information: Yocto Project Reference Manual

CHAPTER 12

am335x Startup



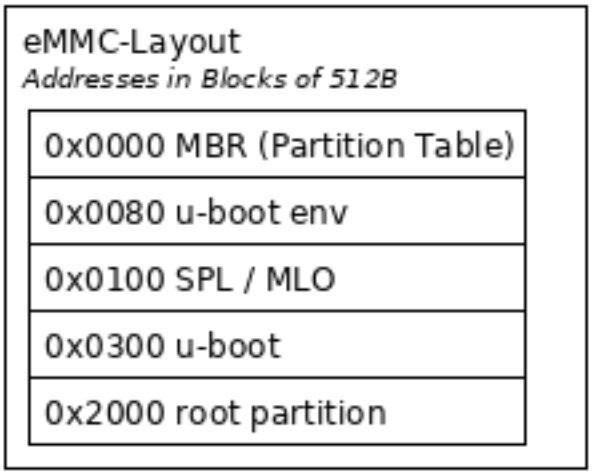
am335x-startup

HW	*list
nmhw21	MMC1, MMC0, UART0, USB0
nmhw21 (jumper on X200)	UART0, XIP, MMC0, NAND

See also: AM335x Technical Reference Manual -> Chapter 26 - Initialization (S. 5014)

CHAPTER 13

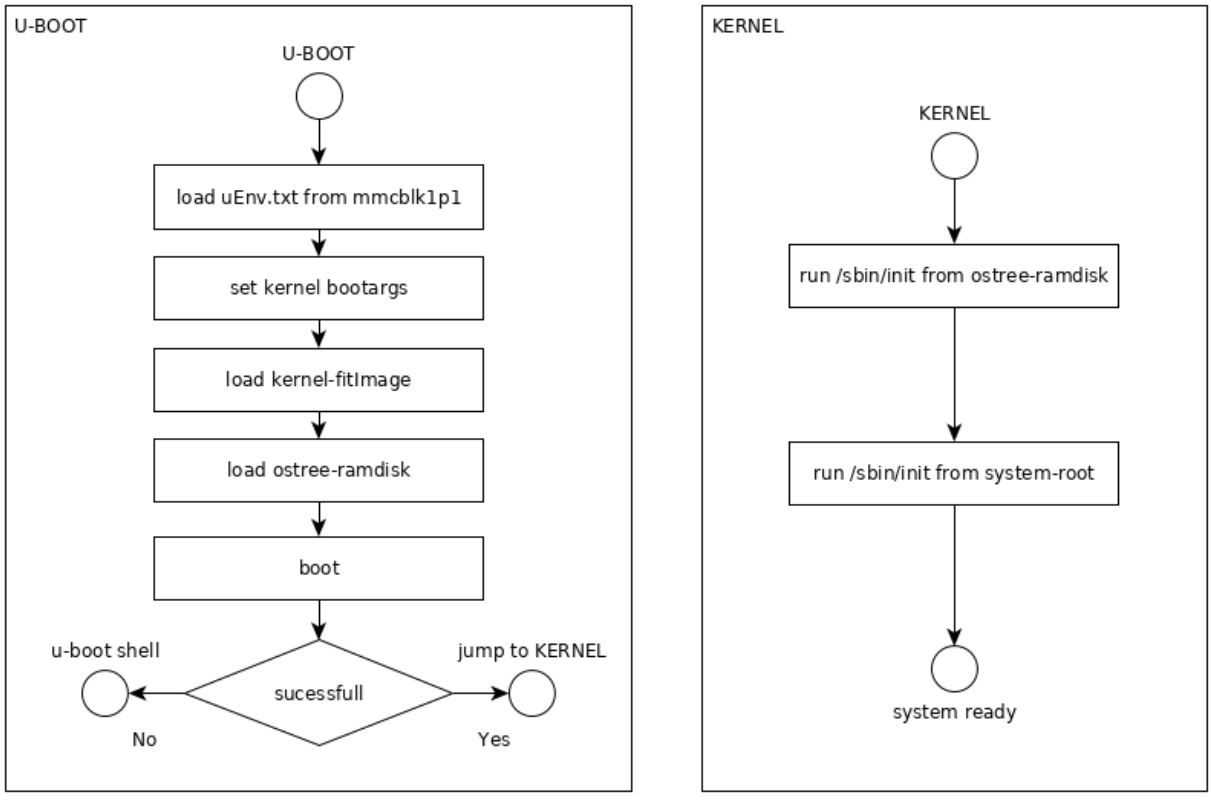
eMMC Contents



eMMC Contents

CHAPTER 14

Startup Sequence



Startup Graph

CHAPTER 15

Automatic Partitioning

When you flashed a ".wic"-file your system will only have one partition with almost no space. To make the filesystem usable, we provide an auto-partitioning tool called `nmhw-auto-part`.

15.1 Recommended settings

1. Run the script in interactive mode.

```
nmhw-auto-part -i
```

2. Press enter without entering values on all the steps.

15.2 Usage

```
nmhw-auto-part.sh [OPTION] 'devicename' 'size' 'mode' 'size'
```

15.2.1 Arguments

'devicename' device to use: e.g. /dev/sdb /dev/mmcblk1

'size' size of the first partition in MB (set 0 to keep current size)

'mode' 'data' or 'overlay'; type of partition to append

'size' size of the appended partition in MB (set to 0 to fill)

15.2.2 Options

```
-i interactive mode
-h help
```

You can either pass the four arguments 'devicename', 'size', 'mode' and 'size' or one option.

15.3 Examples

```
nmhw-auto-part /dev/mmcblk1 1024 overlay 0
```

The same as running the recommended settings.

15.4 How to undo the partitioning

1. Delete Partition information

```
rm -r /etc/nmhw-auto-part
reboot
parted /dev/mmcblk1 rm 2
```

4. Rerun the autopartition script.

Note: The first partition will keep its size.

15.4.1 Files in /etc

/etc/nmhw-auto-part/overlay This is an empty file. It indicates to the init script that it needs to mount an overlay.

/etc/nmhw-auto-part/data-partition This file contains the path of the device, which serves as the data partition. It indicates to the init script that it needs to mount the data partition.

CHAPTER 16

Bluetooth

For full documentation visit bluez.org.

16.1 Commands

16.2 Start and Discover nearby devices

```
root@am335x-vcu:~# bluetoothctl
[NEW] Controller 0C:B2:B7:11:61:9B am335x-vcu [default]
[NEW] Device 40:4E:36:55:DE:CE niconico

[bluetooth]# power on
Changing power on succeeded
[CHG] Controller 0C:B2:B7:11:61:9B Powered: yes

[bluetooth]# agent on
Agent registered

[bluetooth]# default-agent
Default agent request successful

[bluetooth]# discoverable on
[CHG] Controller 0C:B2:B7:11:61:9B Class: 0x200000
Changing discoverable on succeeded
[CHG] Controller 0C:B2:B7:11:61:9B Discoverable: yes

[bluetooth]# scan on
Discovery started
[CHG] Controller 0C:B2:B7:11:61:9B Discovering: yes
[NEW] Device 56:D2:37:FA:DC:8B 56-D2-37-FA-DC-8B
[NEW] Device 74:8D:3C:66:C9:7D 74-8D-3C-66-C9-7D
[NEW] Device 5A:D3:22:54:BD:6C 5A-D3-22-54-BD-6C
```

(continues on next page)

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```
[NEW] Device CC:5B:4F:F4:8A:2B fenix 3 HR
[CHG] Device 74:8D:3C:66:C9:7D RSSI: -80
[NEW] Device 6F:90:CD:32:DE:1B 6F-90-CD-32-DE-1B
[NEW] Device 46:FB:E1:BC:5F:C8 46-FB-E1-BC-5F-C8
[CHG] Device 6F:90:CD:32:DE:1B RSSI: -103
[CHG] Device 6F:90:CD:32:DE:1B RSSI: -85
[CHG] Device 5A:D3:22:54:BD:6C RSSI: -75
[CHG] Device 74:8D:3C:66:C9:7D RSSI: -82
[CHG] Device 40:4E:36:55:DE:CE RSSI: -52
[CHG] Device 5A:D3:22:54:BD:6C RSSI: -66

[bluetooth]# scan off
[CHG] Device E0:E5:CF:96:FA:09 RSSI is nil
[CHG] Device 40:4E:36:55:DE:CE RSSI is nil
[CHG] Device 46:FB:E1:BC:5F:C8 RSSI is nil

[CHG] Controller 0C:B2:B7:11:61:9B Discovering: no
Discovery stopped
```

CHAPTER 17

CAN

17.1 CAN Interfaces

Linux provides CAN driver for physical available CAN controller and for virtual created CAN adapter so called vcan.

17.1.1 Physical CAN Interface

Physical can interfaces depends on hardware and driver support. To check if physical can interfaces are available do:

```
ifconfig -a | grep can
```

Output should be similar to following:

```
can0      Link encap:UNSPEC  HWaddr 00-00-00-00-00-00-00-00-00-00-00-00-00-00-00-00
can1      Link encap:UNSPEC  HWaddr 00-00-00-00-00-00-00-00-00-00-00-00-00-00-00-00
```

To initialize an interface, do the following:

```
ip link set can0 type can bitrate 125000
ip link set up can0
```

It is then possible to send and receive data with:

```
cansend can0 1FFFFFFF#112233445D556677
candump can0
```

17.1.2 Virtual CAN Interface - vcan

To bring up virtual can interface the kernel module vcan is required. Load vcan module:

```
modprobe vcan
```

And controls whether the module is loaded successfully:

```
lsmod | grep vcan
```

Output should be similar to following:

```
vcan                   16384  0
```

Now a virtual can interface vcan0 can be created:

```
ip link add dev vcan0 type vcan
ip link set vcan0 mtu 16
ip link set up vcan0
```

To bring up CAN FD interface mtu size must increased to 72:

```
ip link add dev vcan0 type vcan
ip link set vcan0 mtu 72
ip link set up vcan0
```

And again control new created virtual can interface:

```
ifconfig vcan0
```

Output should be similar to following:

```
vcan0     Link encap:UNSPEC  HWaddr 00-00-00-00-00-00-00-00-00-00-00-00-00-00-00-00
          UP RUNNING NOARP  MTU:16  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)
```

From this point the virtual can interface vcan0 can be used e.g. for SocketCAN.

17.2 SocketCAN

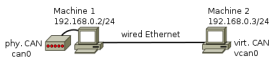
SocketCAN is used to tunnel CAN data over TCP/IP (e.g. ethernet). For linux based system, Cannelloni and socketcand are examples for user space tool which use SocketCAN.

Bind virtual can adapter vcan0 to any counterpart:

```
cannelloni -I vcan0 -R <remote ip> -r <remote port> -l <local port>
```

For non blocking console append a `&` in the command above.

17.2.1 Cannelloni Example



In this example you see Machine 1 with a physical CAN-Interface (can0) and Machine 2 with a virtual CAN-Interface (vcan0). With cannelloni its now possible to link the two CAN-Interfaces together via the TCP/IP stack (UDP and SCTP). This makes it possible to read and write the physical CAN from Machine 2 as if it were directly connected to Machine 2. This is useful if you want to process the CAN-data on an external Machine.

Example use of SocketCAN between two machines.

Config	MACHINE 1	MACHINE 2
IP	192.168.0.2	192.168.0.3
Local cannelloni port	2000	2000

MACHINE 1

```
cannelloni -I can0 -R 192.168.0.3 -r 2000 -l 2000
```

MACHINE 2

```
cannelloni -I vcan0 -R 192.168.0.2 -r 2000 -l 2000
```

Now you can test the functionallity with the following commands.

MACHINE 1

```
candump can0
```

MACHINE 2

```
cansend vcan0 1FFFFFFF#112233445D556677
```

You should now see the data on can0.

17.2.2 External Physical CAN Interface

Ensure that any can participant is on can bus. For communication verification a can PC interface is recommendend. Check also that physical bus is proper terminated with 120 Ohm impedance.

17.3 can-utils

can-utils provides severals tools to e.g. interact and monitor general can interfaces.

To send can frames to vcan0 command cansend can be used:

```
cansend <device> <can_frame>
# example
cansend vcan0 5A2#11.2233.445D556677.66
```

To dump can frames on a can interface use command candump:

```
candump <device>
# example
candump vcan0
```

17.3.1 Resources

Cannelloni: https://github.com/mguentner/cannelloni

CHAPTER 18

Chrony

Chrony is a versatile implementation of the Network Time Protocol (NTP). It can synchronise the system clock with NTP servers, reference clocks (e.g. GPS receiver), and manual input using wristwatch and keyboard. It can also operate as an NTPv4 (RFC 5905) server and peer to provide a time service to other computers in the network.

Chrony Website

Ensure that no other time daemon is running like ntp or ntimed to avoid conflicts.

18.1 Usage

Two programs are included in chrony, chronyd is a daemon that can be started at boot time and chronyc is a command-line interface program which can be used to monitor chronyd's performance and to change various operating parameters while it is running.

If chrony is already configured, time sources can be watched with:

```
chronyc sources
```

18.1.1 Chrony Configuration File

Chrony daemon configuration file is located in directory `/etc/chrony.conf`

18.1.2 NTP Servers

NTP time servers can be defined in configuration files. It is recommended to select time servers which are physicaly close to the device. A pool of time servers can be found at the NTP Pool Project.

Example configuration:

```
server 0.pool.ntp.org iburst
server 1.pool.ntp.org iburst
server 2.pool.ntp.org iburst
```

18.1.3 GNSS

Chrony is able to use GNSS signal and their delivered time. If GPSD is used as GNSS daemon, then chrony can access GPSD shared memory to get time data.

Example configuration with GPSD shared memory access:

```
refclock SHM 0 poll 1 refid GPS offset 0.0 delay 2 filter 16
```

18.1.4 RTC

Chrony can handle hardware real time clock (rtc), measure time drift and correct it automatically. Define rtc device in configuration file by adding device path.

```
rtcdevice /dev/rtc
```

18.2 More configuration option

Chrony is a powerfull tool and provides much more functionality than described here. For further information see Chrony Documentation

CHAPTER 19

Package Management using DNF

For full documentation visit dnf.readthedocs.io <https://dnf.readthedocs.io/en/latest/index.html>‘_.

19.1 Setup

Add the netmodule package repository

```
mkdir /etc/yum.repos.d
touch /etc/yum.repos.d/oe-packages.repo
```

- Add following lines to `/etc/yum.repos.d/oe-packages.repo`

```
[oe-packages]
baseurl=https://nmrepo.netmodule.com/chbe/rpm/
gpgcheck=False
```

19.2 Commands

- `dnf search <pkg-name>` - Search package
- `dnf install <pkg-name>` - Install package
- `dnf remove <pkg-name>` - Remove package

19.3 OSTree compatibility

To use dnf with ostree you have to do the following steps:

1. mount an overlay-fs You might use the auto-partition-script with the recommended settings.
2. Add symbolic link to /lib/rpm

```
ln -s /usr/lib/rpm /var/lib/rpm
```

Hint: If this fails, remove the `/var/lib/rpm` directory and rerun this step.

CHAPTER 20

Ethernet

20.1 Overview

NetModule OEM Linux Distribution comes with built-in support for a number of Ethernet devices. This includes support for hardware solutions as simple as single port standard Ethernet PHY and very complex hardware architecture involving cascading Ethernet switches with external PHYs.

20.2 Supported scenarios

20.2.1 Basic setup

Single network for internal (umnet0) end external (lan0, broadr0 and broadr1) interfaces. Main IP address assigned to eth0. Common broadcast domain.

20.2.2 Multiple isolated interfaces

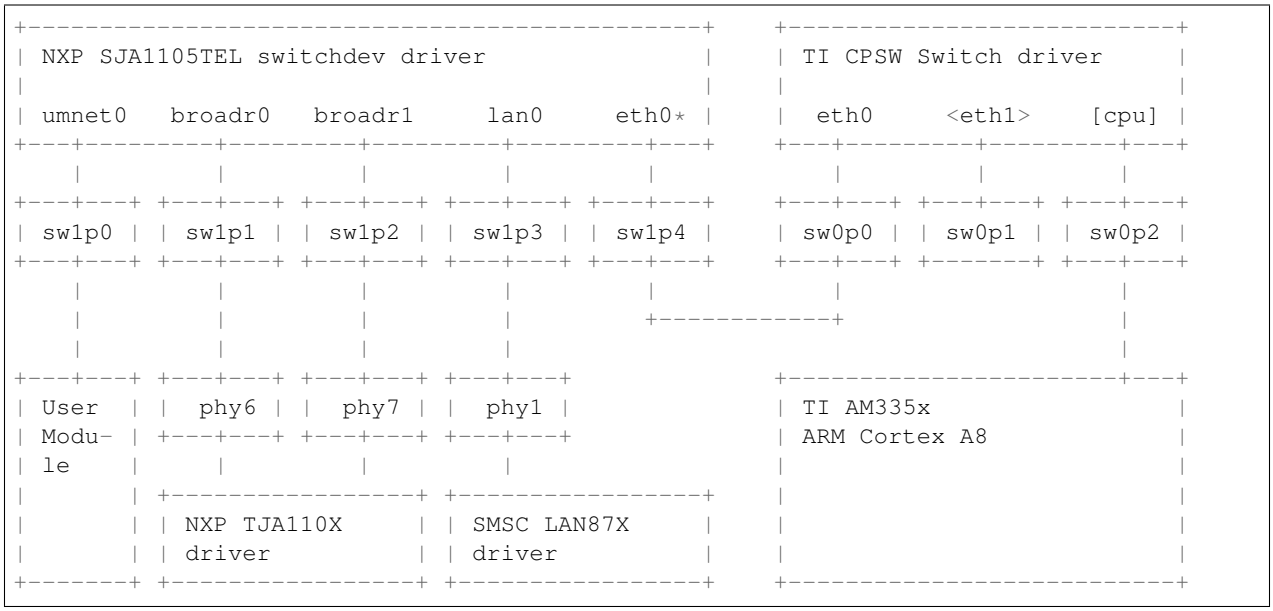
Up to 4 isolated network connections thanks to SJA1105TEL VLAN tagging. IP addresses assigned to VLAN aware interfaces on top of eth0. See *example*.

20.3 Supported hardware

20.3.1 NMHW21

- TI Common Platform Ethernet Switch (CPSW)
- NXP SJA1105TEL Five- Ports AVB & TSN Automotive Ethernet Switch
- NXP TJA1100 100BASE-T1 PHY for Automotive Ethernet

- SMSC LAN8710/LAN8720 PHY



20.4 NXP SJA1105TEL switchdev driver

The SJA1105TEL switchdev driver functionality: - Ports are available in user space as netdevs (e.g. broadr1, lan0) - Hardware statistics and standard information about devices (ethtool) - Rx/Tx and error statistics (ifconfig) - Hardware offloading (bridge fdb) - VLAN tagging/bridging support (brctl, bridge vlan)

The SJA1105TEL switchdev driver limitations: - No VLAN double tagging

20.4.1 Hardware offloading

The idea is to offload the L2 data forwarding (switching) path from the kernel to the switch device by mirroring bridge FDB entries down to the device. An FDB entry is the {port, MAC, VLAN} tuple forwarding destination.

Static bridge FDB entries are installed, for example, using bridge command:

```
$ bridge fdb add ADDR dev DEV [vlan VID] [self]
```

The SJA1105TEL switch device has 1024 entries in the L2 address lookup table. Parts of the table can be statically configured, e.g.:

```
$ bridge fdb add 00:1b:21:2f:fa:1f dev lan0
```

Some of the entries are dynamically learned during operation. Show all valid FDB entries:

```
$ bridge fdb show
```

Loaded entries never time-out and cannot be replaced by learned entries. They have to be removed manually, e.g.:

```
$ bridge fdb del 00:1b:21:2f:fa:1f dev lan0
```

20.4.2 VLAN tagging/bridging

Each port of the SJA1105TEL switch has assigned a PVID in MAC Configuration table. The respective entry in the VLAN Lookup table must be loaded and the flag of the port set to indicate VLAN membership.

A Port VLAN ID (PVID) is a default VLAN ID used to tag untagged incoming frames. In addition to the PVID mandatory definition, a port can be assigned to other VLANs. In this case tagged incoming frames are expected.

E.g. isolate ports 1 (broadr0) and 2 (broadr1) for external traffic by creating a bridge with PVID 10:

```
$ brctl addbr bridge0
$ ip link set dev bridge0 type bridge vlan_default_pvid 10
$ brctl addif bridge0 broadr0
$ brctl addif bridge0 broadr1
$ bridge vlan
port    vlan ids
bridge0  10 PVID Egress Untagged

broadr0  10 PVID Egress Untagged

broadr1  10 PVID Egress Untagged
```

E.g. enable VLAN filtering on bridge0 (untagged incoming frames are dropped):

```
$ ip link set dev bridge0 type bridge vlan_filtering 1
```

E.g. add VLAN for tagged incoming frames and tagged egress:

```
$ bridge vlan add vid 12 tagged dev broadr0
$ bridge vlan add vid 12 tagged dev broadr1
$ bridge vlan
port    vlan ids
bridge0  10 PVID Egress Untagged
         12

broadr0  10 PVID Egress Untagged
         12

broadr1  10 PVID Egress Untagged
```

20.5 NXP TJA110X PHY driver

The driver exposes configuration options through sysfs.

Checking link status of a TJA1100 PHY.

E.g. broadr0, cable connected:

```
# cat /sys/bus/mdio_bus/devices/4a101000.mdio\:02/configuration/link_status
up
```

E.g. broadr1, cable disconnected:

```
# cat /sys/bus/mdio_bus/devices/4a101000.mdio\:03/configuration/link_status
down
```

Both TJA110X PHYs are configured as slaves by default.

E.g. check master/slave configuration of broadr0, default configuration:

```
# cat /sys/bus/mdio_bus/devices/4a101000.mdio\:02/configuration/master_cfg
slave
```

E.g. set broadr1 as master (a counterpart has to be set as slave):

```
# echo master > /sys/bus/mdio_bus/devices/4a101000.mdio\:03/configuration/master_cfg
# cat /sys/bus/mdio_bus/devices/4a101000.mdio\:03/configuration/master_cfg
master
```

The TJA1100 PHY driver can give SNR class of a connection.

E.g. check connection quality of broadr0 to a counterpart over short good quality cable:

```
# cat /sys/bus/mdio_bus/devices/4a101000.mdio\:02/configuration/snr_class
Class G SQI (very good link)
```

E.g. check connection quality of broadr1 to a counterpart over long poor quality cable:

```
# cat /sys/bus/mdio_bus/devices/4a101000.mdio\:03/configuration/snr_class
Class B SQI (unstable link)
```

20.6 User space tools and configuration

Check available interfaces:

```
$ ip link show
```

List IP addresses:

```
$ ip address show
```

List routes:

```
$ ip route show
```

Deactivate a link layer device:

```
$ ip link set dev devicename down
```

Activate a device:

```
$ ip link set dev devicename up
```

Print current settings of the specified device

```
$ ethtool devname
```

Print statistics of the specified device

```
$ ethtool -S devname
```

20.7 Multiple isolated interfaces example

Here are the steps necessary to create 3 IP interfaces able to connect to 3 isolated networks:

- Internal, 192.168.1.0/24 - connection between User Module and Linux
- Ethernet LAN, 172.16.71.0/24 - standard Ethernet connection to Linux
- BroadR LAN, 172.17.1.0/24 - BroadR connection to Linux

1. Set 0.0.0.0 ipv4 address for eth0

```
# nmcli -p con show ethernet
...
ipv4.addresses:                         0.0.0.0/32
...
```

2. Add vlan aware interfaces on top of eth0 using nmcli (routing added automatically)

```
# nmcli con add type vlan con-name eth0.16 dev eth0 id 16 ip4 172.16.71.1/24
# nmcli con add type vlan con-name eth0.17 dev eth0 id 17 ip4 172.17.1.10/24
# nmcli con add type vlan con-name eth0.19 dev eth0 id 19 ip4 192.128.1.1/24
```

3. Create bridge with eth0* as trunk port and separated access ports for all networks

```
# brctl addbr trunk0
# brctl addif trunk0 umnet0
# brctl addif trunk0 broadr0
# brctl addif trunk0 broadr1
# brctl addif trunk0 lan0
# brctl addif trunk0 eth0*
```

4. Update VLAN IDs

```
# bridge vlan add dev eth0* vid 16 tagged
# bridge vlan add dev lan0 vid 16 pvid untagged

# bridge vlan add dev eth0* vid 17 tagged
# bridge vlan add dev broadr0 vid 17 pvid untagged
# bridge vlan add dev broadr1 vid 17 pvid untagged

# bridge vlan add dev eth0* vid 19 tagged
# bridge vlan add dev umnet0 vid 19 pvid untagged
```

5. Clean up default PVID 1

```
# bridge vlan del dev umnet0 vid 1
# bridge vlan del dev broadr0 vid 1
# bridge vlan del dev broadr1 vid 1
# bridge vlan del dev lan0 vid 1
```

6. Verify

```
# bridge vlan
port    vlan ids
umnet0   19 PVID Egress Untagged

broadr0  17 PVID Egress Untagged
```

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```
broadr1  17 PVID Egress Untagged

lan0     16 PVID Egress Untagged

eth0*    1 PVID Egress Untagged
         16
         17
         19

trunk0   1 PVID Egress Untagged
```

7. Analyse traces from eth0 (all traffic should be tagged with VLAN ID assigned to a port)

```
# tcpdump -nnei eth0 -vvv
```

20.8 References

- kernel.org
- dsa
- phy
- netdevices
- switchdev

CHAPTER 21

Updating firmware

The NetModule Linux system provides a tool to upgrade the firmware of the different modules in the system.

The firmware packages are not available in the reference image but the latest supported firmware versions are part of each software release.

21.1 Firmware Location

The firmwares officialy supported by NetModule are available at https://nmrepo.netmodule.com/chbe/fwupdate/

21.2 Preparation

Before upgrading a module, it is recommended to check if it has been properly configured and started. All modules have matching service which is fetching the relevant informations from this module. See module specific examples below to see how to check the service for each type of module.

When the modules are properly configured, the output shows one of the two following lines:

```
Active: active (running)
Active: active (exited)
```

Once the device is started, the firmware version can be read under the following path: */run/<module type>/<module>.config*

See module specific examples below.

21.3 Usage

The update tool can fetch the new firmware from the local device or via http from a remote server.

21.3.1 Local firmware

To upgrade using a local firmware, the firmware must be copied to the target first. The following command can then be executed:

```
nmhw-fwupdate <module> <firmware.tar.gz>
```

Where <module> is the module name as reported in the ".config" filename under */run/<module type>/<module>.config* and <firmware> is the relative or full path to the firmware archive. See module specific examples below.

21.3.2 Remote firmware (HTTP)

If the firmware is available on an HTTP server (reachable from the target), the following command can be used:

```
nmhw-fwupdate <module> <http link>
```

Where <module> is the module name as reported in the ".config" filename under */run/<module type>/<module>.config* and <http link> is the link to the firmware on the HTTP server. See module specific examples below.

21.4 Bootloaders

Warning: Upgrading a bootloader is a critical step and incompatibilities between a bootloader and the linux version in use may break the system. The upgrade should NOT be done without detailed instructions.

21.4.1 Supported systems

- HW21 (u-boot)
- HW26 (u-boot)
- HW23 (imx-boot)

21.4.2 Example

```
# Check service status
systemctl status bootloader-config

# Check bootloader type and version
cat /run/bootloader/bootloader0.config

# Update from local firmware
nmhw-fwupdate bootloader0 nmhw21-u-boot-1.2.2.tar.gz
```

21.5 WWAN

Warning: Downgrading a WWAN modem will likely lead to a broken modem

21.5.1 Supported modules

- u-blox TOBY-L210

21.5.2 Example

```
# Check service status
systemctl status wwan-config@wwan0

# Check wwan0 type and version
cat /run/wwan/wwan0.config

# Update from local firmware
nmhw-fwupdate wwan0 ublox-toby-l210_17.00-A01.00.tar.gz

# Update from remote firmware
nmhw-fwupdate wwan0 https://nmrepo.netmodule.com/chbe/fwupdate/ublox-toby-l210_17.00-
↪A01.00.tar.gz
```

21.6 GNSS

21.6.1 Supported modules

- u-blox NEO-M8L

21.6.2 Example

```
# Check service status
systemctl status gnss-mgr

# Check gnss0 type and version
cat /run/gnss/gnss0.config

# Update from local firmware
nmhw-fwupdate gnss0 UBX_M8_301_ADR_431_NEO_M8L.tar.gz

# Update from remote firmware
nmhw-fwupdate gnss0 https://nmrepo.netmodule.com/chbe/fwupdate/UBX_M8_301_ADR_431_NEO_
↪M8L.tar.gz
```

CHAPTER 22

Creating Bootloader Update Package

22.1 Preparation

Make sure you have the following binaries available:

- The bootloader images:
  - for am335x devices:
    - spl-u-boot-am335x-<hwType>.img
    - u-boot-am335-<hwType>.img
  - for imx8 devices:
    - imx-boot
- the flasher and helper binaries, which you can extract from a previously gotten bootloader update package otherwise call your NetModule Contact
  - for am335x devices:
    - flasher-netbird
    - check_uboot_header.sh
  - for imx8 devices:
    - flasher-net64

22.2 Create the Package

The update package is a simple gzipped tarball of the following content:

- for am335x devices:

```
e.g. for a HW24
.
├── checksums
├── check_uboot_header.sh
├── flasher-netbird
├── info
├── spl-u-boot-am335x-nmhw24.img
└── u-boot-am335x-nmhw24.img
```

- for imx8 devices:

```
.
├── checksums
├── flasher-net64
├── img
│   └── imx-boot
└── info
```

Follow the steps below and use the binaries as described before and you will get your own update package:

1. create a directory, e.g. `fw-pkg`
2. copy the bootloader and flasher binaries into this directory

   NOTE: For imx8 devices the bootloader binary goes into a sub-directory named `img`
3. create the checkum file `checksums` with the following syntax:
   - for am335x devices:

     ```
     <md5-sum>  <spl-image-name>
     <md5-sum>  <u-boot-image-name>
     ```

   - for imx8 devices:

     ```
     <md5-sum>  img/<bootloader-image-name>
     ```

4. create an information file `info` with the following content, whereas the `compatible` string uses the HW numbers as defined as follows:
   - until HW20: `nrhw<HW-Nbr>`
     - example for HW20: `nrhw20`
   - after HW20 to HW24: `nmhw<HW-Nbr>`
     - example for HW24: `nmhw24`
   - after HW24: `hw<HW-Nbr>`
     - example for HW26: `hw26`

   ```
   version: <version>
   type: bootloader
   family: bootloader
   compatible: <hw-compatible-string>
   ```

   for a HW24 with version 1.3.0 you will have this version file:

```
version: 1.3.0
type: bootloader
family: bootloader
compatible: nmhw24
```

5. create the package of the entire content
   - pack the content using tar: `tar czf <package-name>.tar.gz -C fw-pkg .`
     - example for HW24 and version 1.3.0: `tar czf hw24-bootloader-1.3.0.tar.gz -C fw-pkg .`

CHAPTER 23

GNSS

The Global Navigation Satellite System can be accessed using different tools: gpsd provides a useful toolset and the gnss-mgr provides configuration possibilities.

23.1 gpsd

gpsd is used as the interface between the GNSS receiver and other location aware applications. Multiple applications can access the GNSS receiver via TCP connections on port 2947 at the same time, solving the problem of multiple applications requiring access to the same tty interface. gpsd includes several tools to interface to the GNSS receiver, like cpgs, gpsctl, gpscat and ubxtool.

23.2 Connecting ubxtool

The ubxtool might not establish a stable connection to the modem (interruptions, connection issues, ...) depending on how the modem is connected internally. The following command helps to get a stable connection with ubxtool:

```
ser2net -C "2947:raw:0:/dev/gnss0: 115200 8DATABITS NONE 1STOPBIT NOBREAK"
```

23.3 NEO-M8L

The NEO-M8L module is a GNSS receiver by u-blox with the following key features:

- Automotive Grade
- GPS / QZSS, GLONASS, Galileo and BeiDou
- Dead Reckoning using built in IMU

23.4 gnss-mgr

`gnss-mgr` provides GNSS receiver configuration possibilities and replaces the obsolete `gnss-config`, `gnss-save-on-shutdown` and `neom8tool`. This tool operates directly on the serial interface *before* gpsd is staring up and comes with different functionalities like:

- **initialization (runs on each boot-up)**
  - configuring the communciation bitrate of the receiver if necessary
  - configuring the used NMEA protocol version if necessary
  - clearing latest receiver state (save on shutdown)
- save on shutdown (SoS) features like persisting/clearing/verifying receiver state to/from internal storage
- configuring the receiver using a configuration file (in ini file format, see below)
- **control functions**
  - persist the actual configuration into non-volatile storage
  - cold-start the receiver
  - resetting the receiver's configuration to default

The gnss-mgr is set up as systemd service (`gnss-mgr.service`).

On each boot-up the `gnss-mgr` checks and if necessary configures the bitrate and the NMEA protocol version. The `gnss-mgr` configures the recevier with volatile parameters, i.e. the configuration is not persisted and when the power is cut, the receiver looses your configuration (the receiver then re-applies its internally stored setup at the next power-up). Additionally after successfully starting up the gnss services, some basic information about the GNSS receiver can be found at `/run/gnss/gnss0.conf`.

```
root@am335x-nmhw21:~# cat /run/gnss/gnss0.config
Vendor:                              ublox
Model:                               NEO-M8L-0
Firmware:                            ADR 4.21 (Deprecated)
ubx-Protocol:                        19.20
Supported Satellite Systems:         GPS;GLO;GAL;BDS
Supported Augmentation Services:     SBAS;IMES;QZSS
SW Version:                          EXT CORE 3.01 (1ec93f)
HW Version:                          00080000
```

23.4.1 Capabilities

The command `gnss-mgr --help` shows the entire capabilities of the `gnss-mgr`:

```
root@am335x-nmhw21:~# gnss-mgr --help
usage: gnss-mgr [-h] [-V] [-v] [-q] device {init,sos,config,control} ...

Manages GNSS modem

positional arguments:
  device                local serial device to which GNSS modem is connected
                        (e.g. /dev/gnss0)

optional arguments:
  -h, --help            show this help message and exit
```

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```
  -V, --version         show program's version number and exit
  -v, --verbose         be verbose, show debug output
  -q, --quiet           be quiet, only show warnings and errors

command:
  {init,sos,config,control}
                        select command
    init                sets up GNSS modem
    sos                 save on shutdown operations
    config              configures GNSS modem
    control             performs GNSS modem control function
```

Each command (init, sos, config and control) provides a sub-help:

```
root@am335x-nmhw21:~# gnss-mgr /dev/gnss0 init --help
usage: gnss-mgr device init [-h] [-f RUNFILE]

optional arguments:
  -h, --help            show this help message and exit
  -f RUNFILE, --file RUNFILE
                        path to run file

-----------------------------

root@am335x-nmhw21:~# gnss-mgr /dev/gnss0 sos --help
usage: gnss-mgr device sos [-h] {save,clear}

positional arguments:
  {save,clear}  selects sos operation to perform

optional arguments:
  -h, --help    show this help message and exit

-----------------------------

root@am335x-nmhw21:~# gnss-mgr /dev/gnss0 config --help
usage: gnss-mgr device config [-h] [-f CONFIGFILE]

optional arguments:
  -h, --help            show this help message and exit
  -f CONFIGFILE, --file CONFIGFILE
                        path to config file

-----------------------------

root@am335x-nmhw21:~# gnss-mgr /dev/gnss0 control --help
usage: gnss-mgr device control [-h] {cold-start,persist,factory-reset}

positional arguments:
  {cold-start,persist,factory-reset}
                        selects action to perform

optional arguments:
  -h, --help            show this help message and exit
```

23.5 Configuring the GNSS Receiver

The `gnss-mgr` configures the GNSS receiver by using configuration files in ini format. Writing the configuration is managed by feeding the appropriate file to the gnss-mgr.

> **Warning:** A misconfigured GNSS with Dead Reckoning (DR) generates worse results as a GNSS receiver only!

Note: When running the GNSS receiver at 9600 baud some UBX packets might be lost which results in overall worse GNSS performance. Therefore it is strongly recommended to let the receiver operate with 115200 baudto. Additionally it is recommended to configure the GNSS receiver persistent (see example *Persistent configuration of the GNSS receiver* below.

23.5.1 Configuration files

Use the configuration file `/etc/gnss/gnss0.conf` as template to properly configure the GNSS receiver.

The following example of gnss0 config file shows the configuration capabilities of the `gnss-mgr`. The comments show how to setup each parameter:

```
root@am335x-nmhw21:~# cat /etc/gnss/gnss0.conf
#
# This file is part of gnss-mgr service
# To make changes, edit the values in this file and reload
# gnss-mgr service.
#
# Any empty value will use the default or persistent configuration
# of the receiver.

[default]
# Indicates the version of this config file, it should not be modified.
# If unsure of its value, sample config file can always be found in
# /usr/etc/gnss/
#
# Change history
# version 3: Added field navigation.dead-reckoning
# version 4: Added "time" section
version=4

# Select measurement and navigation output rate
# Allowed values : 1 - 10  [Hz]
update-rate=
#update-rate=1


#
# Navigation settings
#
[navigation]
# Enables or disables dead reckoning
# Supported values:
#   enable, disable
dead-reckoning=
```

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```
#dead-reckoning=disable

# Selects dynamic mode
# Supported values:
#   stationary, vehicle
mode=
#mode=vehicle

#
# Selects GNSS systems
# Allowed values:
#   GPS;GLONASS;SBAS
#   GPS;Galileo;Beidou;SBAS
systems=
#systems=GPS;GLONASS;SBAS
#systems=GPS;Galileo;Beidou;SBAS


#
# Installation settings
# For details on this section, see the relevant documentation
#
[installation]

#
# IMU orientation in degrees [°]
#   yaw: value in degrees (0 to  360)
#   pitch: value in degrees (-90 to  90)
#   roll: value in degrees (-180 to 180)
yaw=
pitch=
roll=

# Lever arm lengths in meters [m]
# Format x;y;z
# Example:
#   vrp2antenna=1.0;1.5;0.3
vrp2antenna=
vrp2imu=


#
# Configurations related to time
# For details on this section, see the relevant documentation
#
[time]

#
# Enables or disables the time pulse (PPS) line
# If it is not set, the default or already configured
# state of the receiver will be used.
#
# NB: This feature may not be available on all systems
# Handling of the PPS line must also be done.
#
timepulse=
#timepulse=enable
```

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```
#timepulse=disable


#
# Sets the frequency [Hz] of the time pulse (PPS) line
#
# If not set the default or already configured value is used
#
timepulse-frequency=
#timepulse-frequency=1
#timepulse-frequency=20
```

23.5.2 Lever Arm Lengths

The following figure shows an installation example and how to configure the receiver's lever arm lengths.

Fig. 1: Installation and positioning

LeverConfiguration with values

- vrp2antenna=1.6;0;1.7
- vrp2imu=2.1;0.6;0.8

23.5.3 Timepulse configuration

The timepulse can be enable or disabled and configured in the [time] section. This feature sends a pulse every 1/X seconds. Note that the PPS line must be handled outside of gnss-mgr: depending on the system, it may be:

- not connected
- connected directly to the CPU and in this case handled by the "time" software
- connected to an external component

23.5.4 Examples

Configuring the GNSS receiver:

```
gnss-mgr /dev/gnss0 config -f /etc/gnss/gnss0.conf
```

Persisting the configuration of the GNSS receiver:

```
gnss-mgr /dev/gnss0 control persist
```

Resetting the receiver's configuration to default:

```
gnss-mgr /dev/gnss0 control factory-reset
```

23.5.5 Troubleshooting

If the receiver is no longer accessible, the issue most seen is that baud rates of serial interface (ttyS3) and receiver are not matching.

23.6 Save on Shutdown

The NEO-M8L GNSS receiver can be instructed to save its current state to the internal non-volatile memory and restore it after a power cycle.

Note that the receiver state and the receiver configuration must be distinguished: Saving the state before the system is shut-down can help your GNSS receiver to get a faster fix after booting. Save on shutdown does however not save any configuration done by the user. The receiver configuration needs to be saved manually to the receiver's internal non-volatile memory (only once), see Example *Persiting the configuration of the GNSS receiver*.

The `gnss-mgr` service instructs the GNSS receiver to save its state whenever your linux system receives a shutdown or reboot instruction. Upon reboot the same service logs if the GNSS receiver state has been successfully restored.

23.6.1 Examples

Storing the state to the GNSS receiver's internal storage:

```
gnss-mgr /dev/gnss0 sos save
```

Clearing the state in the GNSS receiver's internal storage:

```
gnss-mgr /dev/gnss0 sos clear
```

23.7 Firmware update (specific to u-blox NEO-M8L)

The firmware of the module u-blox NEO-M8L can be upgraded as explained in *Updating firmware*.:

23.8 Testing

To test the GNSS function connect an active GNSS antenna to X3300 "GNSS".

Run "cgps" tool

Your output should look like this. Typically it takes 3..20 seconds for a fix.

```
┌──────────────────────────────────────────────────────────────────────────────┐
│    Time:       2018-07-05T06:49:00.000Z  ┌──────────────────────────────────┐
│    Latitude:    47.31890666 N            │PRN:   Elev:  Azim:  SNR:  Used:  │
│    Longitude:    7.97375949 E            │  6     18    082    28      Y    │
│    Altitude:   1641.076 ft               │ 17     15    039    30      Y    │
│    Speed:      0.14 mph                  │ 19     35    052    27      Y    │
│    Heading:    0.0 deg (true)            │ 32     32    305    16      Y    │
│    Climb:      0.00 ft/min               │ 66     27    311    23      Y    │
│    Status:     3D FIX (3 secs)           │ 74     43    076    28      Y    │
│    Longitude Err:   +/- 33 ft            │ 84     46    063    21      Y    │
└──────────────────────────────────────────┘└──────────────────────────────────┘
```

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```
    Latitude Err:    +/- 111 ft
    Altitude Err:    +/- 200 ft
    Course Err:      n/a
    Speed Err:       +/- 152 mph
    Time offset:     7176.328
    Grid Square:     JN37xh
```

23.9 Access gps interface

If direct interface access is required, the gps device is available under `/dev/gnss0`. Be aware that `gnss0` is just a symlink to the real device managed by udev. If you need to know the real device, follow the symlink with:

Example output:

```
root@am335x-nmhw21:~# ls -l /dev/gnss0
lrwxrwxrwx 1 root root 5 Jul  2 07:06 /dev/gnss0 -> ttyS3
```

CHAPTER 24

GSM

See *WWAN*.

CHAPTER 25

IMU

ST provides LSM6DSx driver which provides two different ways of reading out IMU data.

25.1 Polling mode

Polling mode is the simplest IMU driver configuration, where data is read out on request. This mode does not support hardware timestamping.

25.1.1 Accelerometer

Get raw value of z-axis

```
$ cat /sys/bus/iio/devices/iio\:device0/in_accel_z_raw
```

Get y-axis scale value

```
$ cat /sys/bus/iio/devices/iio\:device0/in_accel_y_scale
```

Multiply the two to get the acceleration in m/s2. For z-axis this should be around 9.81m/s2.

Example:

```
$ cat /sys/bus/iio/devices/iio\:device0/in_accel_z_raw
16499
$ cat /sys/bus/iio/devices/iio\:device0/in_accel_y_scale
0.000598

# --> 9.8664
```

25.1.2 Gyro

Get raw value of x-axis

```
$ cat /sys/bus/iio/devices/iio\:device1/in_anglvel_x_raw
```

25.2 Buffered mode

Buffered mode enables full driver functionality, but requires hardware interrupts to be processed by the driver, which consumes more CPU load. This mode supports hardware timestamping.

25.2.1 Configuration

Buffered mode requires configuration. Following is a typical configuration to receive all the data IMU provides, including hardware timestamps:

Accelerometer

```
# Disable buffered mode

$ echo 0 > /sys/bus/iio/devices/iio\:device0/buffer/enable

# Subscribe to data elements

$ echo 1 > /sys/bus/iio/devices/iio\:device0/scan_elements/in_accel_x_en
$ echo 1 > /sys/bus/iio/devices/iio\:device0/scan_elements/in_accel_y_en
$ echo 1 > /sys/bus/iio/devices/iio\:device0/scan_elements/in_accel_z_en
$ echo 1 > /sys/bus/iio/devices/iio\:device0/scan_elements/in_timestamp_en

# Set sampling frequency

$ echo 13 > /sys/bus/iio/devices/iio\:device0/sampling_frequency

# Set buffer length

$ echo 2 > /sys/bus/iio/devices/iio\:device0/buffer/length

# Enable buffered mode

$ echo 1 > /sys/bus/iio/devices/iio\:device0/buffer/enable
```

Gyro

```
# Disable buffered mode

$ echo 0 > /sys/bus/iio/devices/iio\:device1/buffer/enable

# Subscribe to data elements

$ echo 1 > /sys/bus/iio/devices/iio\:device1/scan_elements/in_anglvel_x_en
```

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```
$ echo 1 > /sys/bus/iio/devices/iio\:device1/scan_elements/in_anglvel_y_en
$ echo 1 > /sys/bus/iio/devices/iio\:device1/scan_elements/in_anglvel_z_en
$ echo 1 > /sys/bus/iio/devices/iio\:device1/scan_elements/in_timestamp_en

# Set sampling frequency

$ echo 13 > /sys/bus/iio/devices/iio\:device1/sampling_frequency

# Set buffer length

$ echo 2 > /sys/bus/iio/devices/iio\:device1/buffer/length

# Enable buffered mode

$ echo 1 > /sys/bus/iio/devices/iio\:device1/buffer/enable
```

25.2.2 Data

Reading out IMU data in buffered mode is done in a different way comparing to polling mode. In polling mode data is provided via driver SysFS nodes, while in buffered mode data is read out via dedicated char devices.

Accelerometer

```
$ hexdump /dev/iio\:device0
```

Gyro

```
$ hexdump /dev/iio\:device1
```

25.2.3 Reconfiguration

Buffered mode does not allow reconfiguration on the fly. However, it is allowed to temporarily disable buffered mode while IMU char device is opened, which gives a possibility to reconfigure IMU driver. For example, if some application is used to read the data from accelerometer (see example above), it is possible to change its sampling frequency without closing the application:

```
$ echo 0 > /sys/bus/iio/devices/iio:device0/buffer/enable
$ echo 13 > /sys/bus/iio/devices/iio:device0/sampling_frequency
$ echo 1 > /sys/bus/iio/devices/iio:device0/buffer/enable
```

CHAPTER 26

LEDs

NMHW21 provides four LEDs that can be controlled by user application or via command line.

The LEDs are described as follows:

- Indicator onboard (ind)
- Status onboard (status)
- Indicator user-interface (ind ui)
- Status user-interface (status ui)

26.1 Standard LED behavior

On startup (during bootloader/system-boot) the LEDs follow a specific pattern. During the startup the LEDs on the user-interface and the onboard LEDs are synced.

‘ind’ = ‘ind ui’
‘status’ = ‘status ui’

- start of the bootloader (hard coded into u-boot)

ind - red
status - red

- start of kernel (defined in the device tree)

ind - off
status - orange

26.1.1 Hard reset

On a hard reset the onboard status LED starts orange.

26.2 LED: PCB Ind

Green

```
$ echo 1 > /sys/class/leds/ind\:green/brightness
$ echo 0 > /sys/class/leds/ind\:red/brightness
```

Orange

```
$ echo 1 > /sys/class/leds/ind\:green/brightness
$ echo 1 > /sys/class/leds/ind\:red/brightness
```

Red

```
$ echo 0 > /sys/class/leds/ind\:green/brightness
$ echo 1 > /sys/class/leds/ind\:red/brightness
```

Off

```
$ echo 0 > /sys/class/leds/ind\:green/brightness
$ echo 0 > /sys/class/leds/ind\:red/brightness
```

26.3 LED: PCB Status

Green

```
$ echo 1 > /sys/class/leds/status\:green/brightness
$ echo 0 > /sys/class/leds/status\:red/brightness
```

Orange

```
$ echo 1 > /sys/class/leds/status\:green/brightness
$ echo 1 > /sys/class/leds/status\:red/brightness
```

Red

```
$ echo 0 > /sys/class/leds/status\:green/brightness
$ echo 1 > /sys/class/leds/status\:red/brightness
```

Off

```
$ echo 0 > /sys/class/leds/status\:green/brightness
$ echo 0 > /sys/class/leds/status\:red/brightness
```

26.4 LED: UI Ind

Green

```
$ echo 1 > /sys/class/leds/ui\:ind\:green/brightness
$ echo 0 > /sys/class/leds/ui\:ind\:red/brightness
```

Orange

```
$ echo 1 > /sys/class/leds/ui\:ind\:green/brightness
$ echo 1 > /sys/class/leds/ui\:ind\:red/brightness
```

Red

```
# echo 0 > /sys/class/leds/ui\:ind\:green/brightness
$ echo 1 > /sys/class/leds/ui\:ind\:red/brightness
```

Off

```
# echo 0 > /sys/class/leds/ui\:ind\:green/brightness
$ echo 0 > /sys/class/leds/ui\:ind\:red/brightness
```

26.5 LED: UI Status

Green

```
$ echo 1 > /sys/class/leds/ui\:status\:green/brightness
$ echo 0 > /sys/class/leds/ui\:status\:red/brightness
```

Orange

```
$ echo 1 > /sys/class/leds/ui\:status\:green/brightness
$ echo 1 > /sys/class/leds/ui\:status\:red/brightness
```

Red

```
$ echo 0 > /sys/class/leds/ui\:status\:green/brightness
$ echo 1 > /sys/class/leds/ui\:status\:red/brightness
```

Off

```
$ echo 0 > /sys/class/leds/ui\:status\:green/brightness
$ echo 0 > /sys/class/leds/ui\:status\:red/brightness
```

CHAPTER 27

Linux System Logging

Our distribution supports user space and kernel log messages and uses journald as system logger. Its configuration file provides a lot of parameters and can be found under `/etc/systemd/journald.conf` and in the drop-in folders `journald.conf.d` (for the full detailed information, please check journald.conf(5). This section describes the most important parameters and information regarding logging.

27.1 Accessing Log Files

To read out journals the command line tool journalctrl is provided: `journalctl`

To follow latest log messages pass argument -f: `journalctl -f`

Show filtered by units: `journalctl -u <your-unit.service>`

More information in journalctrl man page

27.2 Storage of the Logs

There are two modes about how logs can be stored: - volatile = logs are stored to RAM - persistent = logs are stored to flash

NOTE: The flash memory has limited write cycles which needs to be taken into account for the devices lifetime.

IMPORTANT: To not stress unnecessary the flash memory, our distribution logs as default the messages into RAM = volatile.

The logging system can be tailored to the need of the application. Full system logging makes analyzing an issue simpler and purposeful but it may cost valuable disk space and perfomance as well.

The follow subsection explains the most important configuration settings.

27.3 Configuration Parameters

Be aware about configuration files in the drop-in folders as described in the man pages.

You can take the config file `/etc/systemd/journald.conf` as template and change or tailor the parameters for the application's need. Nevertheless, the following parameters are the most important to understand:

- **Storage=**

  Can be either "volatile", "persistent", "auto" or "none":

  - volatile (*default*) - The logs will be stored in memory below */run/log/journal* - After a reboot the logs will be gone - *The storage parameters with the "Runtime" prefix apply here*
  - persistent - The logs will be stored on the disk below */var/log/journal* - After a reboot the logs will still be there - *The storage parameters with the "System" prefix apply here*
  - auto - If the folder `/var/log/journal` exists, the behavior is the same as with "persistent" otherwise it behaves like "volatile"
  - none - No logs will be saved. Only forwarding will be done (if enabled).

- **SystemMaxUse= / RuntimeMaxUse=**

  Control how much disk / memory space the journal may use up at most. Specify values in bytes or use K, M, G, T, P, E as units. *Default values: SystemMaxUse=64M, RuntimeMaxUse=16M*

- **SystemKeepFree= / RuntimeKeepFree=**

  Control how much disk / memory space the journal may keeps free. Specify values in bytes or use K, M, G, T, P, E as units. Systemd-journald will respect both limits (KeepFree/MaxUse) and use the smaller of the two values. *Default values: SystemKeepFree=350M, RuntimeKeepFree=not set*

- **SyncIntervalSec=**

  The timeout before synchronizing journal files to disk. This setting takes time values which may be suffixed with the units "m" for minutes. *Default value = 5min*

- **ForwardToSyslog=**

  Use "yes" or "no". Enables forwarding to the old syslog (/var/log/messages). If this is enabled, there will still be messages written to the disk regardless of the "Storage=" parameter. *Default = no*

- **ForwardToConsole=**

  Use "yes" or "no". Useful for debugging purposes *Default = no*

27.3.1 How to change the settings

If you want to change the default settings like for example persisting the log files, the following steps need to be done...

Without having drop-in folders:

1. Change the storage parameter in the config file `/etc/systemd/journald.conf` to `Storage=persistent`
2. Reboot your device (`reboot`) or restart the logger system (`systemctl restart systemd-journald`)

Having drop-in folders:

1. Create a drop-in folder like `/etc/systemd/journald.conf.d/`

2. Add your configuration changes to a file within that folder, e.g. `/etc/systemd/journald.conf.d/01-journald.conf`
3. Reboot your device (`reboot`) or restart the logger system (`systemctl restart systemd-journald`)

NOTE: Don't forget to clean the logs when you are switching from persistent to volatile storage. More details see section *Maintaining the Logs* below.

27.4 Maintaining the Logs

In embedded devices the disk usage might be essential. The logger system provides several tools to maintain the logs.

27.4.1 Disk Usage

To check the amount of disk space the logs are taking, just run this command:

```
root@am335x-nmhw21:~# journalctl --disk-usage
Archived and active journals take up 18.0M in the file system.
```

27.4.2 Cleaning

There are several methods provided to clean the logs.

Cleaning your logs to a specific size run `journalctl --vacuum-size=`. This removes the oldest archived journal files until the disk space they use falls below the specified size (specified with the usual "K", "M", "G" and "T" suffixes):

```
root@am335x-nmhw21:~# journalctl --vacuum-size=4M
Deleted archived journal /run/log/journal/c8b8c280f0bc43aba10c21e3574e81fc/
↪system@335f2d7f78764e27ba522dc69770346f-00000000000014c8-0005ae5e2a594f10.journal␣
↪(2.0M).
Deleted archived journal /run/log/journal/c8b8c280f0bc43aba10c21e3574e81fc/
↪system@335f2d7f78764e27ba522dc69770346f-0000000000001af7-0005ae5ecf0899e3.journal␣
↪(2.0M).
Deleted archived journal /run/log/journal/c8b8c280f0bc43aba10c21e3574e81fc/
↪system@335f2d7f78764e27ba522dc69770346f-00000000000020d0-0005ae5f68b8138f.journal␣
↪(2.0M).
Deleted archived journal /run/log/journal/c8b8c280f0bc43aba10c21e3574e81fc/
↪system@335f2d7f78764e27ba522dc69770346f-00000000000026c9-0005ae600002f7a6.journal␣
↪(2.0M).
Deleted archived journal /run/log/journal/c8b8c280f0bc43aba10c21e3574e81fc/
↪system@335f2d7f78764e27ba522dc69770346f-0000000000002cc1-0005ae60973a5468.journal␣
↪(2.0M).
Deleted archived journal /run/log/journal/c8b8c280f0bc43aba10c21e3574e81fc/
↪system@335f2d7f78764e27ba522dc69770346f-00000000000032b9-0005ae612e720fcf.journal␣
↪(2.0M).
Vacuuming done, freed 12.0M of archived journals from /run/log/journal/
↪c8b8c280f0bc43aba10c21e3574e81fc.
```

Cleaning your logs using a specific time run `journalctl --vacuum-time=`. This removes all archived journal files contain no data older than the specified timespan (specified with the usual "s", "m", "h", "days", "months", "weeks" and "years" suffixes):

```
root@am335x-nmhw21:~# journalctl --vacuum-time=1s
Deleted archived journal /run/log/journal/c8b8c280f0bc43aba10c21e3574e81fc/
↪system@335f2d7f78764e27ba522dc69770346f-00000000000038b1-0005ae61c5b11a9d.journal␣
↪(2.0M).
Deleted archived journal /run/log/journal/c8b8c280f0bc43aba10c21e3574e81fc/
↪system@335f2d7f78764e27ba522dc69770346f-0000000000003ef0-0005ae6259e61874.journal␣
↪(2.0M).
Vacuuming done, freed 4.0M of archived journals from /run/log/journal/
↪c8b8c280f0bc43aba10c21e3574e81fc.
```

NOTE: When switched from persistent to volatile and after cleaning, it might also be possible to remove the persistent logs by calling `rm -rf /var/log/journal/*`.

CHAPTER 28

NetModule Linux Networking

28.1 NetworkManager

28.1.1 nmcli

- `nmcli c edit ethernet` - edit the ethernet connection interface.
- `nmcli c modify ethernet ipv4.method auto` - oneline edit, useful for scripts

CHAPTER 29

Power Management

29.1 Overview

NetModule OEM Linux Distribution provides two standard high-level power management strategies:

- system-wide power management,
- working-state power management.

System-wide power management strategy is using global low-power states to reduce system activity. In these states, referred as sleep states, user space code cannot be executed. Depending on sleep state supported by the platform, different levels of energy saving can be achieved. To get back to the working state, the system expects to receive a special signal from one of the designated devices.

Working-state power management strategy corresponds to adjusting the power states of individual hardware components.

29.1.1 Supported hardware

- DA9063 System PMIC

29.1.2 Supported sleep states

Standby This state provides a relatively straightforward transition back to the working state. In this state the system core logic retains power and no operating state is lost. It offers moderate, real energy savings.

PMIC's Power Down Mode Platforms with DA9063 System PMIC can support more sophisticated energy saving options by disabling the system power domain. The system power domain is enabled on a signal received from a preconfigured wake-up device.

29.1.3 Supported wake-up scenarios

- RTC based alarm
- IMU based events: single-tap, double-tap
- ONKEY event
- KL15 event

29.2 Smart Battery

NetModule OEM Linux Distribution can run on devices supplied by a smart battery. To get current status of the battery our distribution provides a battery test tool.

29.2.1 User space tools and configuration

Enter standby state:

```
$ echo standby > /sys/power/state
```

Wake up from standby after 10 seconds:

```
rtcwake -d /dev/rtc0 -m standby -s 10
```

or without rtcwake in your image:

```
echo +10 > /sys/class/rtc/rtc0/wakealarm && echo standby > /sys/power/state
```

Enter PMIC's power down mode:

```
$ poweroff
```

Start system after ~1 min when in PMIC's power down mode:

```
echo +60 > /sys/class/rtc/rtc0/wakealarm && poweroff
```

Using a battery test:

```
$ batterytest -h
battery tool

Examples:
  batterytest -v         get voltage
  batterytest -a         get current
  batterytest -t         do battery test

Main modes of operation:
 -h, --help              print this help
 -A, --all               print all battery information
 -v, --voltage           get battery voltage
 -a, --current           get battery current
 -c, --capacity          get remaining capacity
 -r, --reg               raw mode, register access
 -t, --test              run battery test
```

CHAPTER 30

Remote GPIO driver

30.1 Configuration

By default, driver will create 32 GPIO's (named RGPIO0-RGPIO31), and will set server IP and port as 192.168.1.42:6666.

It is possible, however, to configure Remote GPIO driver via device tree:

```
remote-gpios {
  compatible = "remote-gpios";

  ip = "192.168.1.64";
  port = /bits/ 16 <6666>;

  remote-gpio@0 {
    label = "umgpo0";
  };
  remote-gpio@1 {
    label = "umgpo1";
  };
  remote-gpio@2 {
    label = "umgpo2";
  };
  remote-gpio@3 {
    label = "umgpo3";
  };

  remote-gpio@4 {
    label = "umpu0";
  };
  remote-gpio@5 {
    label = "umpu1";
  };
  remote-gpio@6 {
```

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```
    label = "umpu2";
  };
  remote-gpio@7 {
    label = "umpu3";
  };

};
```

The ip-address and port can be changed via SysFS under `/sys/class/remote-gpio/remote-gpio/config/`. The service "um-service-config.service" will configure the port to either "6666" or "7020" depending on the user-module firmware revision.

30.2 Protocol

The Protocol uses TCP. It consists of *commands* and *events*, where *command* is something that is received by user module (server), and *event* is a state notification to the client. There can be multiple *events* or *commands* in one TCP-Package.

- **Command: set GPIO output**

```
O<id><state>
```

Where:

  - *id* is two digit pin hex number
  - *state* is 0 for low, 1 for high

Examples:

  - Set GPIO 13 low

```
O0D0
```

  - Set GPIO 8 high

```
O081
```

- **Event: GPIO input state**

```
I<id><state>
```

Where:

  - *id* is two digit pin hex number
  - *state* is 0 for low, 1 for high

Examples:

  - GPIO input 2 set to low

```
I020
```

- GPIO input 11 set to high

```
I0B1
```

- GPIO output 1 and 2 are set to high

```
O011O021
```

30.3 Usage

Since linux 4.8 the GPIO sysfs interface is deprecated. User space should use the character device instead. Current de-facto standard of using new GPIO system is libgpiod library and its tools:

- gpiodetect
- gpioinfo
- gpioget
- gpioset
- gpiofind
- gpiomon

CHAPTER 31

System State Framework (SSF)

31.1 Introduction

This document describes an extensible design for tracking and publishing the system state for NG800 and OEM products derived from NG800.

The system state is a string variable that reflects the run-level of the overall system (off, booting, starting, up, shutdown-pending, shutting-down, powering-down). This value is published to user applications via the sysfs (file system).

At the core of the design a state machine tracks the system state and processes multiple inputs such as the ignition signal. Before shutting down Linux because of a de-asserted ignition signal, the state machine grants user-space application time to properly shut down. User applications can prolong the shutdown timer if they need more time to terminate. If the timer elapses, the state machine instructs the kernel to shut down.

31.2 File System Entries

All the entries are available under the directory */sys/kernel/broker*:

- ignition
  - status of the ignition signal
    - 1 = asserted
    - 0 = de-asserted
- system-state
  - state of the system
    - starting –> operating system, applications, etc are starting up
    - up –> system start-up finished, i.e. fully booted, up and running
    - shutdown-pending –> system was told to shut down by giving applications time to terminate, see also *shutdown-delay*

        * shutting-down –> shut down in progress
- system-state-target
  - interface to "command" the SSF, i.e. the following parts can be written in it:
    * up –> –> triggers the SSF for being up (transition from starting to up)
    * reboot –> triggers an immediate reboot
    * powerdown –> triggers an immediate power-off
- shutdown-delay [seconds]
  - set or read the default shutdown-delay
  - this value is initialized in the device-tree
- extend-shutdown-delay [seconds]
  - delay the shutdown to have more time to terminate applications
- remaining-shutdown-delay [seconds]
  - countdown with the remaining time until the device shuts down
- start-reason
  - information about the reason for the start-up
    * power –> ignition and power are both attached to the device
    * reboot –> device is rebooting (reboot command, ignition signal or RTC alarm during shut down process)
    * watchdog –> device is reset by watchdog (see watchdog feature below)
    * wakeup;ignition –> the device was ignited at a power down (power supply still attached)
    * wakeup;rtc-alarm –> the device woke up by an RTC alarm (power supply still attached)
- ping-request
  - used for the watchdog feature to test a correct operation of the kernel modules
  - writing a test string triggers the kernel modules (response shown in ping-response)
- ping-response
  - used for the watchdog feature to test a correct operation of the kernel modules
  - reading the response triggered by writing into ping-request

31.3 SSF Components

The SSF consists of two kernel modules and a user space application:

- SSF broker (kernel module)
  - exposes all important SSF topics as sysfs files
  - distributes SSF notifications to registerd components
- SSF sysstate (kernel module)
  - exposes the current core system state in the sysfs file
- SSF manager (user space application)

  - writes the state to filesys system-state file such as
    * *up* as soon as the system is completely booted
    * *powerdown* as soon as a powerdown is progressing
    * *reboot* as soon as a reboot is progressing
  - handles the watchdog including the ping check (ping-request and ping-response)

Note: The SSF manager is provided with our OEM Linux Release. If a custom handling of the SSF is needed it can be configured with its command line options, see section SSF Manager below.

31.4 Device Tree Entries

At the moment there are only two relevant options to set in the device-tree. The rest of the device tree entries should be left as is or the device may not function properly.

- default-shutdown-delay-s
  - the default shutdown-delay when no extending of the shutdown-delay is requested.
  - sets the value of *shutdown-delay* on startup.
- max-shutdown-delay-s
  - sets the maximum time of the shutdown-delay. This is used to make sure the shutdown delay can't be extended forever.

31.5 Pending Shutdown

When the ignition signal is de-asserted the *system-state* shows *shutdown-pending* for the time located in the file *remaining-shutdown-delay*. Re-asserting the ignition signal during this time the *system-state* changes back to *up*.

Prolonging a pending shutdown is described in the next section.

31.6 Extending a Shutdown

As mentioned above the shut down can be delayed to have time to terminate applications properly. The following example shows about how to use it:

Example: Let's assume the default shutdown is 60s and after 30s we notice that we need to delay it for 75s. Perform the following command:

```
echo "75" > /sys/kernel/broker/extend-shutdown-delay
```

With this command the shutdown countdown starts again from 75s.

Note: The maximum total delay is configured in the device-tree or is 300s by default.

31.7 RTC wake-up

The SSF provides a start reason to differentiate between RTC wake-up and ignition signal. To set up an RTC wake-up you can just use the linux command *rtcwake*.

Example: If I want to wake-up my device after 90s from now and in the meantime it shall be powered off, I can call this:

```
rtcwake -s 90 -m off
```

The start reason read from *start-reason* is *wakeup;rtc-alarm*.

31.8 Device is Shutting down

The system is rebooting if during the shutting down process the following events are given:

- re-assertion of the ignition signal
- wake-up event of an RTC alarm
- reboot commanded

31.9 Powering the Device Off

The system is powering off on the following events:

- poweroff commanded
- RTC alarm set up with mode to power off
- de-assertion of the ignition signal

31.10 Ping Request/Response

The kernel modules of the SSF can be tested by writing a string to *ping-request* and reading the response from *ping-request*. Any request is taken by the SSF broker and forwarded to the SSF sysstate which finally writes the response on the sysfs.

31.11 Watchdog Feature

The provided SSF manager includes a watchdog feature which is linked to the ping request/response mechanism checking that the kernel modules are working as expected. Thus it is using the watchdog feed interval to compare the ping response with the corresponsing request before feeding the watchdog. If the ping response and request are mismatching, the watchdog is not fed and will starve. This leads to a watchdog reset of the device. In this case the start-reason will be shown as watchdog.

31.12 SSF Manager

The SSF manager provides currently two features:

1. marking the system state of the SSF
2. hanlding the system watchdog by using the SSF Ping mechanism

See the following help for further details:

```
root@am335x:~# ssf-mgr -h
Usage: ssf-mgr [args]

    -h | --help                             Show this help
    -d | --daemonize                        Run as daemon
    -p | --pidfile=path                     The PID file, see -d
    -m | --mark-sys-state                   Mark the system state for the SSF
    -w | --with-watchdog                    Enable watchdog and supervise SSF modules
    -t | --wd-timeout=TIMEOUT_MS            Configure watchdog timeout to TIMEOUT_MS
                                              default=8000ms
    -i | --wd-feed-interval=INTERVAL_MS     Set watchdog feed interval to INTERVAL_MS
                                              default=4000ms

Used loggers: - evtloop
              - initSys
              - systemState
              - watchdogMgr
              - brokerPinger

SysLogger    OPTIONS:
             --loglevel=n          Set the max application log level (used for all␣
↪logger
                                   instances as default) to n (0=emcy, 7=dbg). If␣
↪comma separated
                                   list of separate logger instances is provided␣
↪after this
                                   number, the log level for each such instance will␣
↪be overruled
                                   accordingly (e.g. --loglevel=7,evtloop.5,fileOp.6).
             --disable-syslog      disable the log output to syslog
             --enable-stdout       enable output on stdout (e.g. for debugging␣
↪purposes)

SysLogger Examples:
             prog-name --disable-syslog
             prog-name --disable-syslog --enable-stdout
             prog-name --loglevel=6,config.5,serial.7
```

In our OEM Linux Release the *ssf-mgr.service* is starting with the default config where marking of the system state is activated and the watchdog feature is enabled:

```
root@am335x:~# cat /etc/default/ssf-mgr.conf
# Default settings for system-state-framework manager
#  for details run ssf-mgr --help

MARK_SYS_STATE="-m"
WATCHDOG_CONFIG="-w"
LOGGER_CONFIG="--loglevel=6,evtloop.5,systemState.6,initSys.6,brokerPinger.6,
↪watchdogMgr.6"
```

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```
root@am335x:~# cat /usr/lib/systemd/system/ssf-mgr.service
[Unit]
Description=SystemStateFramework Manager daemon

[Service]
Type=forking
EnvironmentFile=-/etc/default/ssf-mgr.conf
ExecStart=/usr/bin/ssf-mgr $MARK_SYS_STATE $WATCHDOG_CONFIG -d -p /run/ssf-mgr.pid
↪$LOGGER_CONFIG

[Install]
WantedBy=multi-user.target
```

31.12.1 Starting Options

Disable System State Marking and Watchdog Feature

Starting the SSF manager without watchdog and without marking the system state, needs to remove the options *-w* and *-m*:

```
root@am335x:~# cat /etc/default/ssf-mgr.conf
# Default settings for system-state-framework manager
#  for details run ssf-mgr --help

MARK_SYS_STATE=""
WATCHDOG_CONFIG=""
LOGGER_CONFIG="--loglevel=6,evtloop.5,systemState.6,initSys.6,brokerPinger.6,
↪watchdogMgr.6"
```

Disable System State Marking

Starting the SSF manager by handling only the watchdog part can be fulfilled by removing the *-m* option:

```
root@am335x:~# cat /etc/default/ssf-mgr.conf
# Default settings for system-state-framework manager
#  for details run ssf-mgr --help

MARK_SYS_STATE=""
WATCHDOG_CONFIG="-w"
LOGGER_CONFIG="--loglevel=6,evtloop.5,systemState.6,initSys.6,brokerPinger.6,
↪watchdogMgr.6"
```

31.12.2 Timeout Settings

The watchdog feed interval and the watchdog timeout are related, i.e. the watchdog timeout must be higher than the check interval. Those times can be changed by the following command line options:

- *-t* watchdog timeout in [ms]
  - default = 8000ms

- *-i* watchdog feed interval in [ms]
  - default = 4000ms

Example setting the timeout to 30s and the interval to 15s:

```
root@am335x:~# cat /etc/default/ssf-mgr.conf
# Default settings for system-state-framework manager
#  for details run ssf-mgr --help

MARK_SYS_STATE="-m"
WATCHDOG_CONFIG="-w -t 30000 -i 15000"
LOGGER_CONFIG="--loglevel=6,evtloop.5,systemState.6,initSys.6,brokerPinger.6,
↪watchdogMgr.6"
```

Note: The timeout may vary due to the PMIC setting which is a multiple of a specific base time, see the datasheet of the PMIC for more details.

31.13 Source for the System State Marking

The init system is systemd and the states of a finished start-up, rebooting or powering off can be collected from dbus messages. Find the dbus registration parameter in the following list.

- State of finished start-up:

```
dbus registartion parameters:
 - sender/service = "org.freedesktop.systemd1";
 - object path    = "/org/freedesktop/systemd1";
 - interface      = "org.freedesktop.systemd1.Manager";
 - signal         = "StartupFinished"
 - item           = "up"     // this is not necessary as StartupFinished␣
↪does not have any other items, it is just for the internal list
```

- The same mechanism for the poweroff and reboot is used where only a different singal and different items are used:

```
- signal       = "UnitNew"   // same signal for poweroff and reboot
- itemPoweroff = "poweroff.target"
- itemReboot   = "reboot.target"
```

31.14 System Watchdog Usage

The system watchdog work with the following principle:

```
/* The watchdog will be activated when opening the the watchdog device file */
fd = open(dev, O_RDWR);
if (-1 == fd)
{
    fprintf(stderr, "Error: %s\n", strerror(errno));
    exit(EXIT_FAILURE);
}
```

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```
/* Setting the watchdog interval */
fprintf(stdout, "Set watchdog interval to %d\n", interval);
if (ioctl(fd, WDIOC_SETTIMEOUT, &interval) != 0)
{
    fprintf(stderr, "Error: Set watchdog interval failed\n");
    exit(EXIT_FAILURE);
}

/* Getting the current watchdog interval - which might be advisable when the
*  watchdog timeout bases on a factor of a base time such as the PMIC
*  watchdog does.
*/
if (ioctl(fd, WDIOC_GETTIMEOUT, &interval) == 0)
{
    fprintf(stdout, "Current watchdog interval is %d\n", interval);
}
else
{
    fprintf(stderr, "Error: Cannot read watchdog interval\n");
    exit(EXIT_FAILURE);
}


/* Interval loop feeding the watchdog
*    There are two ways to kick the watchdog:
*    - by writing any dummy value into watchdog device file, or
*    - by using IOCTL WDIOC_KEEPALIVE
*/
do
{
    /* the device file way: */
    write(fd, "w", 1);
    fprintf(stdout, "Feed watchdog through writing over device file\n");

    /* OR the ioctl way: */
    ioctl(fd, WDIOC_KEEPALIVE, NULL);
    fprintf(stdout, "Kick watchdog through IOCTL\n");
} while (isLoopRunning);


/* The 'V' value needs to be written into watchdog device file to
*  indicate that we intend to close/stop the watchdog
*/
write(fd, "V", 1);
/* Closing the watchdog device deactivates the watchdog */
close(fd);
```

CHAPTER 32

System Clock / Date Time

There might be several time giving sources like GNSS, NTP, etc that can be used to synchronize the system clock and other clock dependent parts.

32.1 Synchronization

Chrony is able to perform such clock synchronizations. For further information please have a look at *Chrony*. Chrony is also able to synchronize the HW clock (RTC) automatically if it drifts away.

Another tool to synchronize/handle/update the HW clock (RTC) is `timedatectl` which competes against chrony. **This means be cautious when synchronizing/updating the HW clock manually**

32.2 HW Clock Synchronization/Update

As described in section above the RTC can be updated using different tools. The following sections show how this can be performed.

32.2.1 timedatectl

NOTE: Using `timedatectl` you are able to update the HW clock manually.

If no time source is present no update takes place automatically. Then a manual update is possible with:

```
timedatectl set-local-rtc n
```

Please read also the timedatectl man page when using `timedatectl`.

CHAPTER 33

Data Volume Monitor

33.1 Introduction

We introduced a data volume monitor called *vnstat* in our develop image, see https://humdi.net/vnstat/ for more information about *vnstat*.

33.2 Configuration

vnstat can be configured with the config file */etc/vnstat.conf*

Our configuration sets *wwan0* as default interface and runs the used database on a ramdisk (volatile). The responsible configuration values are the follows:

```
DatabaseDir "/run/vnstat"
Interface "wwan0"
```

The database is on path */run/vnstat/vnstat.db*.

Note: This volatile configuration gets lost at each reboot. If you want to persist the database then follow the guide in the next section.

The default configuration synchronizes the database every 5 minutes, so be aware that there is a latency in the displayed numbers.

33.3 Persisting Data base

The following lines show you about how you can persist the data volume over reboots:

1. Stop the service: *systemctl stop vnstat*

2. Adapt the configuration:
   - in */etc/vnstat.conf* set the following setting: *DatabaseDir "/var/lib/vnstat"*
3. Start the service: *systemctl start vnstat*

The service runs then on the database residing on the emmc. It will create a new database if no one is existing or continuing with the database residing in */var/lib/vnstat*.

33.4 How To use

The help of vnstat is somehow self explaining and shows you how to use it:

```
vnstat --help

vnStat 2.6 by Teemu Toivola <tst at iki dot fi>

  -5,  --fiveminutes [limit]   show 5 minutes
  -h,  --hours [limit]         show hours
  -hg, --hoursgraph            show hours graph
  -d,  --days [limit]          show days
  -m,  --months [limit]        show months
  -y,  --years [limit]         show years
  -t,  --top [limit]           show top days

  -b, --begin <date>           set list begin date
  -e, --end <date>             set list end date

  --oneline [mode]             show simple parsable format
  --json [mode] [limit]        show database in json format
  --xml [mode] [limit]         show database in xml format

  -tr, --traffic [time]        calculate traffic
  -l,  --live [mode]           show transfer rate in real time
  -i,  --iface <interface>     select interface (default: wwan0)

Use "--longhelp" or "man vnstat" for complete list of options.
```

Example: show only the wwan0 data volume:

```
vnstat -i wwan0

Database updated: 2021-03-24 10:55:01

wwan0 since 2021-03-24

      rx:  84.78 KiB      tx:  84.83 KiB      total:  169.62 KiB

monthly
                  rx      |     tx      |    total    |   avg. rate
 ------------------------+-------------+-------------+---------------
   2021-03     84.78 KiB |   84.83 KiB |  169.62 KiB |        0 bit/s
 ------------------------+-------------+-------------+---------------
 estimated       --      |     --      |     --      |

daily
                  rx      |     tx      |    total    |   avg. rate
```

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```
------------------------+-------------+-------------+---------------
    today     84.78 KiB |   84.83 KiB |  169.62 KiB |       35 bit/s
------------------------+-------------+-------------+---------------
estimated       186 KiB |     186 KiB |     371 KiB |
```

CHAPTER 34

Wi-Fi

34.1 Overview

- Used WIFI (and BT) Chip: WL1837MOD
- linux-firmware repository: `git://git.kernel.org/pub/scm/linux/kernel/git/firmware/linux-firmware.git`
- Commit id: 4c0bf113a55975d702673e57c5542f150807ad66
- Which is basically: wl18xx: update firmware file 8.9.0.0.76
- NetworkManager (nmcli) connection configuration files are stored under `/etc/NetworkManager/system-connections`

34.1.1 802-11 Standard

- a: 5 GHz-Band, up to 54 Mbits/s
- b: 2.4 GHz-Band, up to 11 Mbits/s
- g: 2.4 GHz-Band, up to 54 Mbits/s
- n: 2.4 & 5 GHz-Band, up to 600 Mbits/s
- ac: 5 GHz-Band, up to 1.3 Gbits/s

34.2 Client Mode

Scan and connect to existing access point (AP)

```
$ nmcli d wifi list
$ nmcli d wifi connect <MYWLAN> password <my_password>
```

34.3 Access Point Mode

Note: Set region code to get right channels!

34.3.1 Create Access Point in 2.4 GHz Band

Create hotspot with SSID Hostspot24, no encryption

```
$ nmcli con add type wifi ifname wlan0 con-name Hostspot24 autoconnect yes ssid␣
↪Hostspot24
$ nmcli con modify Hostspot24 802-11-wireless.mode ap 802-11-wireless.band bg ipv4.
↪method shared
$ nmcli con up Hostspot24
```

Create hotspot with SSID SecSpot, wpa-psk encryption with password: 12345678

Note: for wpa-psk encryption password has to be 8 characters or more.

```
$ nmcli con add type wifi ifname wlan0 con-name SecSpot autoconnect yes ssid SecSpot
$ nmcli con modify SecSpot 802-11-wireless.mode ap 802-11-wireless.band bg ipv4.
↪method shared
$ nmcli con modify SecSpot wifi-sec.key-mgmt wpa-psk
$ nmcli con modify SecSpot wifi-sec.psk "12345678"
$ nmcli con up SecSpot
```

34.3.2 Create Access Point in 5 GHz Band

Create hotspot with SSID Hostspot50, no encryption

```
$ nmcli con add type wifi ifname wlan0 con-name Hostspot50 autoconnect yes ssid␣
↪Hostspot50
$ nmcli con modify Hostspot50 802-11-wireless.mode ap 802-11-wireless.band a ipv4.
↪method shared
$ nmcli con up Hostspot50
```

Create hotspot with SSID SecSpot5, wpa-psk encryption with password: 12345678

Note: for wpa-psk encryption password has to be 8 characters or more.

```
$ nmcli con add type wifi ifname wlan0 con-name SecSpot5 autoconnect yes ssid SecSpot5
$ nmcli con modify SecSpot5 802-11-wireless.mode ap 802-11-wireless.band a ipv4.
↪method shared
$ nmcli con modify SecSpot5 wifi-sec.key-mgmt wpa-psk
$ nmcli con modify SecSpot5 wifi-sec.psk "12345678"
$ nmcli con up SecSpot5
```

CHAPTER 35

WWAN

35.1 Overview

- WWAN modules : TOBY - L210
- Modem Firmware : 17.00,A01.00 (Caution: older versions may not work stable or miss features!)
- NetworkManager (nmcli) connection configuration files are stored under `/etc/NetworkManager/system-connections`

35.2 Preparation

1. Insert SIM Card in sim slot

35.3 Usage

All the configuration can be done by NetworkManager but sometimes it can be useful to check lower level configurations with ModemManager.

35.3.1 Firmware update

Warning: Downgrading a WWAN modem will likely lead to a broken modem

On some devices, the modem is delivered with the firwmare 15.63 or 16.19,A01.02. It is highly recommended to upgrade the firmware to most recent version 17.00,A01.00.

How to check firmare version and upgrade is explain at *Updating firmware*.

35.3.2 Initial configuration

The WWAN modem is configured at each boot by a script named wwan-config. This script is using the configuration file */etc/wwan/wwan0.conf* to setup the modem before letting ModemManager handle it.

This configuration file is divided in three sections:

- apn: must configured to use a private APN
- sim: is used to choose between the different sim cards available on the device
- ublox: low level configurations for ublox modem. This should normaly not be modified

APN configuration

When using a private APN, this section has to be configured with the following fields:

```
[apn]
apn=<APN>
user=<USER>
password=<PASSWORD>
```

When the default APN provided by the network when using LTE must be used, make sure that this fields are not set.

After any change to this file, the system has to reooted or the following command to be run:

```
$ systemctl restart wwan-config@wwan0
```

SIM card configuration

This section is used to choose which SIM card to use with the modem. There are four SIM cards slot that can be used by the modem.

```
[sim]
SIM=<value>
```

Where <value> can be :

- auto: The script will detect if a physical SIM card is present and switch to m2m SIM card (soldered to the board) if it is not the case
- sim1: Use the physical SIM card on the main board
- m2m: Use the m2m SIM card soldered on the main board
- ui-top: Use the SIM card that is on top of the User Interface
- ui-btm: Use the SIM card that is on the bottom of the User Interface

After any change to this file, the system has to be rebooted or the following command to be run:

```
$ systemctl restart wwan-config@wwan0
```

35.3.3 NetworkManager commands

```
$ # Create connection
$ nmcli c add type gsm con-name wwan ifname "" ipv6.method ignore gsm.apn <APN>

$ # Create connection with APN authentication
$ nmcli c add type gsm con-name wwan ifname "" ipv6.method ignore \
  gsm.apn <APN> gsm.username <USER> gsm.password <PASSWORD>

$ # Set PIN number
$ nmcli c modify wwan gsm.pin <pin number>

$ # Start the connection
$ nmcli c up wwan
```

35.3.4 ModemManager configuration

```
$ mmcli -L  # list modems and get modem id
$ mmcli -M  # list modems in a loop, useful when waiting after a reset
$ mmcli -m 0 # See state of the modem 0
$ mmcli -i 0 --pin=<pin number>  # Entering pin on modem 0
$ mmcli -m 0 -r # Reset the modem
```

35.3.5 Low level configuration

1. Launch ModemManager in debug mode

```
$ systemctl stop ModemManager
$ ModemManager --debug > /dev/null 2> /dev/null &
```

2. Execute the commands

```
$ mmcli -m 0 --command "AT+UBMCONF=2"  # Set modem to bridge mode
$ mmcli -m 0 --command 'AT+UUSBCONF=2,"ECM",0'  # Set USB mode to ECM
$ mmcli -m 0 --command 'AT+UUSBCONF=3'  # Set USB mode to RNDIS
```

3. Restart ModemManager normaly

```
$ killall ModemManager
$ systemctl start ModemManager
```

35.3.6 ModemManager extensions

The ModemManager version used in NetModule linux is the version 1.14.8. with some NetModule specific extensions.

It is maintained and up to date with latest bug and security fixes.

NetModule did the following changes to the community version :

1. Support configuration of default EPS bearer for u-blox modems

In 4G (LTE), the handling of the APN configuration is different than in 2G and 3G and specific to each vendor. U-blox modems is not supported in the community version.

2. Handling of reconnect requests

Events like reconnection and disconnection on the radio side trigger AT messages that are not handled by ModemManager. The NetModule version handles this messages, leading to a faster reconnection.

3. Change AT commands timeout to 3 minutes

The u-blox modems can take up to 3 minutes before answering and AT command. The default timeout varies between 3 and 60 seconds depending on the commands. This difference made MM send more commands while the modem was still processing the first one, leading to a lock of the modem.

4. Show more precise signal quality in output of mmcli -m

By default MM is showing a pretty coarse value for signal quality when showing modem status with *mmcli -m 0* (20% steps). With this change MM is showing a more precise value, more representative of what is retrieved with *mmcli -m 0 –signal-get*.

CHAPTER 36

Booting with custom Linux kernel or ramdisk

If it's necessary, it is possible to boot custom a Linux kernel with existing OSTree controlled file system.

36.1 Provisioning over tftp

1. Load the ostree necessary variables.

```
run bootcmd_otenv
```

2. Load your own kernel.

```
tftp $kernel_addr_r fitImage
```

xor load the installed kernel:

```
ext4load mmc 1:1 $kernel_addr_r /boot$kernel_image
```

3. Load your own ramdisk.

```
tftp $ramdisk_addr_r ramdisk
```

xor load the installed ramdisk:

```
`ext4load mmc 1:1 \$ramdisk_addr_r /boot\$ramdisk_image;
```

4. Boot the system.

```
bootm $kernel_addr_r $ramdisk_addr_r
```

36.2 Provisioning over USB

1. Initialize USB

```
usb reset
```

2. Load the ostree necessary variables.

```
run bootcmd_otenv
```

3. Load your own kernel.

```
fatload usb 0:1 $kernel_addr_r fitImage
```

xor load the installed kernel:

```
ext4load mmc 1:1 $kernel_addr_r /boot$kernel_image
```

4. Load your own ramdisk.

```
fatload usb 0:1 $ramdisk_addr_r ramdisk
```

xor load the installed ramdisk:

```
ext4load mmc 1:1 $ramdisk_addr_r /boot$ramdisk_image;
```

5. Boot the system.

```
bootm $kernel_addr_r $ramdisk_addr_r
```

CHAPTER 37

Create a fitImage

To create a fitImage you need a .its file. Luckily YoctoProject creates this file for us. You find in the deployed image folder (e.g. `hancock-os/shared-build/tmp/deploy/images/am335x-nmhw21/fitImage-its-am335x-nmhw21.its`).

In this file, you will find this line in the kernel section:

```
data = /incbin/("linux.bin");
```

This tells us what the filename of your legacy kernel (zImage, uImage, Image) needs to be called.

You will also find this line in the dtb section:

```
data = /incbin/("arch/arm/boot/dts/am335x-nmhw21-prod1.dtb");
```

This tells us where the the dtb is expected.

37.1 Steps (nmhw21)

1. Create a folder structure that looks like this:

```
|-- fitImage-its-am335x-nmhw21.its
|
|-- linux.bin ( --> your kernel image)
|
|-- arch/arm/boot/dts/am335x-nmhw21-prod1.dtb
```

2. To create the fitimage now run in your folder:

```
mkimage -f fitImage-its-am335x-nmhw21.its fitImage
```

CHAPTER 38

Indices and tables

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