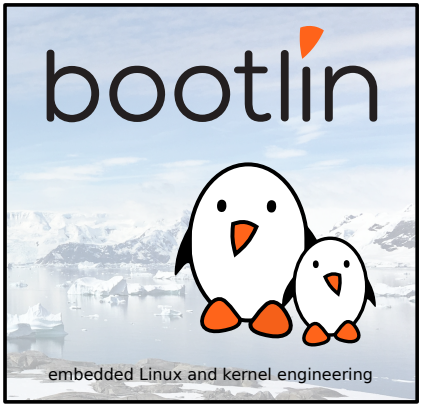
Getting started with RAUC

Kamel Bouhara
kamel.bouhara@bootlin.com



Kamel Bouhara

- Embedded Linux engineer at Bootlin
  - Embedded Linux **expertise**
  - Bootloader, Linux kernel, Yocto Project, Buildroot
  - Complete Linux BSP development
  - Strong open-source focus: upstreaming and contributions
- Significant experience in board bring up with NXP SoCs
- Small contributions to Yocto Project, Buildroot and Linux
- Living in **Lyon**, France

About this talk

- Brief introduction to RAUC
- Explore RAUC integration with Yocto/Buildroot, U-Boot/Barebox
- Share some insights and field experience
- Give some important keys to be ready to start with RAUC

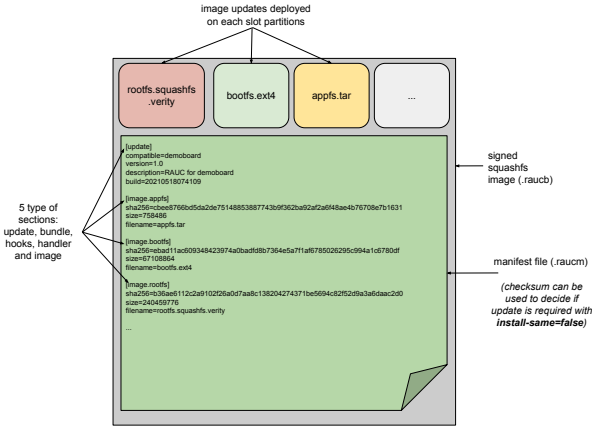
What is RAUC ?

- RAUC is an update system mechanism
- Developed by Pengutronix (Barebox, PTXDist)
- Licensed under LGPL-2.1
- https://rauc.io/

Non exhaustive list of RAUC features

- Fail-safe and atomic
  - Using symmetric or asymmetric update (redundant A/B scheme, rescue system)
  - Update result is either valid or invalid (interrupt, corrupted bundle, device not compatible)
- Security
  - Using OpenSSL x.509 certificates
  - Using an Hardware Secure Module with PKCS11 keys
- Flexible and customizable update with bundle handlers

What's a RAUC bundle artifact ?



RAUC and Build systems

Yocto integration

- *meta-rauc* layer
  - Mainly provide a generic *class* for bundle generation
  - A fragment file `rauc.cfg` for the kernel squashfs support
  - A basic example of bundle recipe `core-bundle-minimal.bb`
  - The rauc package provide support for both sysVinit and systemd
  - A script to generate development certificate with openssl
  - Some useful packages: dt-utils, casync, rauc-hawkbit ...
  - https://github.com/rauc/meta-rauc

Yocto integration

- Add the `meta-rauc` layer to your `bblayers.conf`:

```
$ git clone https://github.com/rauc/meta-rauc.git
$ bitbake-layers add-layer meta-rauc
```

- Create a recipe `rauc\_\%.bbappend` to install your own rauc configuration:

```
FILESEXTRAPATHS_prepend := "\${THISDIR}/files:"
SRC_URI_append := " file://system.conf"
```

Yocto integration

- Setup a minimal rauc configuration through packageconfig:

```
PACKAGECONFIG_remove_pn-rauc = "service"
PACKAGECONFIG_remove_pn-rauc = "network"
PACKAGECONFIG_remove_pn-rauc = "gpt"
```

- See *rauc.inc* for the exhaustive list of packageconfig

A bundle recipe

- Create your bundle recipe `demoboard-bundle.bb`

```
inherit bundle

RAUC_BUNDLE_COMPATIBLE ?= "Demo Board"
RAUC_BUNDLE_SLOTS ?= "rootfs"
RAUC_SLOT_rootfs ?= "core-image-minimal"
RAUC_IMAGE_FSTYPE = "ubifs"

RAUC_KEY_FILE = "\${YOCTOROOT}/meta-demoboard/keys/dev.key.pem"
RAUC_CERT_FILE = "\${YOCTOROOT}/meta-demoboard/keys/dev.cert.pem"
```

RAUC_BUNDLE_COMPATIBLE the target compatible

RAUC_BUNDLE_SLOTS list of partitions to update

RAUC_IMAGE_FSTYPE root filesystem (ubifs, squashfs, ext4, vfat, raw)

Building and Using

- Add the `rauc` package to your image

```
IMAGE_INSTALL_append = "rauc"
```

- Generate your bundle image

```
$ bitbake demoboard-bundle
```

- On the target, install the generated **.raucb* using `rauc install` command
- Run `rauc status mark-good` to validate the boot on the new slot (shall be done by an initscript or systemd service)

Using RAUC with Buildroot

- Select `BR2_PACKAGE_RAUC=y`
- Options enabled as dependencies:

```
select BR2_PACKAGE_SQUASHFS # run-time dependency
select BR2_PACKAGE_UBOOT_TOOLS if BR2_TARGET_UBOOT
select BR2_PACKAGE_UBOOT_TOOLS_FWPRINTENV if BR2_TARGET_UBOOT
```

- To deploy rauc files on target use `BR2_ROOTFS_OVERLAY`

```
board/.../demoboard/rootfs-overlay/
   etc
       rauc
           dev.cert.pem
           dev.key.pem
           system.conf
```

Using RAUC with Buildroot

- Generate the bundle with a post image script using `BR2_ROOTFS_POST_IMAGE_SCRIPT`

```
#!/bin/bash
...
cat >> ${BINARIES_DIR}/temp-dir/manifest.raucm << EOF
[update]
compatible=demo-board
version=${VERSION}
[image.rootfs]
filename=rootfs.ext4
EOF

${HOST_DIR}/bin/rauc --cert ${BOARD_DIR}/dev.cert.pem \
                     --key ${BOARD_DIR}/dev.key.pem \
                     bundle ${BINARIES_DIR}/temp-dir/ \
                     ${BINARIES_DIR}/bundle.raucb
```

RAUC and Bootloaders

Barebox and RAUC: Pre-requisites

Hardware pre-requisite:

- A non-volatile memory with ~200 KBytes of dedicate space (not updated with Barebox)

Software pre-requisite:

- Install **dt-utils** on your filesystem from: https://git.pengutronix.de/cgit/tools/dt-utils
- If using EEPROM backend make sure you have the following kernel patch (nvem core) : https://lkml.org/lkml/2020/4/6/445

Barebox and RAUC: In brief

- Enable bootchooser and barebox state support:

```
CONFIG_STATE_DRV=y
CONFIG_STATE=y
CONFIG_BOOTCHOOSER=y
CONFIG_CMD_STATE=y
CONFIG_CMD_BOOTCHOOSER=y
```

- The **Bootchooser** is the algorithm implemented in Barebox to provide a mean to work with abstract boot targets.
- The **State** allows storing the set of variables required by RAUC

Updating with Barebox

Example of A/B update scenario setup:

```
$ tree arch/arm/boards/demoboard/env/nv/ |grep boot
   bootchooser.disable_on_zero_attempts
   bootchooser.reset_attempts
   bootchooser.reset_priorities
   bootchooser.retry
   bootchooser.state_prefix
   bootchooser.system0.boot
   bootchooser.system0.default_attempts
   bootchooser.system0.default_priority
   bootchooser.system1.boot
   bootchooser.system1.default_attempts
   bootchooser.system1.default_priority
   bootchooser.targets
   boot.default
...
```

- Double check barebox dts and *state.prefix* above !

U-Boot and RAUC: Pre-requisites

Hardware pre-requisites:

- A non-volatile memory with ~200 KBytes of dedicate space (not updated with u-boot)

Software pre-requisites:

- Install U-boot *fw-utils* on your filesystem, define u-boot environment offset in */etc/fw_env.config*
- Use `CONFIG_ENV_IS_IN_*` and/or `CONFIG_SYS_REDUNDAND_ENVIRONMENT=y` when updating u-boot

Updating with U-Boot

- Example of boot script:
  https://github.com/rauc/rauc/blob/master/contrib/uboot.sh
- Mainly based on three variables:
  BOOT_ORDER Which slot to boot first
  BOOT_*_LEFT Counters for boot attempts on A/B slots
- On target, load and run the boot script:

```
setenv loadscript "fatload mmc ${mmcdev}:${mmcpart} ${loadaddr} ${script};"
run loadscript;
source ${loadaddr}:${script};
```

Basic update scenarios

Update with a rescue system or asymmetric update

```
[system]
compatible=demo-board
bootloader=barebox

[keyring]
path=/etc/rauc/dev.cert.pem

[slot.rescue.0]
device=/dev/ubi0_0
type=raw
bootname=system0
readonly=true

[slot.rootfs.1]
device=/dev/ubi0_2
type=ubifs
bootname=system1
```

- Good solution for devices with minimal storage resource
- No fallback possible, require to define a backup plan when update failed
- Several reboots required to achieve the update

Example of rauc usage from initramfs

```
#!/bin/sh

PATH=/sbin:/bin:/usr/sbin:/usr/bin
USB=/mnt

# Sync clock on RTC
hwclock -s
# Attach ubi rootfs volume
ubiattach /dev/ubi_ctrl -m 2

...

# Install the new system image
rauc install "\${USB}/demoboard-bundle-demo-board.raucb"

# Change the active boot slot and reboot on the main system
rauc status mark-active rootfs.1

reboot -f

exit 0
```

- Make sure the system clock is correctly setup (use RTC/*hwclock -s* or NTP)

```
LastError: signature verification failed: Verify error:self signed
 certificate
 Installing `/media/demoboard-bundle-demo-board.raucb` failed
```

Redundant A/B system update

```
...
[slot.rootfs.0]
device=/dev/mmcblk1p1
type=ext4
bootname=A

[slot.rootfs.1]
device=/dev/mmcblk1p2
type=ext4
bootname=B

[slot.bootfs.0]
device=/dev/mmcblk1p3
type=ext4
parent=rootfs.0

[slot.bootfs.1]
device=/dev/mmcblk1p4
type=ext4
parent=rootfs.1
```

- Good solution for devices with large size storage
- Use the *parent* entry to bind all slots together in a single bundle update
- Depending on the application it can be a complex scenario, use post-install script handlers wisely

Conclusion

What you need to know

- Both Yocto or Buildroot fully support RAUC
- Well integrated in Barebox (developed by the same Pengutronix folks)
- With Barebox you don't need to directly deal with environment variables
- U-Boot is good enough for a simple redundant A/B scenario
- More complex scenario need modification in rauc *bootchooser* code (`uboot_get_state`/`uboot_set_state`)
- Make sure your device is well sized for your update strategy and application requirements
- New RAUC version 1.5 supporting the verity format for verified boot

Questions? Suggestions? Comments?

Kamel Bouhara
kamel.bouhara@bootlin.com

https://bootlin.com/pub/conferences/2021/lee/bouhara-rauc