Software Updates with RAUC, the Yocto Project and OpenEmbedded

Leon Anavi
Konsulko Group
leon.anavi@konsulko.com
leon@anavi.org
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Konsulko Group

- Services company specializing in Embedded Linux and Open Source Software
- Hardware/software build, design, development, and training services
- Based in San Jose, CA with an engineering presence worldwide
- http://konsulko.com/

Agenda

- Introduction to software updates and RAUC
- RAUC practical example with Raspberry Pi 4
- Eclipse hawkBit
- Conclusions
- Q&A

Common Embedded Linux Update Strategies

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- A/B updates (dual redundant scheme)
- Delta updates
- Container-based updates
- Combined strategies

Combined Strategies

- Container technology has changed the way application developers interact with the cloud and some of the good practices are nowadays applied to the development workflow for embedded devices and IoT
- Containers make applications faster to deploy, easier to update and more secure through isolation
- Yocto/OE layer meta-virtualization provides support for building Xen, KVM, Libvirt, docker and associated packages necessary for constructing OE-based virtualized solutions
- There are use cases on powerful embedded devices where contains are combined with A/B updates of the base Linux distribution built with Yocto/OE

Are there any RAUC open source alternatives?

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- Mender
- SWUpdate
- Swupd
- UpdateHub
- Balena
- Snap
- OSTree
- Aktualizr
- Aktualizr-lite
- QtOTA
- Torizon
- FullMetalUpdate
- Rpm-ostree (used in Project Atomic)

RAUC

- A lightweight update client that runs on an Embedded Linux device and reliably controls the procedure of updating the device with a new firmware revision
- Provides tool for the build system to create, inspect and modify update bundles
- Uses X.509 cryptography to sign update bundles
- Compatible with the Yocto Project and OpenEmbedded, PTXdist and Buildroot
- Created by Pengutronix in 2015

RAUC Licenses

- RAUC – LGPLv2.1
  https://github.com/rauc/rauc
- meta-rauc - MIT
  https://github.com/rauc/meta-rauc
- rauc-hawkbit – LGPLv2.1
  https://github.com/rauc/rauc-hawkbit
- rauc-hawkbit-updater – LGPLv2.1
  https://github.com/rauc/rauc-hawkbit-updater

meta-rauc

- Yocto/OpenEmbedded meta layer for RAUC
- Supports releases Gatesgarth, Dunfell, Zeus, Warrior, Thud, Sumo, Morty, Pyro and Krogoth
- Available under MIT license in GitHub: https://github.com/rauc/meta-rauc
- 22 contributors, the RAUC co-maintainer Enrico Jörns from Pengutronix is the leading contributor

RAUC Integration Steps

- Select an appropriate bootloader
- Enable **SquashFS** in the Linux kernel configurations
- **ext4** root file system (RAUC does not have an ext2 / ext3 file type)
- Create specific partitions that matches the RAUC slots
- Configure Bootloader environment and create a script to switch RAUC slots
- Create a certificate and a keyring to RAUC’s system.conf

RAUC Example with Raspberry Pi 4

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RAUC Example with Raspberry Pi 4

- Download Poky, meta-openembedded and meta-raspberrypi:

```
git clone -b dunfell git://git.yoctoproject.org/poky poky-rpi-rauc
cd poky-rpi-rauc
git clone -b dunfell git://git.openembedded.org/meta-openembedded
git clone -b dunfell git://git.yoctoproject.org/meta-raspberrypi
```

- Download RAUC related layers:

```
git clone -b dunfell https://github.com/rauc/meta-rauc.git
git clone -b dunfell https://github.com/leon-anavi/meta-rauc-community.git
```

- Initialize the build environment:

```
source oe-init-build-env
```

RAUC Example with Raspberry Pi 4

- Add layers:

```
bitbake-layers add-layer ../meta-openembedded/meta-oe/
bitbake-layers add-layer ../meta-openembedded/meta-python/
bitbake-layers add-layer ../meta-openembedded/meta-networking/
bitbake-layers add-layer ../meta-openembedded/meta-multimedia/
bitbake-layers add-layer ../meta-raspberrypi/
bitbake-layers add-layer ../meta-rauc
bitbake-layers add-layer ../meta-rauc-community/meta-rauc-raspberrypi/
```

RAUC Example with Raspberry Pi 4

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- Add to local.conf:

```
MACHINE = "raspberrypi4"
DISTRO_FEATURES_append = " systemd"
VIRTUAL-RUNTIME_init_manager = "systemd"
DISTRO_FEATURES_BACKFILL_CONSIDERED = "sysvinit"
VIRTUAL-RUNTIME_initscripts = ""
IMAGE_INSTALL_append = " rauc"
IMAGE_FSTYPES="tar.bz2 ext4 wic.bz2 wic.bmap"
SDIMG_ROOTFS_TYPE="ext4"
ENABLE_UART = "1"
RPI_USE_U_BOOT = "1"
PREFERRED_PROVIDER_virtual/bootloader = "u-boot"
WKS_FILE = "sdimage-dual-raspberrypi.wks"
```

RAUC Example with Raspberry Pi 4

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- Build a minimal bootable image:

```
bitbake core-image-minimal
```

- Flash the image to a microSD card and boot it on Raspberry Pi 4:

```
sudo umount /dev/sdX*
bzcat tmp/deploy/images/raspberrypi4/core-image-minimal-raspberrypi4.wic.bz2 | sudo dd of=/dev/sdX
sync
```

- Attach USB to UART debug cable to Raspberry Pi 4, plug ethernet cable and the microSD card. Turn on Raspberry Pi 4. Verify that the system boots successfully.

RAUC Update Bundle

- Add to conf/local.conf:

```
IMAGE_INSTALL_append = " nano"
```

- Build a RAUC bundle:

```
bitbake update-bundle
```

Manual RAUC Update of Raspberry Pi 4

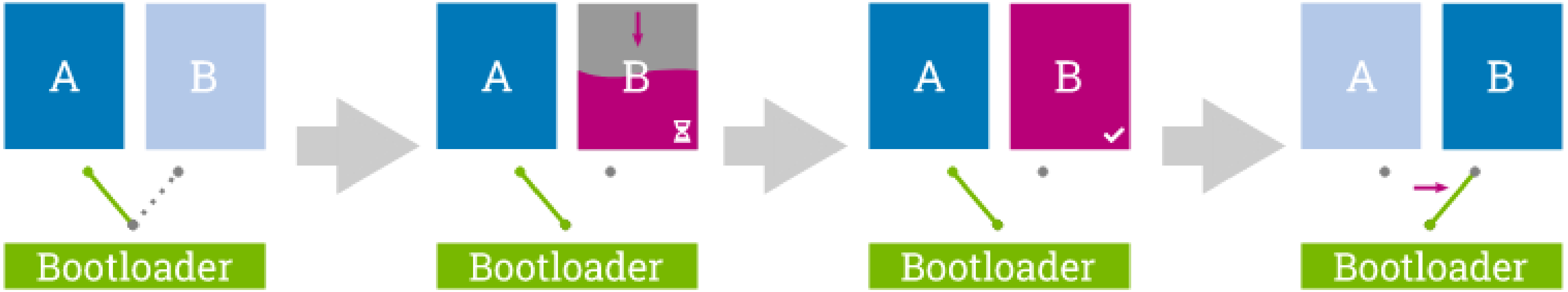
- On the build system:

```
cd tmp/deploy/images/raspberrypi4/
python3 -m http.server
```

- On the embedded device, in this case Raspberry Pi 4:

```
wget http://example.com:8000/update-bundle-raspberrypi4.raucb -P /tmp
rauc install /tmp/update-bundle-raspberrypi4.raucb
reboot
```

Manual RAUC Update of Raspberry Pi 4



Check RAUC Status After Update

leon@leon-ThinkPad-T480s: ~

```
raspberrypi4 login: root
root@raspberrypi4:~# which nano
/usr/bin/nano
root@raspberrypi4:~# rauc status
=== System Info ===
Compatible:  RaspberryPi4
Variant:
Booted from: rootfs.1 (B)

=== Bootloader ===
Activated: rootfs.1 (B)

=== Slot States ===
x [rootfs.1] (/dev/mmcblk0p3, ext4, booted)
        bootname: B
        mounted: /
        boot status: good

o [rootfs.0] (/dev/mmcblk0p2, ext4, inactive)
        bootname: A
        boot status: good


root@raspberrypi4:~#
```

How Does It Work?

U-Boot Environment for RAUC

RAUC relies on the following U-Boot environment variables:

- BOOT_ORDER - a space-separated list of boot targets in the order they should be tried
- BOOT_<bootname>_LEFT - contains the number of remaining boot attempts to perform for the respective slot
- For details:

https://rauc.readthedocs.io/en/latest/integration.html#set-up-u-boot-environment-for-rauc

boot.cmd.in for RAUC & Raspberry Pi

```
fdt addr ${fdt_addr} && fdt get value bootargs /chosen bootargs
test -n "${BOOT_ORDER}" || setenv BOOT_ORDER "A B"
test -n "${BOOT_A_LEFT}" || setenv BOOT_A_LEFT 3
test -n "${BOOT_B_LEFT}" || setenv BOOT_B_LEFT 3
test -n "${BOOT_DEV}" || setenv BOOT_DEV "mmc 0:1"
setenv bootpart
setenv raucslot
for BOOT_SLOT in "${BOOT_ORDER}"; do
  if test "x${bootpart}" != "x"; then
    # skip remaining slots
  elif test "x${BOOT_SLOT}" = "xA"; then
    if test ${BOOT_A_LEFT} -gt 0; then
      setexpr BOOT_A_LEFT ${BOOT_A_LEFT} – 1
      echo "Found valid RAUC slot A"
      setenv bootpart "/dev/mmcblk0p2"
      setenv raucslot "A"
      setenv BOOT_DEV "mmc 0:2"
    fi
  elif test "x${BOOT_SLOT}" = "xB"; then
    if test ${BOOT_B_LEFT} -gt 0; then
      setexpr BOOT_B_LEFT ${BOOT_B_LEFT} – 1
      echo "Found valid RAUC slot B"
      setenv bootpart "/dev/mmcblk0p3"
      setenv raucslot "B"
      setenv BOOT_DEV "mmc 0:3"
    fi
  fi
done
```

```
if test -n "${bootpart}"; then
  setenv bootargs "${bootargs} root=${bootpart} rauc.slot=${raucslot}"
  saveenv
else
  echo "No valid RAUC slot found. Resetting tries to 3"
  setenv BOOT_A_LEFT 3
  setenv BOOT_B_LEFT 3
  saveenv
  reset
fi
fatload mmc 0:1 ${kernel_addr_r} @@KERNEL_IMAGETYPE@@
if test ! -e mmc 0:1 uboot.env; then saveenv; fi;
@@KERNEL_BOOTCMD@@ ${kernel_addr_r} - ${fdt_addr}
```

SquashFS & Loopback Device Support

- To install RAUC bundles the kernel used on the embedded device must support both loop block devices and the SquashFS file system
- For Raspberry Pi in linux-raspberrypi_%.bbappend:

```
do_configure_append() {
	kernel_configure_variable SQUASHFS y
	kernel_configure_variable BLK_DEV_LOOP y
	kernel_configure_variable SQUASHFS_FILE_CACHE y
	kernel_configure_variable SQUASHFS_DECOMP_SINGLE y
	kernel_configure_variable SQUASHFS_ZLIB y
	kernel_configure_variable SQUASHFS_FRAGMENT_CACHE_SIZE 3
}
CMDLINE_remove = "root=/dev/mmcblk0p2"
```

Generate RAUC Certificate

Use script openssl-ca.sh from meta-rauc to to create a certificate and a key:

- The target RAUC package must use the generated keyring file
- RAUC bundle recipe must use the generated key and certificate

- For details:
https://github.com/rauc/meta-rauc/blob/master/scripts/README

RAUC Bundle Generator update-bundle.bb

```
DESCRIPTION = "RAUC bundle generator"

inherit bundle

RAUC_BUNDLE_COMPATIBLE = "RaspberryPi4"
RAUC_BUNDLE_VERSION = "v20200703"
RAUC_BUNDLE_DESCRIPTION = "RAUC Demo Bundle"
RAUC_BUNDLE_SLOTS = "rootfs"
RAUC_SLOT_rootfs = "core-image-minimal"
RAUC_SLOT_rootfs[fstype] = "ext4"

RAUC_KEY_FILE = "${THISDIR}/files/development-1.key.pem"
RAUC_CERT_FILE = "${THISDIR}/files/development-1.cert.pem"
```

One More Thing...

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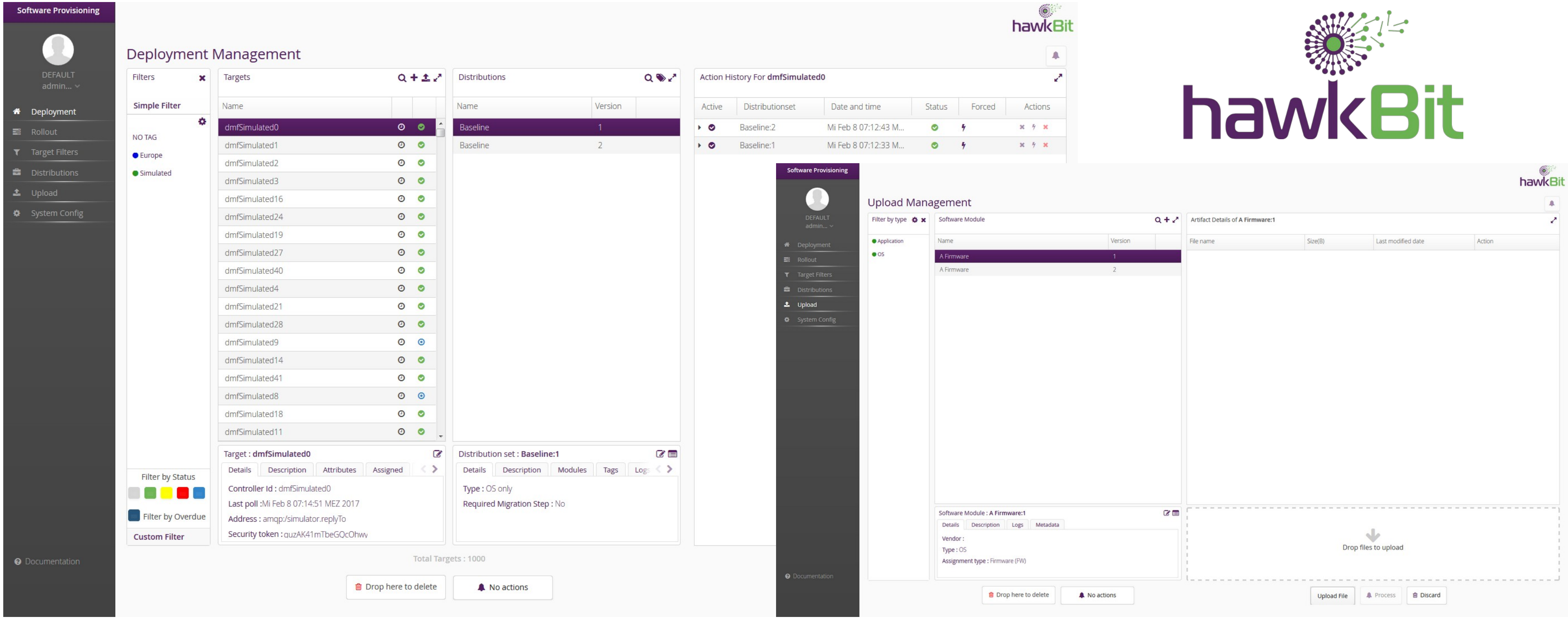
Eclipse hawkBit

- Domain independent back-end framework for rolling out software updates to constrained edge devices as well as more powerful controllers and gateways connected to IP based networking infrastructure
- Written in Java
- Available in GitHub under EPL-1.0 License
- Compatible with **RAUC** and **SWUpdate**
- https://www.eclipse.org/hawkbit/

Eclipse hawkBit



Conclusions

- RAUC is a secure, reliable, free and open source framework for A/B software updates of embedded Linux devices
- meta-rauc is the Yocto/OpenEmbedded layer providing RAUC
- Additional specific integration is required depending on the hardware and the BSP
- Recipe should create the RAUC update bundles
- Eclipse hawkBit is a domain independent back-end framework with web interface for managing update and it is compatible with RAUC

Thank You!

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Useful links

- https://rauc.io/
- Getting Started with RAUC on Raspberry Pi, an article at konsulko.com
  https://www.konsulko.com/getting-started-with-rauc-on-raspberry-pi-2/
- Behind the Scenes of an Update Framework: RAUC, Enrico Jörns, ELCE 2019
  https://www.youtube.com/watch?v=ZkumnNsWczM
- Embedded Recipes 2019 - Remote update adventures with RAUC, Yocto and Barebox
  https://www.youtube.com/watch?v=hS3Fjf7fuHM
- Secure and Safe Updates for Your Embedded Device, Enrico Jörns, FOSDEM 2017
  https://archive.fosdem.org/2017/schedule/event/secure_safe_embedded_updates/