Automotive Grade Linux on Raspberry Pi: How Does It Work?

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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

- Automotive Grade Linux
- Raspberry Pi
- Building an AGL image for Raspberry Pi
- Understanding how AGL works on Raspberry Pi
- Conclusions
- Q&A
Automotive Grade Linux (AGL)

- Project of the Linux Foundation
- Open source GNU/Linux automotive distribution with In-Vehicle-Infotainment (IVI)
- Based on the Yocto Project and OpenEmbedded
- Founded in 2014
AGL Core Technologies

- Qt/QML HMI
- HTML5
- GStreamer
- Weston with agl-shell-desktop
- Wayland
- SOTA Updates: OSTree & Aktualizr
- PipeWire
- systemd
- Linux kernel
- Security
  - AppFW, Cynagora, SMACK
Yocto/OpenEmbedded Layers in AGL

- poky
- meta-agl
- meta-agl-cluster-demo
- meta-agl-demo
- meta-agl-devel
- Meta-agl-extra
- meta-agl-telematics-demo
- meta-openembedded
- meta-security
- meta-virtualization
- meta-qt5
- meta-updater
- neta-spxxscanner
- meta-clang
- BSP layers: meta-raspberrypi, meta-intel, meta-ti, meta-renesas-rcar-gen3, meta-sancloud, etc.
AGL Releases

- Twice per year release cycle
- Releases are named on fishes
- Latest stable release is Itchy Icefish
- https://wiki.automotivelinux.org/agl-distro/release-notes
- https://wiki.automotivelinux.org/schedule

2020 AGL Schedule

As of 27 April 2020
AGL Supported Devices

- Renesas R Car Starter Kit gen3 board
- Most Intel 64-Bit hardware platforms (including Minnowboard Max/Turbot)
- Quick EMUlator (QEMU) or VirtualBox
- Raspberry Pi 3 and 4
- Various supported ports and/or older AGL releases for multiple other hardware platforms: i.MX6, Dragonboard 410, TI Vayu, Renesas Porter, Intel Cyclone V, Raspberry Pi 2, etc.
- https://wiki.automotivelinux.org/agl-distro?&#supported_hardware
Raspberry Pi

- Series of small single-board computers developed by the Raspberry Pi Foundation
- All models feature a Broadcom system on a chip (SoC) and ARM CPU
- Designed primary to promote teaching of basic computer science but also very popular in the maker community for hobby projects and demonstrations
Raspberry Pi Milestones

- 2009 - Raspberry Pi Foundation
- 2012 - The 1st Raspberry Pi
- 2014 - Raspberry Pi B+
- 2016 - Raspberry Pi Zero
- 2016 - Raspberry Pi 3
- 2016 - Raspberry Pi 3 B
- 2018 - Raspberry Pi 3 B+
- 2019 - Raspberry Pi 4 B
AGL Raspberry Pi Milestones

- 2015 – Mauro Chehab at that time working for Samsung OSG (Open Source Group) ported Tizen based on Yocto/OpenEmbedded to Raspberry Pi 2
- 2016 – GENIVI Dev Platform was ported to Raspberry Pi 2
- 2016 – AGL was ported to Raspberry Pi 2
- 2016 – Support for Raspberry Pi 3 was added in AGL
- 2019 – Support for Raspberry Pi 4 was added in AGL
Building AGL for Raspberry Pi (1/2)

- Prepare Repo Tool:

  ```
  mkdir -p ~/bin
  export PATH=~/bin:$PATH
  curl https://storage.googleapis.com/git-repo-downloads/repo > ~/bin/repo
  chmod a+x ~/bin/repo
  ```

- Download source code:

  ```
  mkdir agl-rpi
  cd agl-rpi
  repo init -b master -u https://gerrit.automotivelinux.org/gerrit/AGL/AGL-repo
  repo sync
  ```
Building AGL for Raspberry Pi (2/2)

- Set up build environment:
  ```bash
  source meta-agl/scripts/aglsetup.sh -m raspberrypi4 agl-demo agl-appfw-smack
  ```

- Launch the build process:
  ```bash
  bitbake agl-demo-platform
  ```

- The build from scratch takes a significant amount of the time depending on your Internet connection speed and the hardware capabilities of the build machine.
Supported Raspberry Pi models in the AGL master as of the moment:

- raspberrypi4
- raspberrypi3

AGL features:

- agl-demo
- agl-appfw-smack
- agl-sota
- agl-netboot

source meta-agl/scripts/aglsetup.sh -h
Flashing the Image on MicroSD Card

- Output Image location in build machine for Raspberry Pi 4:
  ```
  tmp/deploy/images/raspberrypi4-64/agl-demo-platform-raspberrypi4-64.wic.xz
  ```

- Extract the wic.xz and flash it on a microSD card
  ```
  sudo umount [sdcard device]
xzcat [output image] | sudo dd of=[sdcard device] bs=4M status=progress sync
  ```

- Plug the microSD card in the Raspberry Pi and turn it on (the first boot of AGL takes a bit longer)
Common AGL Images

- agl-demo-platform
- agl-image-ivi - base for IVI targets
- Agl-cluster-demo-platform - cluster demo image
- agl-image-boot - just enough to boot
- agl-image-minimal - minimal filesystem with APIs
- agl-image-weston - minimal filesystem with Wayland and Weston
Booting the image

- Serial output from AGL on raspberry Pi 4:

  Automotive Grade Linux 9.90.0+snapshot raspberrypi4-64 ttyS0
  
raspberrypi4-64 login: root
  raspberrypi4-64:~# uname -a
  Linux raspberrypi4-64 4.19.115-v8 #1 SMP PREEMPT Tue Mar 10 00:00:00 UTC 2020 aarch64 aarch64 aarch64 GNU/Linux

- Serial baud rate: 115200
AGL on Raspberry Pi 4 Screenshots
Weston on AGL

[[0;1;32m*[[0m weston@display.service - Weston Wayland Compositor
    Loaded: loaded (/lib/systemd/system/weston@.service; static; vendor preset: disabled)
    Drop-In: /lib/systemd/system/weston@.service.d
      `-weston-init.conf
    Active: [][0;1;32m active (running)[][0m since Tue 2020-03-10 00:01:47 UTC; 3 months 9 days ago
    Main PID: 768 (weston)
    Tasks: 1 (limit: 1703)
    Memory: 28.8M
    CGroup: /system.slice/system-w Weston@display.service
      `-768 /usr/bin/weston --idle-time=0 --tty=7 -log=/run/platform/display/weston.log

Mar 10 00:01:46 raspberrypi4-64 systemd[1]: Starting Weston Wayland Compositor...
Mar 10 00:01:47 raspberrypi4-64 systemd[1]: Started Weston Wayland Compositor.
Supported Raspberry Pi Peripherals in AGL

- HDMI monitors
- Raspberry Pi official 7” touchscreen display
- WiFi
- Bluetooth
- Various 3rd party add-on boards and HATs
OK, How Does It Really Work?
The Yocto Project

- Open source collaborative project of the Linux foundation for creating custom Linux-based systems for embedded devices using the OpenEmbedded Build System
- OpenEmbedded Build System includes BitBake and OpenEmbedded Core
- Poky is a reference distribution of the Yocto Project provided as metadata, without binary files, to bootstrap your own distribution for embedded devices
- Bi-annual release cycle
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<th>Support Level</th>
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<tr>
<td>Rocko</td>
<td>2.4</td>
<td>Oct 2017</td>
<td>Community</td>
</tr>
</tbody>
</table>
AGL Repo Manifests

- As of today **default.xml** is based on Yocto release Dunfell:

```xml
<project name="poky" path="external/poky" remote="yocto"
revision="a44b8d2856a937ca3991cbf566788b0cd541d777" upstream="dunfell" />
<project name="meta-gplv2" path="external/meta-gplv2" remote="yocto"
revision="60b251c25ba87e946a0ca4cdc8d17b1cb09292ac" upstream="dunfell" />
<project name="openembedded/meta-openembedded" path="external/meta-openembedded" remote="github"
revision="b1aa5f785094d25765657f1df7db0748680ae7fb" upstream="dunfell" />
```

- Use other manifest from AGL/AGL-repo for a specific AGL release: icefish_9.0.0.xml, halibut_8.0.6.xml, guppy_7.0.4.xml, etc.
General Yocto/OpenEmbedded Board Support Package (BSP) layer for the Raspberry Pi boards

- Depends on layers from meta-openembedded: meta-oe, meta-multimedia, meta-networking, meta-python

- Provides specific variables as knobs to enable/disable hardware specific features: ENABLE_I2C, ENABLE_SPI_BUS, RPI_USE_U_BOOT, ENABLE_UART, etc.

- For AGL VC4DTBO must be set to vc4-fkms-v3d to support Wayland, Weston and the apps on both HDMI and the official Raspberry Pi 7” touch screen display
New features and bug fixes are accepted as GitHub pull requests: https://github.com/agherzan/meta-raspberrypi

Maintained by Andrei Gherzan with more than 90 contributors

Documentation: https://readthedocs.org/projects/meta-raspberrypi/
Meta-raspberrypi in AGL

- Script `meta-agl/scripts/aglsetup.sh` for Raspberry Pi initializes the build environment with `conf/local.conf` and `conf/bblayers.conf`
- Yocto/OE layer `meta-agl/meta-agl-bsp` contains sub-layers with AGL hardware specific configurations
- Configurations from `conf/include/agl_raspberrypi4.inc` or `conf/include/agl_raspberrypi3.inc` are automatically included in `conf/local.conf` depending on the targeted Raspberry Pi model
AGL on Raspberry Pi 4

- Uses U-Boot as a bootloader
- GPU memory is set to 256MB
- UART is enabled
- Includes kernel modules
- Includes WiFi and Bluetooth firmware
Software Over the Air (SOTA) Updates

- The agl-sota feature enables support for software over the air (SOTA) updates in AGL images.
- Libostree (OSTree) and Aktualizr provide a "git-like" model for committing, downloading and automated provisioning of bootable filesystem trees to a fleet of vehicles.
- Yocto/OE layers meta-updater and meta-updater-raspberry provide the SOTA implementation for AGL on Raspberry Pi.
- For more details:
  - https://wiki.automotivelinux.org/subsystem/agl-sota/ostree
  - https://docs.ota.here.com/getstarted/dev/raspberry-pi.html
AGL Developer Tools

- Git & Repo
- Gerrit https://gerrit.automotivelinux.org/
- GitHub https://github.com/automotive-grade-linux
- JIRA https://jira.automotivelinux.org/
- Wiki https://wiki.automotivelinux.org/
- Documentation http://docs.automotivelinux.org/
- Jenkins for CI and Lava + Fuego for running test
AGL Gerrit

- Free and open source web-based team code collaboration tool for code reviews
- Create an account at identity.linuxfoundation.org to get started
- https://gerrit.automotivelinux.org/
Contributing to AGL

- Report an issue or a new feature in JIRA
- Modify the source code
- Include references to the JIRA issue in the Git commit messages
- Contribute to the upstream following the AGL Gerrit workflow
<table>
<thead>
<tr>
<th>Gerrit</th>
<th>CHANGES</th>
<th>YOUR</th>
<th>DOCUMENTATION</th>
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<td></td>
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<td>as a8f9814</td>
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**22872: agl_raspberryi3.inc: Switch to firmware KMS**

Updated: Nov 07, 2019
Owner: Leon Anavi
Assignee: Set assignee...
Reviewers: Jan-Simon Moeller, Walt Miner, Tadao Tanikawa
AND 8 MORE
ADD REVIEWER
CC: ADD CC
Repo: AGL/meta-agl
Branch: halibut
Parent: 0a620bf5
Topic: No topic
Hashtags: ADD HASHTAG

---

**agl_raspberryi3.inc: Switch to firmware KMS**

Switch to firmware KMS with appropriate Linux kernel and Mesa version to support both HDMI and the official 7" Raspberry Pi touch screen display on Raspberry Pi 3B/8+ and 4. Device tree changes are not required for firmware KMS.

Bug-AGL: SPEC-2465

Change-Id: I5f8f62c0151b7eb79ab1f96419d9c62469a1554e
Signed-off-by: Leon Anavi <leon.anavi@konsulko.com>

---

Relation chain:
- raspberrypi*/50_local.conf.inc: Update... (Merged)
- agl_raspberryi3.inc: Switch to firmware... (Merged)
- bcm2835-bootfiles.bbappend: Update... (Merged)
- linux-raspberryi_4.19.bb: Update to 4... (Merged)
- rpi-config: Set max_framebuffers to 21... (Merged)

Submitted together:
- AGL/meta-agl: halibut: raspberrypi*/50_local_co...
- AGL/meta-agl: halibut: agl_raspberryi3.inc: Swi...
- AGL/meta-agl: halibut: bcm2835-bootfiles.bbap...
- AGL/meta-agl: halibut: linux-raspberryi_4.19.bb
- AGL/meta-agl: halibut: AGL/meta-agl: halibut: ...

Cherry picks:
- master_agl_raspberryi3.inc: Switch to firmware...
AGL Communication Channels

- AGL mailing list
  https://lists.automotivelinux.org/g/agl-main

- Weekly Developer Call
  (Tuesday 14:00 - 15:00 UTC)
  https://wiki.automotivelinux.org/dev-call-info

- IRC
  channel #automotive on freenode.net
Conclusion

- Automotive Grade Linux is a collaborative open source project that is bringing together automakers, suppliers and technology companies to accelerate the development and adoption of a fully open software stack based on Linux for the connected car.

- Raspberry Pi is a community supported hardware platform compatible with AGL that is useful for getting started and proof of concept demonstrations.

- Join Automotive Grade Linux by contributing to the development, testing and/or the documentation of the project!
Thank You!

Useful links:
- https://www.automotivelinux.org/
- https://docs.automotivelinux.org/
- https://wiki.automotivelinux.org/agl-distro/agl-raspberrypi
- Pre-built binary images: https://wiki.automotivelinux.org/agl-distro?&supported_hardware